Assessment and Practical Inquiry in Scientific Argumentation (APISA) Project:

A Professional Development Programme for Secondary Science Teachers

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The booklet contains resources for the professional development of science teachers who are aiming to teach scientific argumentation in secondary schools. The resources were generated as part of the S-TEAM Project and conducted at University of Bristol in collaboration with science teachers from the Bristol area from 2009-2010. The booklet is divided into several sections. The first four sections focus on particular strategies that can be used by teacher trainers in conducting workshops with groups of science teachers. The first section is an introduction to argumentation including approaches for supporting the teaching of argumentation at the level of the classroom. The second section concentrates on aspects of practical inquiries and investigations in science education with particular reference to the “Getting Practical” work developed by the Association for Science Education in England. Our aim with the use of these resources was to situate argumentation within the key frameworks on practical work promoted in England. The third section illustrates the national assessment framework called “Assessing Pupils’ Progress”. In the fourth section we draw together the different components on argumentation, practical inquiries and assessment in an effort to facilitate the coordination of these various aspects of teaching science in secondary schools. Each section is introduced with a set of aims, suggested activities for professional development sessions and resources needed for the implementation of the sessions. The Appendix consists of the resources that are included as part of each section that can be viewed as a training session. The last two sections of the document include verbatim feedback from the teachers who have participated in the project in order to illustrate the sorts of issues that science teachers face in dealing with the proposed strategies in promoting argumentation in science lessons. The document concludes with example lesson resources that teachers can use with pupils.
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1.1 Introduction to Argumentation in the Context of Scientific Inquiry

As a first step in supporting science teachers in adopting inquiry-based teaching methods including argumentation, we need to find out what teachers actually know about argumentation. Clearly there is little point in starting enquiry-based activities which teachers will not find useful or which they already know. One starting point is to highlight some exemplar activities already produced as a basis for discussion on the pedagogical aspects of scientific argumentation in the classroom.

AIMS

1. To engage the teachers in argumentation as a key pedagogical strategy in science teaching;

2. To use existing resources as a basis for promoting discussion among teachers;

3. To provide teachers with models of argumentation in science teaching.

SUGGESTED ACTIVITY

1. Show the video from the 'Mind the Gap' Resources: Steve's 'Runny Honey' lesson.

2. Ask teachers to think about the ways in which Steve incorporates aspects of argumentation and inquiry in the classroom.

RESOURCES TO USE

1. Video of Runny Honey lesson:

   In this video, excerpts from a whole lesson are presented, including an initial demonstration modelling friction. This task serves to establish the necessity of considering temperature in relation to viscosity. The teacher Steve sets a task where pupils need to propose an experimental design on measuring viscosity and investigating the relationship between viscosity and temperature. Pupils produce various methodological approaches, evaluate and discuss their results and Steve reflects on the lesson.

2. Slides for Session 1 in the Appendix.
1.2 Strategies for Defining and Supporting Argumentation

The session begins with a review of Stephen Toulmin’s model of argument (Toulmin, 1958). This is a model that has been used extensively by science educators (Erduran & Jimenez-Aleixandre, 2008). There is an initial overview of the model with a subsequent time to allow for group evaluation of the model for classroom use. Teachers can also be asked to apply the model to scientific or socio-scientific examples.

AIMS

1. To introduce a model of an argument;

2. To develop participants’ knowledge and understanding of Toulmin’s Argument Pattern (TAP);

3. To develop resources for the use of TAP with pupils.

SUGGESTED ACTIVITY

1. Show a diagram of Toulmin’s Argumentation Pattern (Toulmin, 1958) such as the one below.

![Toulmin's Argument Pattern Diagram]
2. Talk through each component of the argumentation pattern. Ask the group to discuss how Toulmin's Argument Pattern (TAP) could be translated into a framework for use by school pupils. TAP illustrates the structure of an argument in terms of an interconnected set of a claim; data that support that claim; warrants that provide a link between the data and the claim; backings that strengthen the warrants; and finally, rebuttals which point to the circumstances under which the claim would not hold true. More specifically, in Toulmin's definition "a claim is an assertion put forward publicly for general acceptance." Grounds are "the specific facts relied on to support a given claim." Backings are "generalizations making explicit the body of experience relied on to establish the trustworthiness of the ways of arguing applied in any particular case." Rebuttals are "the extraordinary or exceptional circumstances that might undermine the force of the supporting arguments." Toulmin further considers the role of qualifiers as "phrases that show what kind of degree of reliance is to be placed on the conclusions, given the arguments available to support them."

3. Show the following example of a writing frame.

Writing Frame Example:
- My idea is...
- My reasons are that...
- I believe my reasons because...
- Ideas against my idea are...
- I would convince someone who doesn't believe me by...

4. Working in pairs, ask the teachers to develop an argument sheet that can be used with their pupils. Explain that adoption of a theoretical framework such as TAP involves a creative process to suit our own purposes, and that there are many ways in which this adoption and transformation of the original model can proceed.

5. The next stage is to develop pedagogical strategies and ways in which argumentation can be used in the classroom. Show teachers the following points:

Pedagogical strategies:
- Materials for student activities
- Arguing prompts
- Role-play
- Writing frames
- Group presentations

Ask the teachers to select one of the strategies and brainstorm some of the ways in which these strategies could support argumentation in science teaching.
6. Now ask teachers to keep these aspects of argumentation in mind in developing their own resources. In between the future sessions, teachers will go back to their schools and develop a classroom activity based on some of the discussions carried out in the sessions. It would be advisable to collaborate with teachers to film their lessons so as to provide a record for discussion in subsequent sessions. The videotaping facilitates teachers' reflections on their teaching and also provides evidence of various strategies that can emerge in experimenting with different resources.

RESOURCES TO USE

1. Slides:

Toulmin's argument pattern

Writing frame example

Different pedagogical strategies

2. References:


1.3 Developing a Sense of Ownership

In developing effective learning environments for teachers, it is important that teachers feel a sense of ownership if they are to fully engage with the learning and creative aims of the workshops. Part of this process is about allowing participants to set the agenda. This can seem a contradiction in terms when workshops are invariably ‘led’ by facilitators or staff who have planned sessions with the aims and outcomes already established, and teachers attend workshops already equipped with such expectations. Part of this opening session is therefore being clear that the aims are precisely that of developing a sense of ownership.

AIMS

1. To enable teachers to set an agenda for their own learning against the ideas introduced in the workshops;

2. To encourage teachers to collaborate and communicate outside of the workshop times;

3. To communicate that professional development is not necessarily about following courses but rather can involve active engagement in designing and implementing own learning agendas.

SUGGESTED ACTIVITY

1. In pairs ask teachers to discuss their expectations from a professional development course;

2. Ask the pairs to report to the whole group;

3. Conduct a plenary discussion on different professional development models and what works best for each of the teachers participating in these workshops.

RESOURCES TO USE

Flipchart to make a record of brainstormed ideas on models of professional development.
2.1 Sharing Teaching Practices

Opportunities for teachers to share ideas and practice need to be built into a teacher training programme. Group work may not be a realistic option outside of the workshop but showing videos of their lessons to other teachers can bring tangible benefits in terms of developing new ideas, sharing resources and sharing practices. For example, how do teachers manage their science classrooms when pupils are role-playing in an argumentation-based activity? How can teachers enable pupils to share their ideas? Teachers sharing practices based on evidence from the classroom including student work can be beneficial in their learning of concrete approaches to teaching and learning, particularly when the topic under investigation might be relatively new in the curriculum.

AIMS

1. To discuss example teaching and learning resources from different teachers;
2. To encourage ownership of the professional development agenda through the use of resources generated by the teachers themselves;
3. To share classroom practices, strategies and pupils' work.

SUGGESTED ACTIVITY

Show a video of a lesson where students are arguing about a scientific or socio-scientific topic. Ideally this is a lesson filmed by teachers participating in the workshops. Prior to the workshop date, it would be advisable for the workshop coordinator to contact the teachers and remind them to bring with them evidence from their practice. Working in pairs, ask teachers to review the video-taped lessons and/or resources in terms of:
1. Pedagogy
2. Classroom management
3. Ideas on how this lesson could be used in their own school
4. Feedback to the group their ideas for development

RESOURCES TO USE

Videos of lessons and pupils' resources developed by teachers.
2.2 Example Teaching Practices and Reflections on Lessons

For some teachers, filming lessons may not be feasible or practical. Ideally, we would use participant-created videos of practice but ideas can also be stimulated through written or verbal descriptions of lessons. What is most important here is that teachers’ thought processes and the conversations develop through discussing the activities. This session uses a teacher’s description of a lesson to stimulate discussion of scientific argumentation in practice. It concludes with teachers developing their own, new lesson plans for argumentation.

AIMS

1. To develop teacher conversations on the teaching of scientific argumentation;
2. To share practices and resources in lesson development;
3. To develop teaching resources using exemplar materials.

SUGGESTED ACTIVITY

1. Distribute a copy of the Hearing Loss activity as described by a S-TEAM project teacher.

2. Ask teachers to read through the lesson description and think about the key points of the lesson. For example, why teach this particular practical with a certain class? What is the teacher trying to achieve with these lessons in terms of argumentation in science?

3. In pairs, let the teachers discuss these key points and work out how they could be developed in a lesson in their school.

4. Report back to the group on their ideas for lesson development, either expanding on the lesson or as a basis for a new lesson.

5. If time permits, repeat activity by distributing copies of the Wind Farms activity developed by a S-TEAM project teacher.

RESOURCES TO USE

Teachers’ descriptions of:
1. The Hearing Loss lesson; 2. The Wind Farms lesson (Appendix).
Linking Practical Work in Science with Argumentation

The aims of this session are to focus on developing strategies for formulating clear learning objectives and outcomes for practical activities undertaken in school science classes. The activity is adapted from the published materials of the Getting Practical CPD course, developed by the Association of Science Education in the UK, together with its collaborative partners (© The Association for Science Education, 2009. All rights reserved).

The ‘Improving Practical Work in Science’ project stems from recommendations in the SCORE report: Practical Work in Science: A Report and Proposal for a Strategic Framework (2008). SCORE is a partnership of seven organisations, which aims to improve science education in UK schools and colleges by influencing government and policy-makers and supporting the development and implementation of effective education policy and projects.

Project websites:

Getting Practical http://www.gettingpractical.org.uk/
SCORE http://www.score-education.org/home

AIMS

1. To develop strategies for formulating clear learning objectives and outcomes for practical activities;

2. To link ideas on scientific argumentation with coursework that includes practical investigations;

3. To make use of existing resources of national importance in situating argumentation in teachers’ practices.

SUGGESTED ACTIVITY

1. Give teachers a series of worksheets illustrating practical activities that routinely form parts of the teaching schemes of most science departments in England. These practical activities can be chosen from three websites:

Practical biology http://www.practicalbiology.org/


The practical activities that can be selected are:

*How much energy is there in food?*

*Testing a leaf for starch?*

*Causes of rusting*

*Reaction of carbon dioxide and water*

*Using ammeters*

*Timing a trolley on a slope*

2. Arrange the practical instruction sheets on walls around the room. Distribute packs of post-it notes to the teachers. Ask the teachers to write on these post-it notes the purposes for which these practical activities were undertaken. Write each reason on a post-it note (one or two reasons for each activity will suffice).

3. Ask teachers to place their post-it notes on the relevant activity sheet.

4. Organise the teachers into small groups and divide up the practicals between them. Teachers should then remove the post-its from their practicals and arrange the post-its into groups, sticking them onto a big piece of paper.

5. Ask teachers to discuss how they classified their ‘post-its’ - what groups did they use? How does their classification compare with other teachers’?

6. As a group, discuss the reasons for carrying out practical work.

For example, a discussion of the outcomes might suggest that there are four reasons for carrying out practical work:

- To teach and develop skills of practical work
- To develop or reinforce scientific knowledge and understanding
- To develop the skills of scientific inquiry
- To develop an affective sense of enjoyment, curiosity or wonder.

The first three of these aims are considered to be a key part of the Getting Practical philosophy. The inter-relationship between these three domains is shown below.
Three main purposes for practical work

The model reflects published about practical work by Millar (2009), who presents the following reasons for doing practical work:

1. to teach laboratory skills;
2. to enhance the learning of scientific knowledge;
3. to give insight into scientific method and to develop expertise in using it.

The fourth category reflects the affective outcomes of practical science or the motivational aspects of doing practical work. This was not included as a core category for Getting Practical. The developers of the course state:

"Whilst these are clearly important outcomes to practical activities, they are not (or ought not to be) the sole purpose of planning or doing the activity. Indeed every teaching and learning activity should inspire, engage and motivate pupils; it would be inconceivable to set a converse objective which was to 'de-motivate' or 'disengage' pupils."

This led into a consideration of the some of materials from the Getting Practical CPD, which is included below.

7. Revisit the practical activities presented at the start, using the practical audit grid to map specific learning outcomes onto each practical activity.

8. Encourage the teachers to situate argumentation skills that would be promoted in these practical activities. Ask them to think of an extension to the activities to incorporate ideas from the first session, particularly the use of Toulmin's argument pattern in linking experimental data with scientific claims.
RESOURCES TO USE

1. Set of worksheets illustrating practical activities downloaded from web sites:
   
   Practical biology [http://www.practicalbiology.org/]
   Practical chemistry [http://www.practicalchemistry.org/]
   Practical physics [http://www.practicalphysics.org/]

2. One pack of post-it notes per teacher

3. Getting Practical Session one PowerPoint

4. Session one practical audit grid


5. Personal reflections by the teachers, who developed and implemented these resources, including any outcomes from the lessons (e.g. work, comments, etc).

The teachers can choose a variety of purposes for the practical activities, which formed into the four categories outlined above. Early attempts to map specific learning outcomes onto practical activities led to a consideration of how many outcomes should be included for any practical. Given the need to ensure that all students are able to experience these outcomes, the eventual feeling was that a practical activity should have a relatively few key outcomes, that the teacher can focus effectively onto.
4.1 Assessment in Argumentation

Assessment in the context of argumentation remains an understudied issue in terms of research and also in application to the design and implementation of professional development programmes. In this session, the aims are to consider critically the current protocol in England for teacher-based assessment in middle years education (Key Stage 3, 11-14 years) called “Assessing Pupils’ Progress” (APP). In so doing, the objective is to establish consistency with the assessment frameworks that science teachers are expected to operate by.

AIMS

1. To critically consider teacher-based assessment in middle years education;

2. To establish consistency with current assessment provision in secondary schooling in England;

3. To situate the role of argumentation in the APP framework;

4. To generate some strategies for and criteria of assessment of argumentation in science lessons.

SUGGESTED ACTIVITY

1. Show the power-point presentation on the aims of APP.

2. At slide No. 6 (Title: I.3 How does APP contribute to the AfL Strategy?) ask teachers to discuss in groups how different aspects of assessment and their implications for assessing argumentation in science classrooms.
1.3 How does APP contribute to the Afl Strategy?

APP provides systematic support for the three linked aspects of assessment:

<table>
<thead>
<tr>
<th>Aspect</th>
<th>AFL Strategy</th>
<th>APP contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day-to-day</td>
<td>Learning objectives made explicit and shared with pupils. Peer-and self-assessment in use. Pupils engaged in their learning and given immediate feedback.</td>
<td>APP encourages recognition of a wide range of evidence from pupils’ ongoing, day-to-day work.</td>
</tr>
<tr>
<td>Periodic</td>
<td>Broader view of progress across subject for teacher and learner. Use of national standards in the classroom improvements to medium-term curriculum planning.</td>
<td>APP enables the review of evidence to be systematic by focusing closely on level-related criteria in each of the assessment focuses (AFs).</td>
</tr>
<tr>
<td>Transitional</td>
<td>Formal recognition of pupils’ achievement. Reported to parents/careers and next teacher(s). Use external tests or tasks.</td>
<td>APP strengthens teachers’ assessments and their understanding of pupils’ progress, so that this more formal sharing can be valid, reliable and detailed</td>
</tr>
</tbody>
</table>

3. Discuss the links between National Strategy Frameworks and APP guidelines (Slide No. 7 below). The purpose in this activity to establish that the particular assessment guidelines represented in the APP model relate to the broader national policy frameworks. In otherwise, any new strategy such as argumentation to be introduced in the classroom will need to be contextualised in the national policy and assessment frameworks.

<table>
<thead>
<tr>
<th>National Strategy Frameworks</th>
<th>APP guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>While schools and teachers are free to plan a curriculum which will engage their particular learners, the Frameworks specify what needs to be covered within the teaching of a specific subject.</td>
<td>The assessment criteria are sufficiently broad to allow a wide range of evidence to be taken into account. Much of this derives from classroom teaching of the subject but evidence can be drawn from other subjects and from pupils’ learning beyond the school.</td>
</tr>
<tr>
<td>Framework learning objectives are presented within ‘strands’; teachers can use the curriculum progression within these strands to determine the appropriate pitch of the work for pupils of different abilities within the class.</td>
<td>The assessment guidelines provide a structure for looking at the evidence of pupils’ learning. They focus on significant aspects of performance in the subject.</td>
</tr>
<tr>
<td>Framework learning objectives set out in reasonable detail the knowledge, skills and understanding which need to be acquired in that subject across a period of time.</td>
<td>APP criteria generally describe a small number of features of pupils’ work or learning which are characteristic of their independent performance at each level in each strand.</td>
</tr>
<tr>
<td>Clarity about the objectives of specific teaching gives pupils a greater sense of purpose and direction. It also provides a strong basis for immediate feedback to the pupil in the specific context of the teaching and learning.</td>
<td>Use of the APP criteria gives teachers and pupils a broader view of learning across the whole subject over a period of time (typically over a term) and across different contents.</td>
</tr>
<tr>
<td>The learning objectives represent the basis of a curriculum experience for every learner; teachers will organise and present them in a variety of ways and pupils in all types of settings will engage with them differentially.</td>
<td>APP criteria are predicated on pupils of all abilities having access to the full curriculum; they allow the variation in pupils’ responses to be assessed periodically and they help teachers identify where more work is required in day-to-day learning and teaching and where medium-term planning needs to be adjusted.</td>
</tr>
</tbody>
</table>

5. Show Slide No. 8 listing the five AF elements and ask teachers to consider where argumentation techniques might fit in with AF frameworks, using examples from their lesson plans. Ask the teachers to choose examples of lessons that would target each AF.
AF1 – Thinking scientifically

AF2 – Understanding the applications and implications of science

AF3 – Communicating and collaborating in science

AF4 – Using investigative approaches

AFS – Working critically with evidence

5. Hold a plenary discussion encouraging lesson examples that map onto each AFs.

Note: Argumentation seems to be appropriate to a range of the criteria for APP, especially AFS – Working critically with evidence, and AF3 - Communicating and collaborating in science.

RESOURCES TO USE

1. Power-point presentation: “Assessing pupils’ progress in Secondary science at Key Stage 3” (Appendix)

2. Personal reflections by the teachers, including the argumentation resources produced and assessment approaches already taken in the implementation of these resources.
4.2 Practical Inquiry and Assessment: Linking Argumentation, APP and Getting Practical

The primary aim of this session is to bring together argumentation theory, approaches to practical work and assessment into a single framework that can be implemented in science activities. In this respect, the session is intended to draw a synthesis of all the previous activities in the sessions.

AIMS

1. To synthesise the perspectives and activities from the previous sessions;

2. To create coherence across national policies and professional development agendas;

3. To encourage teachers' thinking about a coordinated set of objectives in addressing argumentation in their lessons.

SUGGESTED ACTIVITY

1. Set up the power-point presentation: 'Why do we do practical work?'

2. At the opening slide (Slide #1) state that the presentation develops the position that argumentation can serve as a bridge between practical work and theoretical ideas, and that practical work can too act as a connector between the domains of ideas and observables. In the sense of Toulmin's argument pattern, it would be useful to remind the participants that the claims or conclusions belong to the domain of ideas whereas the data relate to the domain of objects and observables. Even though these distinctions are not always very easily defined (given the theoretical bias on observations), this is a useful entry point to the conceptual differentiation of promoting students' not only "hands-on" engagement in but also "minds-on" engagement in science.
3. Show Slide #2. Explain that the model in Slide #1 can be regarded as a simplified version of Karl Popper's three-world model, where World 1 contains the world of physical objects and events (i.e. domain of objects and observables) and World 3 contains the products of human thought (i.e. domain of ideas). Popper's second world is the world of subjective mental events. It is within this world that children engage with practical work and where argumentation arises. The value of introducing World 2 into the model is that it allows argumentation and practical work to both become a bridge between the domains of objects and observables and the domain of ideas.

![Diagram of Popper's three-world model](image)

4. Show Slide #4 below that reconciles the approaches of APP and Getting Practical. Ask the teachers to develop key learning outcomes for argumentation that mirror those of experimental science. Argumentation can arise from the interaction of the three domains. Ask the participants to discuss the model and what it contributes to science teaching and learning.

![Diagram of learning outcomes](image)
5. The overarching aim of the following two activities is to start thinking about why we do a particular practical with a particular class. In groups, ask teachers to discuss: what are we trying to achieve? What is most important here, therefore, is teachers' thought processes and the conversations that develop through the activities.

It would be worth unpicking some of these reasons and outcomes, for example:

- State or use a classification system refers not just to the biological idea of classification but is broader – examples from chemistry and physics include testing metals and non-metals, and identifying energy transfers.

- Describe and carry out a standard procedure – in this context, by standard procedure we mean any technique that pupils ought to be confident in carrying out without repeated instruction. Examples include using a measuring cylinder, lighting a bunsen burner, setting up a microscope and connecting wires in a circuit.

- Data here refers to both quantitative and qualitative information.

6. Ask teachers to report back on their discussion of potential learning outcomes. Some proposed learning outcomes can be:

- Construct an argument
- Evaluate an argument
- Science in society

7. Show Slide #5 and discuss with the group how these outcomes could be mapped directly onto the Getting Practical audit grid below:

RESOURCES TO USE

Powerpoint presentation: 'Why do we do practical work?'

Personal reflections by the teachers, who developed and implemented these resources, including any outcomes from the lessons (e.g. video clips, pupils' work, lesson plans).
4.3 Assessing Argumentation

In this session, the teachers will begin to think through how the quality of argumentation can be assessed, in particular in spoken discussions in the classroom. The key theoretical work guiding this session is the work of Erduran et al. (2004) who have generated a levelling scheme to classify the quality of interactive argumentation. The teachers can be encouraged to extend this framework for generating assessment criteria in written arguments as well.

AIMS

1. To introduce an example framework for assessing the quality of argumentation in whole class and group discussions;

2. To extend the use of the assessment framework from spoken to written argumentation through group tasks.

SUGGESTED ACTIVITIES

1. Introduce the Levels of Argument framework developed by Erduran et al (2004). Explain that the development of the framework was guided by Toulmin’s Argument Pattern as a model of argument. Different features of this pattern were applied to generate a way to capture the quality of interactive argumentation.

Analytical Framework Used for Assessing the Quality of Argumentation

**Level 1:** Level 1 argumentation consists of arguments that are a simple claim versus a counter-claim or a claim versus a claim.

**Level 2:** Level 2 argumentation has arguments consisting of a claim versus a claim with either data, warrants, or backings but do not contain any rebuttals.

**Level 3:** Level 3 argumentation has arguments with a series of claims or counter-claims with either data, warrants, or backings with the occasional weak rebuttal.

**Level 4:** Level 4 argumentation shows arguments with a claim with a clearly identifiable rebuttal. Such an argument may have several claims and counter-claims.

**Level 5:** Level 5 argumentation displays an extended argument with more than one rebuttal.
Note that in Erduran et al. (2004)’s work rebuttals were identified as key features of the quality of argumentation. This is because the presence of a rebuttal assumes that another argument is understood enough to be opposed. So the arguer would not only need to understand his or her argument but also the opponent’s argument and present evidence against their argument. In other words, the use of rebuttal indicates higher level engagement with evidence in particular and argumentation in general.

2. Ask teachers to work in groups to identify a short (5 minute) video clip from their classroom discussions, either whole class discussions or group discussions, and use the levelling framework to identify some examples.

3. Conduct a plenary discussion on the use of the framework. Note the points raised and ask for potential strategies to resolve them. For example, there may not be many instances of discussions where there is the use of rebuttals. Ask the teachers to brainstorm about potential strategies for promoting disagreement in group discussions so as to ensure that rebuttals can emerge. One strategy is for the teacher to play a devil’s advocate by suggesting an opposite point of view and getting the pupils to provide evidence against that point of view.

4. The next activity will focus on the use of the levelling scheme in written arguments. Ask the teachers to produce rubrics that can be applied to pupils’ written work. There are some examples in Erduran & Villamanan (2009) in the use of Toulmin’s Argument Pattern in the assessment of written arguments. Ask the teachers to identify some written work of their pupils and identify features of arguments such as claims, data and warrants. For teachers’ purposes, it might be more appropriate to collapse some of the categories of Toulmin’s framework because the level of detail may not be necessary. For example, it may not be necessary to distinguish warrants from backings but rather a collapse category of “justification” would serve the purpose of tracing this aspect of an argument.

RESOURCES

1. Video clip examples of pupil or whole class discussions (5 minute maximum).

2. References:

The following section is a resume of teacher reflections on the workshops guided by the sessions described earlier and conducted with a group of S-TEAM Project teachers in Bristol, England. Teachers were asked to reflect on the content of the individual sessions and to explore the impact of the workshops on their professional development. The outcomes of these reflections will be detailed. For example, teachers mentioned the impact on their teaching stemming both from the workshop content and the process of interaction with academic staff and other science teachers. In all cases, the teachers were asked to produce lessons using argumentation and most importantly, to bring them back to the group of teachers for discussion and development. There was no set time for production of the lesson plans – the content and format were products of each individual teacher’s own interest and school context. Some lessons were designed for use with the younger Year 7 groups (age 11); others were for older examination years.

The section in included in this booklet to provide a context for teacher trainers in anticipating some of the outcomes that can be expected from the implementation of the ideas in the sessions.

The first section includes verbatim comments from the S-TEAM project teachers followed by some example lesson resources produced by them. The lessons comprise ideas formulated and resources developed as a direct result of the S-TEAM workshops. These lessons illustrate the types of activities that teachers who have attended the S-TEAM workshops have produced. Not all activities are in their final form – the teachers continue to reflect on how their lessons could have been improved and how they might conduct the lesson differently at the next opportunity.
Teacher Reflections

The following section includes verbatim comments made by the S-TEAM Project teachers organised around the key themes advanced in the workshops. They highlight some of the key opportunities and challenges in infusing argumentation in science teaching and learning, as well as the related themes of practical work and assessment. The comments also illustrate the impact of the professional development programme on teachers’ practices from their own points of view. For example, several teachers valued the opportunity to collaborate with other teachers and share resources as well as practices.

Introduction to argumentation

“They are quite open the sessions and so they can sometimes lead off in a different direction and that takes me out of my comfort zone a little bit so maybe - I’m not saying it’s something I didn’t enjoy but something I found challenging, going off in different directions rather than being told what to do all the time.”

“It’s always useful to collaborate and network with other people anyway so those kinds of events always give you that opportunity which is really good. From that point of view I have lots of good practice and ideas from people like Catherine and Damian who have done lots of work. It’s also a chance to discuss things that at you don’t have time to in other aspects of your day-to-day work. It’s been really useful in that respect….In terms of argumentation which has been the big part of this it has really made me think about how you have to structure and plan that into your lesson. In the past we have all done debates on this that and the other and there is a tendency to set up in a really simple, loose format but when you look at argumentation and how a good argument really looks, actually what you do do isn’t that and you really need to break it down a lot more and do it more slowly. You have to train the kids rather than let them loose on a discussion of some thing.”

Strategies for supporting argumentation

“As a teacher I think its made me plan things more carefully in terms of argumentation and actually I know how to… as a teacher you know how to construct an argument, you know you need to have evidence and you need to have a claim and you need to back it up with something but as a student you don’t really know that. You make a point and you don’t know how to support it so in terms of being a teacher it has made me aware that students need a more structured understanding and you need to deliver it in that way.”
Developing a sense of ownership

“I knew early on that with a bit of input about argumentation, it was up to us to drive the agenda and that was fine that was good and we did keep along with that theme quite happily and we managed to produce some good work.”

“The strengths are the bits that I actually find most awkward to start with. It’s quite a loose – there’s obviously an agenda for the day and things are planned in and thought about but it’s quite loose in that when the conversation does start, if it goes off on a useful tangent or a meaningful direction, we just go with it really and things change quite rapidly throughout the day At first I did find that a little bit difficult, I didn’t know what we were doing, I didn’t know if we were meant to reach a conclusion about something or making a decision but a lot of it is just discussing and thinking and that is a strength but it just took me a while to get used to that way of doing things. So its got structure but in an informal way which is quite nice.”

Sharing practice

“So it was the discussions and the fact that they were open discussions as well and think that’s almost like the project itself – it’s very difficult to get a discussion that’s open and structured at the same time – the sort of things that are almost contradictory really, and I think that the Stream way of dealing with things, how it’s managed to get across those problems – I guess its because people are all trying to solve the same sort of problem but they come from different directions so you get this mixing of ideas and it’s really good.”

“It’s been really good. I’ve liked interacting with the other teachers and particularly there was a teacher in my local area and there were also teachers from my previous school so it was nice making links between those different people and also trying to get their experiences and helping them was really beneficial to me to think through my practice and what I actually did.”

“It’s actually given me some really good ideas in terms of teaching & learning because in the past with argumentation I’ve literally done a discussion where you do for and against and then that’s it and actually it’s shown me that argumentation is a lot more complicated than that and it needs structuring a little better and it can be really interesting.”

“I tried Steve’s, the sawdust one and I did try and it didn’t work very well so I have asked him about it and he has told me how to do it properly – where he had water in one and he had sawdust in the other and he added the same amount or volume of water to both. It’s literally a very, a really open argument rather than giving them a really structured, something to write down or giving them all the different steps to an argument you are just trying to tease an argument out of them rather than just telling them what to do. You are saying, ‘Why? Why do you think that?’ And they have to come up with reasons themselves.”

“It’s a lot less planned and a bit more scary but it seemed to work quite well with Steve so I’m hoping that if I do it again it will be fine!”
Getting practical

“I really like that we’ve had Neil [Science Education lecturer] involved in the project too to bring in an extra dimension and the fact that he was a science teacher too until relatively recently so totally understands exactly where we’re coming from and what we’re doing. His work with the ASE and talking about the Getting Practical project and how that links in has been really good.”

Assessing pupils progress (APP)

“It was more that I was given time to sit down and think through how I would do things in an effective manner and then my job as KS3 co-ordinator meant that I had to have some kind of concrete way of linking it in with APP so that was one of my main aims going into the project – I wanted to make sure I could use it in my school with APP and given the time to do that and use it in my school was really good. It’s meant that I’ve thought through the process of argumentation and how it fits into my science teaching and actually worked out that it fits in to quite a lot of places that I wasn’t sure it did fit before and it really, really does and also it directly maps into the APP framework so from my point of view that was brilliant because I’ve now got a lot of tools to extend pupils, especially at the higher end, to get levels 7 and level 8 and work out a way of doing it.”

“I’ve really enjoyed sharing ideas with different people from different schools and there are some ideas I would never have thought of myself and I have gone back to school and tried some of those myself with varying levels of success (I need to practice some of them). And also I have liked how it’s allowed us to tie a lot of what we’ve done and what we’ve learnt in with the APP criteria because that’s really important in schools at the moment and its an area we are really still working on so its given me a lot of ideas and I enjoyed that too.”

Linking APP and Getting Practical

“Coming to the workshop made me realize that argumentation is in practically everything you do. There is always something where you might try and justify why you might do something.”

“I’ve really enjoyed sharing ideas with different people from different schools and there are some ideas I would never have thought of myself and I have gone back to school and tried some of those myself with varying levels of success (I need to practice some of them). And also I have liked how it’s allowed us to tie a lot of what we’ve done and what we’ve learnt in with the APP criteria because that’s really important in schools at the moment and its an area we are really still working on so its given me a lot of ideas and I enjoyed that too.”
Assessing argumentation

“I am completely won over by all the arguments to do with argumentation, looking at that bridge between evidence which is so important in science and the theory and trying to find ways of constructing a persuasive argument in order to make those results there believable, and for people to just change your mind accordingly.”
Resources for Session 1: Introduction to Argumentation

Power-point slides:

Slide 1

Slide 2

Introduction to project

Main objectives:

• To improve motivation, learning and pupil attitudes in European science education resulting in increased scientific literacy and recruitment to science-based careers by
• Enabling large numbers of teachers to adopt inquiry-based and other proven methods for more effective science teaching
• Supporting teaching by providing training in and access to innovative methods and research-based knowledge
Slide 3

Mind the Gap project

Slide 4

Theoretical Model

Slide 5

Writing Frame Example

- My idea is...
- My reasons are that...
- I believe my reasons because...
- Ideas against my idea are...
- I would convince someone who doesn’t believe me by...
Slide 6

Pedagogical strategies
- Materials for student activities
- Arguing prompts
- Role-play
- Writing frames
- Group presentations

Slide 7

Arguing Prompts
- Why do you think that?
- What is your reason for that?
- Can you think of another argument for your view?
- Can you think of an argument against your view?
- How do you know?
- What is your evidence?
- Is there another argument for what you believe?
Resources for Session 2: Ownership of Professional Development

Jennie’s lesson on hearing loss

I was trying to get them used to the idea of why you would actually argue about something. First of all I tried to illustrate it with...we started with a starter, where they had a piece of paper with some information on it, a piece of text from an advert basically, it was about the akai berry diet, about super foods and that sort of thing. I asked them, we went over what a claim is, what evidence is, we talked about data and came up with some definitions for different terms. Then I asked them to basically in different colours to highlight where they found a claim, where they found the different evidence in the text and actually it turned out that mainly it was mainly just claims and I said to them, ‘Is there any evidence to back this up, is this basically true, can you trust this source of material?’, and most of them said, ‘No, you can’t because there isn’t any evidence’. And I told them that that’s why anything that anyone tells you, you should ask them to come up with some evidence and you should ask why and argue your point as well, make sure it is actually reliable. So we did that and then I tried to keep it to around the topic we had been doing which is about sound and we did some very crude hearing tests the lesson before which they found quite fun so I though I would carry that on and I gave them some data which was about hearing loss in a factory and I gave them 2 claims one of which was that ageing causes reduced hearing loss and the other was that loud sounds causes reduced hearing loss and they said that was obvious, so I said, ‘Well you still have to make sure you question it and go through the correct process’, and basically they were given some data and they had to analyse it, maybe go through the for and against the claim they were given so they had to choose which claim they were for and then they came up with a conclusion at the end, whether they thought the claim was true or not and actually, it was really interesting because they went into the fact that the data was really strong and they talked about the actual reliability of the data they had and whether it had been collected in the right way but the conclusion they actually came to was actually the data is stronger evidence than any of the evidence that is against that claim so we think actually the claim is true. So although they had for or against, they were able to then weigh up which was the strongest type of argument and go towards that one so it was quite interesting because they progressed because they had to think about both sides rather than just accepting it.

Planning

I actually sat down with Craig (another S-TEAM Project teacher) for a little while and we talked about what we wanted to do. I had a look round to see if I could find anything. I wanted to keep it to do with the subject of hearing or hearing tests or something about sound because it was something they had been doing and it followed on quite nicely and literally. I thought it would be nice to know what a claim is so maybe go through definitions, it was like a thought process, starting off with key definitions and trying to apply them to a situation and I tried to find some data really and went from there.
How was it taught?

I split the class into 8 groups, they were in pairs when they were looking at the pieces of paper and they had to highlight the claims and they fed back to the class and they had to get into larger groups to look at the actual data I was giving them and when they got in to the groups they could choose which of the two claims they wanted to investigate. I told them that one of them was harder than the other one to analyze so with some people there might be a bit of differentiation, they might have gone for the harder one, they might have gone for the easier one, and they worked in groups and were given a piece of A3 paper for their groups. They split it into 2 halves for and against the claim, they wrote the claim at the top and they basically wrote their points, 'I think this data shows that actually the claim is true. However they didn't repeat the experiment they only looked at 3 factories. They didn't look at more, their range wasn't very good', and they came to their conclusion at the end. We fed back to the rest of the class.

I think it went quite well. The work they produced was actually — I wasn't sure how well they would do it when I gave out the sheet of paper. I didn't give them any guidance at all on how to read the graphs we had done it in the past in previous lessons so it was practising skills from before, we had done it before but I did have to give them a bit of prompting as I went round; they were really struggling to find against their claim, they were really struggling with that column and I said that one will be harder but actually when I looked at their work afterwards you could see they had had really come up with some good arguments for and against, and again that put me out of my comfort zone and I was, ‘Right I am not going to structure it too much; give me your work and see what you come up with’. and it was a nice surprise to see that the majority had come up with something quite strong. I think it went very well actually. I will definitely do it again. They were Y8 middle to top ability group.
Craig's lesson on wind farms

When I first started the project my immediate thought was in debating in science, how you might debate using different alternative energy sources to generate electricity so that's the one I went with. So what we did my first thoughts were to plan a debate where we get people arguing for and against a particular method for using electricity and originally I wanted to make it quite broad but I realized you had to give it a direct focus so the way I set it was you had a government advisor who had to write a report on nuclear power whether or not the government should build more nuclear power stations so that was the end product over a period of lessons but to start that process I needed to take it back to the very beginning: what are arguments for and against but what makes an argument valid, what makes it a reliable argument and an important argument for and against. My first activity was to get each group to create a spectrum from strongly for to strongly against and a continuous spectrum in between and huge number of statements about nuclear power and glue them on this line wherever they thought it should be. The first were wind turbines to get them to practice the method Some were statements eg the first wind turbines were built in 1999 in Cornwall and they would have spotted that was neither for nor against and put it in the middle. From that they would go on to say, would I think this is a strong argument for and how would I validate that eg get scientific data to back up that particular thing and build their argument from that point. We haven't got to the point where they have done their report but that have done their spectrum and the different bits of data to go with that and that was the plan of the lesson. How it's gone? It's really useful for me because really interesting things came out. In the past we have made power-points and arguments came out for and against but we don't talk about why they are like that or discuss it in anyway and it become really interesting that depending on your position in society, building a nuclear power station is somebody's argument for is somebody else's argument against and you can use the same piece of data to make an argument for or against – its much more complicated and that got them thinking about how they take a viewpoint and take a stance based on the evidence and sum things up and think about what they believe. A huge amount of thought went into it. From my perspective what I've learnt is that if you are going to do something like construct a really good argument it's a multi layered process not just a case of listing for and against. You have to give it time, train them in the right skills to do it and what they have learnt is how to think for themselves. It's a proper thinking activity it does get them thinking which is quite difficult at first but when you get them rolling its quite difficult to stop them. I did it with a Y7 group and the longer we did it, it was higher thinking skills a lot of the stuff. In the future I might practice the small skills the building blocks of constructing an argument at an earlier stage in Y7 but whether I follow it through to writing a report...they need to practise the skills around it in KS3 more and build it later on a bigger scale. Mainly because the end result, in all I don't think I'll follow it through to write a report I don't think they'll gain anything extra from that but the whole process of doing it has taught me a lot of how to do it.
I really liked using the spectrum of ideas for and against and I'm thinking of using a washing line across the room where there is a spectrum of for and against and so they can pin up statements on the line and access bits of data so that it may be better more over there, it an becomes a fluid thing and move it as they get more data. One example is talking about the statements about wind farms are an eye sore - well what data can you get to prove that? It's an opinion in the end, some people think they look very nice so how can you prove that, so it's opinions - it's about separating opinion and fact. Another piece of info is about wind farms being v noisy and causing lots of problems like stress and someone found a piece of data and when we looked at it closely it was data from the 90s and someone said maybe they are quieter now so it's about getting valid data depending on what data you had would make that argument for or against. It generated huge amounts of debate and once they got started they become very good.

It's just about if you are going to do debate style things it's about breaking it down into small steps, you can't just let them loose. I gave them the outline, I wanted it to be a sequence of 3 lessons, they would do this over and I outlined the whole idea of a govt advisor for and against but I just said that all we are going to do is consider what makes a good argument in Lesson 1 and the second lesson was about how to take the arguments for and against and organise that into a coherent piece and the final lesson was to transfer that into a complete written report. They worked in 2s for the arguments for and against I was going to allow them to work in pairs to formulate their ideas. I would in the future it was quite interesting, was when they had finished gluing their facts onto the paper and all the information was to take their finished product to another pair and you have to compare yours with their one and discuss with them to why you have placed this here etc and go round to all the other groups that would get loads of ideas flowing. It needs to be a lively, visual, lesson but that's teaching generally but to bring in the argumentation to do that.
Resources for Session 3: Practical Inquiry and Argumentation

Slides on Getting Practical:

**Slide 1**

Getting Practical

Improving Practical Work in Science

Session 1
Secondary

**Slide 2**

Session 1 Reflecting on practical work

Outline of Session 1
1. Why do we do practical work?
2. Auditing a series of practical activities
3. Reflecting on individual practical activities

**Slide 3**

Teachers’ views of practical work

- ‘Science teaching must take place in a laboratory; about that at least there is no controversy’
  
  Jean Schimm, 1980

- ‘Science is a practical subject ... You know, end of story, I think’
  
  Teacher quoted by Tim Dowdall, 1995

- ‘Science without practical is like swimming without water’
  
  Head of science quoted in SCER Report, 2008
Why do we do practical work?

The purpose of practical work is to help pupils make links between two domains of knowledge:

- Domain of objects and observables
- Domain of ideas

'Hands-on, minds-on'

Activity 1

1. Look at each practical activity and think about why you would choose to do it in a lesson.
2. On a 'post-it' note, write down the key reasons for doing the activity—one reason per 'post-it'.
3. Attach the 'post-it' to the activity.
4. In groups of two or three, take all the reasons from a sample of the practical activities.
5. Classify the 'post-its' into groups.

Feedback

- How did you classify your 'post-its'—what groups did you use?
- How does your classification compare with other people's?
- The literature suggests that the reasons for doing practical work can be classified into three groups:
  A. Scientific knowledge and understanding
  B. Practical skills
  C. Scientific enquiry and process
- How does your classification compare with this?
Slide 7

Why do we do practical work?

- Knowledge and understanding of science
- Scientific enquiry and process
- Practical skills
- In your opinion, is there anything missing?

Slide 8

Reflecting on practical work

A. Developer's objectives
   - What the aims and expected outcomes were

B. Task specification
   - What the pupils and intended to do

C. Classroom events
   - What the pupils actually did

D. Learning outcomes
   - What the pupils actually learned

Effectiveness at Level 1
Did pupils do what they were intended to do (and see the things they were meant to see)?

Effectiveness at Level 2
Did pupils learn (and can later show understanding of) what they were intended to learn?

Slide 9

Getting Practical: Improving Practical Work in Science

- Why?
  - To promote the message that practical work in science is not always as effective as hoped in helping learning. However, through some relatively modest changes to teaching practices, the learning outcomes from practical work can be substantially increased.

- When?
  - April 2009 – March 2010 (funded by DCSF)

- How?
  - Mapping (Centre for Science Education, Sheffield Hallam University)
  - Professional Development (NNSLC & ASE)
  - Communications (CLEAPSS & ASE)
  - Independent Evaluation (Institute of Education, London)
Slide 10

Working Together

- The Association for Science Education
- Centre for Science Education, Sheffield Hallam University
- CLEARSS
- National Network of Science Learning Centres
- Specialist Schools and Academies Trust
- Institute of Physics (IOP)
- Institute of Biology (IOB)
- Royal Society of Chemistry (RSC)
- Gatsby Science Enhancement Programme
- National STEM Centre
- Science Community Representing Education (SCORE)
- The Royal Society
- Gatsby Science and Plants for Schools Programme
- National Strategies
- Independent evaluators - Institute of Education, University of London
- Funded by the DCSF

Slide 11

Improving Practical Work in Science

Learning outcomes of the CPD strand

- To consider why you do practical work in science
- To reflect on how you develop learners' understanding and skills through practical work
- To explore how you present and stage practical activities so that they effectively deliver particular learning objectives

Slide 12

Improving Practical Work in Science

Outline of the CPD strand

Session 1  Reflection
  Thinking about practical work

Session 2  Staging
  Best practice in carrying out practical work

Session 3  Modelling
  Practice in staging effective practical work

Session 4  Next steps
  Resources and action planning
Why do we do practical work?
-the key learning outcomes

- State observable features
- State or use a classification system
- State a relationship between variables
- Show understanding of scientific theory

scientific
understanding
of science

practical
skills

knowledge and
process

- Propose a question
- Plan a strategy
- Evaluate risk
- Collect relevant data
- Present data effectively
- Process data
- Interpret data
- State a conclusion
- Evaluate a conclusion

Auditing practical activities
-and identifying the key learning outcomes

Activity 2
Complete the sheet for the last five or six practical activities you did with one particular class.

Auditing practical activities
-and identifying the key learning outcomes

Feedback
- How many intended learning outcomes have you ticked for each activity?
- Is there a spread of learning outcomes in your audit?
- Should there be?
- How should the range of intended learning outcomes look for a pupil in Year 7/8/9 or across a key stage?
- Do you always tackle the same intended learning outcomes when you do a particular practical?
Reflecting on individual activities
- to consider their effectiveness

Activity 3
Choose two practical activities you have done recently - one which you were happy with, and one which was less successful. Complete one sheet for each practical.

Feedback
- What evidence do you have for a successful practical?
- What are the key features of the ‘less successful’ practical?
- What improvements could you make to improve the success of a practical?

Current research about practical work
- ‘Much practical work is ineffective, unscientific and a positive deterrent for many students to continue with their science.’
  Woolfenden, 1995
- ‘Practical work is generally effective in getting students to do what was intended with physical objects, but much less effective in getting them to use the intended scientific ideas to guide their actions and reflect upon the data they collect.’
  Abrahams and Miller, 2009
- ‘When well-planned and effectively implemented, practical work stimulates and engages students’ learning...challenging them both mentally and physically in ways that are not possible through other science education experiences.’
  SCORE report, 2009
Session 1 Reflecting on practical work

Feedback
- Note two key points from your reflections on practical work
- Note one key action you are going to take forward
- Share your ideas with the group

Gap task 1
- Back in school, explain to the rest of department what you have done today
- Share your green sheet with them and discuss whether/how it could be useful
- Gather their thoughts to share at the start of the next session
Resources for Session 4: Assessment, Practical Inquiry and Argumentation
Slides on APP:

Slide 1

The aims of APP

The aims of the strategy are that:
- every child knows what progress they are making, and understands what they need to do to improve and how to get there.
- every teacher is equipped to make well-founded judgements about pupil attainment, understanding the concepts and principles of progression and knowing how to use their assessment judgements to forward plan, particularly for pupils who are not fulfilling their potential.
- every school has in place structured and systematic assessment systems for making regular, useful, manageable and accurate assessments of pupils, and for tracking their progress.
- every parent and carer knows how their child is progressing, what they need to do to improve, and how they can support the child and their teachers.

Slide 2

Thinking philosophically

- So, is this formative assessment or summative assessment?
- Summative assessment will require external validation/moderation; formative assessment may not.

Slide 3

Is it trying to ride both horses at the same time?

The KSL Strategy document provides a vocabulary that helps to clarify the three linked aspects of assessment which can be coherently applied across curriculum areas and phases.

Day-to-day assessment provides a wide range of evidence of learning in specific contexts which shapes immediate next steps.

Periodic review of this evidence gives a clear profile of pupils’ achievement across a whole subject and informs and shapes future planning and targets for improvement.

When required, these judgements and insights can be more formally shared between pupils, parents and teachers at transition points between key stages, schools and phases.
Where might argumentation techniques be beneficial to pupils?

AF5 – Working critically with evidence

[Content of AF5 slide]

[AF5 content]

[AF5 content]

[AF5 content]
Linking APP and Getting Practical

Slide 1

Why do we do practical work?

The purpose of practical work is to help pupils make links between two domains of knowledge:

'hands-on, minds-on'

Slide 2

Popper’s three worlds model

World One: domain of objects and observables

World Two: domain of experiences

World Three: domain of ideas

practical work

argumentation

Slide 3

World One: domain of objects and observables

practical work

World Two: domain of experiences

World Three: domain of ideas

knowledge and understanding of science

scientific enquiry and process

practical skills

argumentation

argue science in society
Practical work and APP
- the key learning outcomes

- State observable features
- State or use a classification system
- State a relationship between variables
- Show understanding of scientific theory
- Identify requirements
- Plan an experiment
- Draft a standard procedure
- Carry out a scientific procedure
- Communication skills

Practical work and APP
- activity audit grid

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>APP mapping</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</table>
The section gives examples of lessons developed by teachers participating in the S-TEAM Project. They are reproduced in their entirety as examples of how argumentation can be introduced into science lessons.

**Lesson 1: Getting students to use argument (Steve Topham)**

**Objectives**

- Students should engage with each other through the use of argument
- Students should use argument to explain observations
- Students should use arguments to evaluate ideas

**Introduction**

The introduction is a simple demo (sawdust volume demo) that everyone can understand, although it's not so easy to explain. The fact that what is going on is so ordinary (not technical) invites people to have a go at explaining it, after all, how hard can it be? I'm reminded of the tongue twister 'Peggy Babcock'; it's inviting partly because it's so simple. Students are told that an argument in science is what happens when scientists put together ideas to explain something. Other scientists can then look at the argument and agree with it, or not!

**Stage 1:**

The initial discussion: In groups of 4, 5 or 6 students discuss their ideas. They are guided to use ideas about particles to explain what is happening to produce the behaviour they observe. To help crystallise their ideas they are given a sheet with 6 boxes drawn on it. These should be used to draw diagrams of particles before and after in the two demos. The discussion is broadened by the students being given different bits of coloured paper. Then they are reorganised by moving to the bench that matches their coloured paper. Those students that don't move explain their ideas to those that do. After this discussion students move back to the original group and explain the new ideas to those students that didn't move. At the end of this process students have all had an opportunity to discuss their ideas and learn and critique the ideas of others.
Stage 2: Reviewing Ideas
This section is specifically designed to get the students to look at some ideas that are flawed and to develop arguments to highlight their shortcomings. The students are given diagrams that are incorrect representations of what happens in the demo. Each group is given several different sheets, printed on to different coloured paper. They have a few moments to think about the diagram before they move to groups of students with the same coloured diagram as themselves. In the new groups the student discuss the shortcomings with their diagrams and then after a few minutes they move back to their original mixed groups. Each student should now be able to explain to the rest of their group what the problems are with the diagrams. Again the students have an opportunity to enter into discussions with a variety of other students, and are also given some support in these discussions by the diagrams.

Powerpoint presentation:

Slide 1

Arguments and Sawdust

- Getting students to use argument
- Argument to explain
- Argument to evaluate

Slide 2

Stage 1

- Introducing the demonstration
- Argument to explain
  - Students explain in groups aided by the template
  - Students are given different bits of coloured paper
  - Reorganise groups by students moving to the bench that matches their coloured paper
  - Those that don't move explain their ideas to those that do
  - After discussion students move back to the original group and explain new ideas to those students that didn't move
Stage 2

- Argument to evaluate
  - Students given different incorrect diagrammatic explanations of the demonstration on coloured paper
  - After a couple of minutes familiarisation they move to the bench matching the colour of their diagram
  - Each group then discusses the diagram to find the faults in the argument
  - Students return to their original groups and feedback on the discussions of all the various diagrams

Benefits

- Peggy Babcock
  - Accessible, non-threatening demonstration
  - Simple models employed in the argument
  - Promotion of discussion of ideas
  - Discussion across a wide range of students
  - Short, but open, activities
  - Focus on models and ideas through images not text
I know it's wrong.....but why?

This diagram shows what happens to the particles when sawdust is mixed with water.

It isn't right, but can you see why it's wrong?

Does this fit with what you see happening?
Are the particles drawn correctly?
Can particles behave this way?

This diagram is wrong because: 

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........................................................................................................................................
I know it's wrong.....but why?

This diagram shows what happens to the particles when sawdust is mixed with water.

It isn't right, but can you see why it's wrong?

Does this fit with what you see happening?
Are the particles drawn correctly?
Can particles behave this way?

This diagram is wrong because...........................................................................................
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I know it's wrong.....but why?

This diagram shows what happens to the particles when sawdust is mixed with water.

It isn't right, but can you see why it's wrong?

Does this fit with what you see happening?
Are the particles drawn correctly?
Can particles behave this way?

This diagram is wrong because..................................................................................
..................................................................................................................................
Lesson 2: Arguing For and Against Chocolate!
(Catherine Barnes Cain)

Slide 1

Is chocolate good for us?
What do you think?
Put your answers in your books.

Slide 2

objectives

• To distinguish between evidence and opinion.
• To discuss the reliability of evidence.
• To examine the source of evidence.

Slide 3

Finding the evidence

• Find 3 pieces of evidence for chocolate being good for you.
  Write these on the green cards.

• Find 3 pieces of evidence against chocolate being good for you.
  Write these on the red cards.
Slide 4

Looking at opinions

- Survey the opinions of 3 people around you about whether they think chocolate is good for you.
  Remember that they need to give a reason.
  Write these on the blue cards.

Slide 5

How good is your evidence?

- In order to make a valid decision to the question, you need to decide how reliable your evidence is.

- Look at the source of the information
  - Have you heard of the author/organisation before?
  - Is it recent?
  - Do they give data that backs up their conclusions?
  - Could they be bias in any way?

Slide 6

Writing your report

- Use the structure guide to help you get your report in the best order.

- You may write in the boxes on the sheet, or write on a piece of lined paper.