Chapter 6
The Design and Enactment of Argumentation Activities

Shirley Simon, Katherine Richardson, and Ruth Amos

Introduction

In recent years new approaches to the teaching of school science have focused on extending the goals of science education beyond the learning of a body of established knowledge to encompass cognitive, epistemic and social aims. School science has become more concerned with foregrounding the epistemic basis of science, providing opportunities for the development of scientific reasoning through the co-ordination of theory with evidence (Kuhn, 1991), and of epistemological understanding through the evaluation of scientific knowledge claims (Sandoval & Reiser, 2004). By engaging collaboratively in argumentation activities that make reasoning public, students can gain experience of constructing arguments, justifying arguments with evidence, evaluating alternative arguments and reflecting on the outcomes of argumentation. Experience of argumentation in different contexts can equip students with the skills to make decisions about controversial issues in science, to understand how evidence is used to construct explanations and to understand the criteria that are used in science to evaluate evidence. Though the role of argumentation has become more highly valued in science education, research shows that only if it is specifically addressed in the curriculum and explicitly taught through task structuring and modelling will students gain the skills needed to explore its use in science and socio-scientific contexts (Erduran & Jiménez-Aleixandre, 2008; Osborne, Erduran & Simon, 2004a).

The development of argumentation activities in science education, and strategies for implementing such activities in science classrooms, has emerged alongside and been influenced by a global research programme into students' argumentation and teachers' professional development in argumentation. The work presented in this chapter has its origins in three UK-based research and development projects that grew from recognition of the importance of argument in science education (Driver, Newton, & Osborne, 2000) and a lack of discursive practice in school science in

S. Simon (✉)
Institute of Education, University of London, London, UK
e-mail: s.simon@ioe.ac.uk

M.S. Khine (ed.), *Perspectives on Scientific Argumentation*,
DOI 10.1007/978-94-007-2470-9_6, © Springer Science+Business Media B.V. 2012

the UK (Newton, Driver, & Osborne, 1999). The first of these projects focused on enhancing the quality of argumentation in school science (EQUASS) and was concerned with the development of argumentation activities by researchers in partnership with teachers. As teachers implemented the activities over a nine-month period, a quasi-experimental study showed that the quality of student argumentation improved, but that the change was not significant (Osborne et al., 2004a). The authors concluded that developing the skill and ability to argue effectively is a long-term process requiring many opportunities to engage in argumentation throughout the curriculum. A focus on the teachers' pedagogic skills in using argumentation activities also showed that though some teachers became more skilled at scaffolding argumentation, many found the enactment of argumentation in school science challenging and did not change their practice (Simon, Erduran, & Osborne, 2006). The second project was concerned with developing a pack of materials, called IDEAS, that consolidated the teachers' activity designs within a set of resources, each with learning objectives and a set of procedures (Osborne, Erduran, & Simon, 2004b). These resources were accompanied by training sessions for teachers to develop their strategies in using the activities.

Recent observations of teachers using IDEAS and an analysis of the interpretations required for effective use of the resources (Simon & Richardson, 2009) now suggest that the design and enactment of argumentation activity requires more attention and could be a critical factor in developing effective pedagogy of argumentation. The third project, called Talking to Learn in science (TTL), is currently studying the enactment of argumentation activities by groups of teachers working together in school science departments. These teachers are drawing on IDEAS resources and other sources of activities, and embedding these within the science curriculum for all teachers to use across the age range of students within the school. Observations of these teachers' practice confirm the complexity of the interpretive steps teachers need to take for effective enactment of argumentation activities (Simon & Richardson, 2009). Further work on activity design has taken place with some teachers from the TTL project; in this chapter we report on one study of argumentation design, interpretation and enactment to highlight the issues involved in transferring design between teachers.

Background

To promote the use of argumentation requires activities that are designed to achieve the cognitive and epistemic aims referred to above and an understanding of how these aims can be realised through student engagement. Argumentation activities set in social contexts can be the vehicle for developing students' epistemological understanding as with appropriate scaffolding by teachers and peers students can be encouraged to value the role of evidence in knowledge claims. Although we now have an established body of work on the value of argumentation and small group discussion in science education, few studies have attempted to unpack the nuances of how argumentation activities are designed (Howe and Mercer, 2007),

as research has tended to focus on evaluating argumentation outcomes. Activities need to engage students' interest, stimulate discussion and provide resources that can be used as the basis of evidence in constructing and evaluating arguments, provide alternative choices or positions, involve a solution that is not obvious and be manageable for teachers.

Argumentation activities were developed in the EQUASS project by working together with teachers, according to the curriculum needs they identified and their interpretation of the meaning of argumentation. Frameworks were used for developing argumentation activities that involved the generation of differences, for example, presenting competing theories for students to examine and evaluate. In addition to providing stimulus material, the activities included small group discussion so that students would co-construct arguments justifying their case for alternative positions. As students require data to construct arguments, the activities also included information that could be used as evidence to support different theories. In this research nine generic frameworks were developed from literature sources (see Osborne et al., 2004a for the sources) that included concept mapping, designing an experiment, constructing an argument and different designs involving competing theories.

Building on this original research, the IDEAS pack was developed (Osborne et al., 2004b) to include a resource of 15 lessons that incorporate a variety of frameworks, including examples based on the frameworks introduced in the original research. One of the lessons is set in the context of a socio-scientific issue (SSI), requiring students to make a decision about the funding of a new zoo, and was intended to be accessible to most students aged 11–14 years. The framing of this lesson involves weighing up evidence for and against the new zoo and reaching a decision with reasons. The activity thus requires students to take a position and justify their claims with data, warrants and backing. The arguments for and against the zoo can be equally weighted, that is students can be asked to construct both sides of the argument thus forcing consideration of counter-claims, so the zoo activity can provide a good stimulus for argumentation involving rebuttals and counter-argument. The EQUASS research used this zoo lesson as a means of collecting data on teachers' developing pedagogy, so it was observed many times, at intervals with the same teacher and across 12 different teachers (Simon et al., 2006). Each teacher interpreted the lesson guidance and resource differently, so even though they worked from the same basic design, enactment showed differences in how they organised and managed group discussion, for example paired work, large group brainstorm or role-play. Teachers drew on and encouraged the use of different sources of evidence, from website information on breeding and habitats to students' own experiences and emotive responses. Teachers also interacted differently with students to scaffold argumentation processes such as justification and counter-argument. The findings showed that there was more variation in interpretation and enactment of the activity across teachers than for an individual teacher across time, even though there was evidence of developing pedagogic skills.

In our analysis of the IDEAS lessons (Simon & Richardson, 2009), we focused on a selection of lessons to examine the design framework, the science context used,

lesson planning notes and the teacher's role. This analysis revealed the importance of purposeful design throughout the initial activity construction, to align the design framework with a suitable science context and create resources to help students reason argumentatively in that context. It also identified purposeful design by the teacher as a key process for ensuring effective enactment, both in interpreting the layers of the activity design to plan a specific teaching episode and in their role during teaching. The complexity of the interpretation required suggests a need for closer study of the design, enactment and transfer of argumentation activities.

Designing argumentation activities is an important aspect of supporting teachers in teaching argumentation (Osborne et al., 2004a). Teachers lack time to fully design their own argumentation activities, which often require more preparation than teacher-led lessons. When teachers draw on existing activities or share their own activity designs with other teachers, this time burden is reduced. Further, argumentation activities often serve an educative purpose, supporting teacher learning by outlining teaching strategies which are considerably different from standard practice (Davis & Krajcik, 2005). Since most argumentation activities are designed for other people to use, it is crucial to support the successful enactment and transfer of argumentation activities within the design itself.

Activity Design, Enactment and Transfer

We frame *activity design* as the creation of a tool which can be used by teachers to achieve their goals. Activities embed the author's purpose in representations which are used by teachers or students. These may include teaching notes, lesson plans and sample student responses as well as resources for direct use by students.

The initial design of argumentation activities involves several layers of purpose (Simon & Richardson, 2009). In some cases, the design begins by specifying learning aims for argumentation and science, considering the nature of the scientific knowledge involved. These aims are embedded in a student activity which supports the intended learning. Alternatively, the design may begin with a student activity, which is then analysed to identify potential learning outcomes in argumentation and science. In either design sequence, teaching notes are often layered onto the design, to provide procedural guidance intended to help teachers align their actions with the activity goals. To help teachers to interpret the activity, it is useful to share the rationale and purpose behind the activity design as well as the activity itself. This involves a shift from 'teacher-proof' activity design, which seeks to minimise teacher agency by providing highly detailed procedure-centric resources, to 'teacher-transparent' materials which support teachers in designing appropriate instruction by providing resources which can be used flexibly, and which are annotated to help teachers identify their affordances and constraints (Davis & Krajcik, 2005).

The *enactment* of an activity describes how teachers use an activity to design and implement instruction. The term 'enactment' acknowledges that practice involves the translation of beliefs, knowledge and experience into action (Clarke &

Hollingsworth, 2002). In enactment, the teacher draws on the argumentation activity, their existing practice and their intentions, knowledge and beliefs. Teacher use of argumentation activities therefore involves a collaborative design process where the teacher influences the use of the activity, and the activity design influences the teacher (Brown, 2009). Teachers' use of activities can be characterised according to the distribution of agency between teacher design and activity design. The teacher may *offload* design agency to the activity, relying on the design embedded in the activity to achieve their goals. As the teacher increases their design agency, they may *adapt* the activity, or *improvise*, creating their own design with the activity as a starting point (Brown, 2009). Since no activity design can completely specify classroom practice, the teacher always retains some agency in interpreting and reconstructing the activity (Ben-Peretz, 1990).

The successful transfer of activities between curriculum designers and teachers, or between different teachers, has been studied primarily as *fidelity to* or *adaptation from* the pre-existing design. However, the framework of distributed agency allows us to see both these options as principled design decisions by a teacher, and so focuses attention on how to help teachers creating principled teaching designs using the activities available to them. Teachers' agency in interpreting and adapting argumentation activities is supported by their pedagogical design capacity, their 'ability to perceive and mobilize existing resources in order to craft instructional episodes' (Brown, 2009, p. 29). For an individual teacher, this is likely to vary depending on their familiarity with 'reading' different types of curriculum material. For example, teachers who are new to argumentation may begin with minimal pedagogical design capacity for argumentation, and so may benefit from more detailed support in understanding the activity materials. This support can be provided through discussion with more experienced teachers or curriculum developers, included in the activity design via annotations or more extensive teaching notes, or provided via generic supports for analysing curriculum materials (Beyer & Davis, 2009; Brown, 2009). Since some teachers exhibit resistance to overt analysis of curriculum materials as they believe that good use of materials is often based on implicit and intuitive notions of teaching (Schwarz, Gunckel, Smith, Covitt, Bae, Enfeild, et al., 2008), the more subtle supports of discussion and teaching notes may be more fruitful in aiding the transfer process.

The Olympic Activity

Background to the Design

One of the authors, Ruth Amos, was asked to design an argumentation activity for an out-of-classroom learning initiative being led by the UK's Field Studies Council (FSC) in a small venue overlooking the construction site of the London 2012 Olympic Park in Stratford, East London. The FSC aims to bring groups of 11–14-year-old students to the site and provide them with opportunities to explore how it is

being developed, including impacts on the local community and environment. The construction site was originally a busy industrial area, supporting small businesses, some residential housing and amenities such as allotments (local authority allocation of space for community horticulture) and local shops. The initiative runs from 2010 until 2013, therefore activity designs needed to encompass as many aspects of continuous site development as possible. The argumentation activity was intended to be part of a suite of science activities, alongside others such as those involving the physics of the structures in the Olympic stadium.

At the initial project meeting, with engineers and planners from the Olympic Delivery Authority (ODA), discussion centred on the ODA's strategy for making London 2012 the most sustainably constructed Olympic site yet. Their sustainability strategy has won a national award (London, 2012), and an impressive catalogue of sustainable construction practices has been presented to the public. However, there are some voices of discontent in the background, and the clean, green corporate image being portrayed by the ODA has been questioned to see if the claims being made are accurate and truthful (Slavin, 2006). The existence of these opposing sources of 'evidence' for the sustainable construction of the London 2012 Olympic Park offers the opportunity for the creation of a potentially engaging socio-scientific argumentation activity which would enable students to critically examine the case being made by the ODA for sustainable development. Such an SSI affords argumentation activity design involving multiple stances and opposition, similar to that of the zoo lesson.

Approach to Activity Design

An FSC tutor, Heather, with a geography background, was leading all the FSC activity sessions. Though she was an experienced fieldwork tutor, she had not led argumentation activities before and had received no training in supporting successful argumentation in a science setting where she would be teaching a whole class of students. She was apprehensive about the prospect and it became evident that the activity needed to be designed by Ruth to incorporate clear guidance on purpose and enactment, and on the nature of students' argumentation. The guidance in the IDEAS pack (Osborne et al., 2004b) provided a useful foundation for the creation of the Olympic activity.

The design of the activity was influenced by the findings of earlier research on the challenges faced by teachers using argumentation (Simon et al., 2006), the problems of interpretation of IDEAS (Simon & Richardson, 2009), and by Ruth's experience of training pre-service teachers in the use of argumentation activities. To build Heather's confidence a detailed approach was provided, including a list of resources to support initial engagement with the activity, evidence statements, tutor guidance and student guidance. Specific suggestions for activity stages, group design and outcomes were made (see Appendix 1). Thus procedural guidance was used to support low pedagogical design capacity for argumentation associated with lack of experience.

When designing a context for a socio-scientific argumentation, the inclination of students towards engaging with contexts and their ability to access evidence, either from their own experience or from a resource, needs to be taken into account. Issues around the sustainable building of an Olympic site may not be universally appealing, and students would need to have sufficient resources to stimulate interest and be able to take part successfully. Ruth therefore took a resource-centric approach by providing a range of supports which could be selected by Heather and other teachers according to their aims and student needs. She drew on aspects of activity design from IDEAS resources, including evidence statements to support different claims, role-play, and a decision-making brief. Strategies such as the use of argument prompts and writing frames were also included to support students in organising their thinking (see Appendix 2). As the designer, Ruth took the view that all the available resources would need to be used effectively during the session, but there was potential for them to be used in a number of ways (e.g. by giving students written or oral guidance). Ruth then organised a pilot session with a local teacher, Alan, and a class of 14-year-old students, all of whom were already experienced in the enactment of argumentation in school, in order to allow Heather to focus fully on developing her embryonic skills for leading such an activity.

Planning the Pilot Session

A planning meeting for the pilot session was held between Ruth, Heather and Alan, in which Ruth briefly outlined the initial purposes of the activity and the activity design was discussed. Subsequent design choices reflected the purposes of all three agents involved and how these were aligned. For example, Alan was already envisaging creating groups of three which blended students of differing confidence together, thus bringing his experience of group work into the design. He also anticipated students' perspectives with respect to the activity and considered drafting an introductory activity to 'inspire them beforehand' with recourse to the various website sources, thus building on his experience of needing to provide a stimulus for engagement. Heather gave Alan information about alternative useful websites (London 2012, Get Set), in doing so bringing her agency to the design based on her desire that students should look at both sides of the sustainability argument. Heather was conscious that all the official Olympic websites portrayed only the positive side of the argument.

Heather asked Alan what he felt were the important outcomes of the activity. This was an interesting question as it revealed a limited sense of purpose on Heather's part and an offloading response by Alan who asked 'why are you looking at me?'. This interaction probably arose from the use of a third-party design rather than something self-initiated by either Heather or Alan. Ruth as the original designer suggested one purpose might be for students to explore their understanding of the term 'sustainability' in the light of its very frequent, contemporary use by the media. She also hoped that students might be able to look 'behind' the evidence statements, particularly the pro-case, to contemplate what had been deliberately excluded. Both

Alan and Heather agreed to this suggestion, thus accepting and reinforcing Ruth's agency in the design. Another feature of the discussion was how the design included a distinction between types of evidence, as Ruth's earlier work with SSI had shown that students focus more readily on economic and social evidence rather than scientific evidence, and she had thus included a 'type of evidence' writing frame to explore this dimension. This purpose of the design would not have been clear to the teachers without the opportunity to discuss the intention behind it.

The design involved encouraging students in their groups of three to identify stronger pieces of evidence from statements provided, discarding others, and then to compare and argue for their position with another group of three using the evidence they kept. It was agreed that students would pick the 10 strongest pieces of evidence; however, Alan was concerned that the choice of evidence would be too consensual and students would have minimal differences once they came together from threes to sixes. He proposed that groups of three be assigned a position, that is either a pro-case or an against- case, and asked to identify the strongest pieces of evidence for their position, so that when threes came together as a group of six there would be the need for persuasion and counter-argument. In Alan's experience, students all tend to arrive at the same position quickly if left to their own devices, he also felt that students would not be challenged if following their natural inclination towards a particular position. Heather listened carefully to this experience and was keen to learn from it. She and Alan continued to discuss further aspects of the activity design, Alan focusing on small group procedures and outcomes, Heather on organizational features such as timings and phases of the activity. Eventually they agreed on a design based on his pedagogical experience and her desire to create an activity that would be effective for her purpose. Alan made the point that any argumentation activity tends to develop itself depending on what the students bring up, thus demonstrating the improvised aspect of design based on responses to the situation.

As a result of her planning discussions with Alan, Heather adapted the student guidance sheet for the activity to facilitate the pre-assignment of a position either 'for' or 'against' for the small groups of three, as well as to direct them to reach agreement upon the 10 'strongest' pieces of evidence to support this position. She also prepared an introductory session of PowerPoint slides for students based on the question 'A Sustainable Olympic Park?' drawing on geographical, historical and social issues relating to the site. Heather invested much of her pre-session preparation time in finalising the resources and in the preparation of her introductory scene-setting role. The focus of her preparations accords with one of her main purposes in the design of the activity, to provide interest in the topic and to have the procedures well-structured for small-group discussion. In this way she would rely on the resources to guide her through the lesson, thus offloading design agency to the activity during enactment. Her reliance on the resources became more apparent through her preparation of 'student packs' for the session, which included 30 evidence cards, labelled 'for' or 'against', so that students were told how the evidence supported each position, and colour-coded for altering group composition according to positional role-play. This aspect of the design added to the structure Heather thought necessary for controlling small group discussion and role-play.

Alan set up a group of 27 students from several different teaching groups (13–14-year-olds) who were experienced in argumentation. He had arranged for the group to meet three days before the session and had asked them to select their own groups of three for the activity. This meeting gave the students a chance to look at some of the Olympic websites that showed different sources of evidence to support, and to challenge, the issues around sustainable construction of the site. Alan gave the students a short worksheet of information about the session, which included an instruction to prepare their own understanding of 'sustainability' in relation to construction. Alan's preparatory focus thus adopted the resource design created by Ruth in terms of exploring their understanding of sustainability and using different sources of evidence. It was also aligned to his own purpose of focusing on the nature of evidence the students might use in their argumentation.

The Pilot Session

The argumentation session was video-recorded by Ruth, who observed the session and also made field notes. Heather introduced the session, reviewing its purpose, the issue of sustainability and the role-play context. She built a structure to the session that would enable her to rely on the activity itself to facilitate smooth running of the session once argumentation began, which initially focused on providing interest to the students, an aspect of the design where she exercised high agency. She took the students out on to a balcony overlooking the site, then showed them photos and video-clips of people talking about the site, for example from people who would lose their allotments and local businesses who were being relocated. Students were interested and attentive throughout the introduction.

After the scene setting was complete, Heather gave out the student packs, which the students opened immediately to discover whether they were 'for' or 'against' the sustainability issues, and she explained that they had to develop their argument using 10 pieces of evidence. From the start, all students were actively discussing evidence with one another. Some of the groups of three also started listening to, and counter-arguing with, another group of three who were focusing on an opposite position. Thus students of their own accord began the next stage of the activity, a common feature we have observed in highly structured argumentation lessons. Heather's resource-reliant approach meant that she subsequently introduced the use of a worksheet or writing frame to explore the evidence further. This was a rather mechanistic and unnecessary embellishment of what the students had just accomplished through discussion. The students completed it very quickly and two groups began to lose concentration. Heather became concerned that the students were working too fast and she moved on to the opposing arguments stage. Heather's design was to use the colour-coded cards to set-up oppositional groups, an aspect of the design that did in fact afford an almost seamless, uncomplaining movement of students, something she had been concerned about before the session. Once everyone was re-positioned, students immediately started to relate their positions to one another. The debates became quite heated at times and students started to use personal evidence and opinion, that is, not presented on the evidence cards. Heather tried to

focus students' attention on the provided evidence, as well as asking them to think about the accuracy of their own sources of personal evidence, thus showing some doubts about offloading agency to students.

After a period of fairly heated debates within groups of six, Heather gave each group two minutes to present their consensus position via a selected spokesperson, praising their 'fantastic debating skills', and invited them to think of questions as they listened to each group. Whilst arguments were presented by each group, Heather:

- answered any questions raised;
- encouraged applause and praise 'now this group lasted longest in their attempt to convince their opposition, well done, but . . .';
- agreed with evidence cited 'yes, that's a very interesting one about moving animals . . .';
- embellished evidence 'but the newts and frogs will just make their way back to where they were before, so. . .';
- asked questions in response to evidence cited 'well, how many trees were cut down to make way . . .?' to model countering a group citing the positive effects of the proposed new tree-planting on site;
- encouraged some counter-argument 'anyone else, points 'against'?'

Very few students asked questions or raised counter-arguments during this stage. Heather invited anyone who was originally on an 'against team' to make a strong point against the 'pro-sustainability' argument. No one responded, as students had inclined mostly to the 'for' position, finding the evidence for the 'against' position to be weak and based on peoples' opinion. Heather then summarised some of the shorter- and longer-term goals for sustainability from ODA sources.

Discussion

Through the design, planning and implementation of this Olympic argumentation activity, we can see how the framework of distributed agency can be used to interpret actions of the designer, (Ruth), new tutor (Heather) and experienced teacher of argumentation (Alan), and how these actions have implications for the way in which an activity is enacted with students. One key issue is how purpose, or intended learning outcomes, guide the actions of each person during design, planning and implementation stages. Ruth had a range of purposes informing her resource-centric approach to designing the argumentation activity. Her concern was to create resources and guidance that could be effectively used by a tutor inexperienced in facilitating argumentation. She also wished to include a role play scenario for the activity, with appeal for students coming from anywhere in the UK, and to provide prompts and writing frames for students based upon IDEAS to enhance argumentation and debate. Both Heather and Alan offload agency to the designer and the activity with

respect to identifying learning outcomes, but accept more agency with respect to design choices for scaffolding argumentation, such as assigning stances and providing ways for groups to learn from others' discussions. The resistance to clearly identifying learning outcomes suggests that Heather and Alan assume these are either embedded in the activity design, or they expect them to be provided by the designer.

The purposes of both Heather and Alan became more apparent during the enactment of the argumentation activity. During small group discussion Alan became more focused on encouraging students in their approaches to argumentation. Whilst circulating amongst the small groups of students, he continuously:

- embellished the provided evidence;
- explained the scientific and technological processes being used in the construction processes;
- rephrased students' developing arguments 'so what you are saying is. . .'
- prompted students to justify their arguments, using phrases such as 'what if. . .'.

Thus Alan's contribution to the design was focused on the nature of the evidence and its use in providing justification for the students' position. In contrast, Heather continuously:

- kept an eye on the time, and communicated time targets;
- encouraged by nodding, smiling, praising and injecting a little humour;
- focused students on their assigned positions and on one of the goals of Task 2 'remember you are trying to decide on the 'strongest' 10 pieces of evidence for if you are 'for' or 'against'';
- shared progress 'ok, we have a couple of groups who are down to their final 10. . .';
- answered task-related questions.

Heather's contribution was focused on the structure of the session and the control of the discourse, rather than the nature of argumentation. Her primary purpose was managing the process of group work, while Alan's was improving the quality of argumentation. The contrast between the novice and the experienced teacher of argumentation is striking and shows the importance of building experience over time in the teaching of argumentation, in order to purposefully include scaffolding of argumentation processes. Alan's design choices are much richer because of his knowledge of argumentation and the students – he anticipates students' responses. During the episode where students had formed into larger groups with opposing positions, Heather continued to focus on procedural aspects and also basic scaffolding processes such as:

- reminding students to listen well to one another;
- defining the process: 'you argue 'for', you argue 'against'';
- reminding them to persuade their opponents;

- focusing them on the evidence;
- embellishing upon evidence;
- keeping an eye on the time, but less so than in the first stage.

Alan, on the other hand, concerned himself with modelling how both sides could go back and forward across the debate, countering each others' arguments by suggesting 'come on, offer a piece of evidence against that'. He continued to adopt the role he had taken in the first argument phase, in addition focusing on:

- giving more encouragement to considering counter-arguments to their own position;
- encouraging students to consider the validity of their own arguments 'so what you are saying is that the soil was already contaminated, but now the contamination is concentrated into a smaller area, so that's better?';
- reminding students about the rules for effective small group discussion 'excuse me, listen to . . . .'.

To explore how both Heather and Alan reflected on the activity afterwards, Ruth conducted telephone interviews with each teacher. Heather expressed a positive reaction overall and was pleased with how the students engaged. When Ruth pointed out the limited time spent in whole-class debate, Heather expressed less confidence about encouraging prolonged counter-argument with the whole class, which is why she had not adopted suggestions made by Alan for students recording their final argument and presentations on posters for viewing and discussion. Heather suggested adapting the design by introducing 'blank' cards to allow students to input their own personal evidence. Heather could see the potential, through her experience of the argumentation activity, for marketing sessions in a more cross-curricular way involving geography, history and citizenship. Teaching the activity had helped her to articulate a better way forward for her project design, thus creating new ways in which she would exercise her design capacity. Alan thought that all the students definitely needed time to 'get into the evidence' though he felt that the language was appropriate and ideas accessible. Even though he had brought a group experienced in argumentation, his view was 'learning to argue is only part of the jigsaw of their development in science and all the other things they need to do'. He had perceived his role as encouraging students to think about the argument they were building by directing the students back to the original evidence cards at all stages and anticipating counter-arguments and rebuttals. He had witnessed even the four/five 'good debaters' were slow to do this. Though students were definitely engaged with the activity throughout, they were still facing challenges in terms of demonstrating higher-level argumentation skills. Alan was a little disappointed that Heather did not take up his suggestion about poster presentations as in his view better opportunities for counter-arguing would have ensued. Though students had needed a lot of time to get their own arguments sorted out, Alan knew from experience of argumentation in school that plenary strategies, with a reasonable time allocation, are needed to explore thinking. Thus we can see a contrast between the novice teacher,

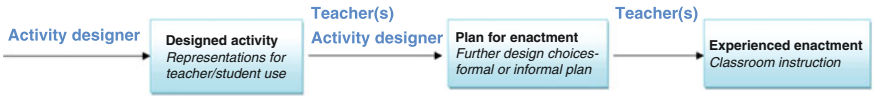

Fig. 6.1 Purpose into practice: Design, enactment and transfer diagram

Heather, and the more experienced teacher, Alan, in their reflection of salient outcomes (Clarke & Hollingsworth, 2002), as Heather's was focused on engagement, whereas Alan's was on higher-level argumentation.

From our interpretations of the Olympic activity we have summarised the process of design, enactment and transfer that took place in this study. In Fig. 6.1 design outputs are represented by boxes, and the processes between them are represented by arrows showing who was involved at each stage of the study.

The first stage draws on the designer's knowledge of the teaching context, learning aims and pedagogical content knowledge. The output is a designed activity, which usually includes representations for students to work with, such as evidence cards or writing frames, and representations for teachers to use directly, such as teaching notes or lesson plans. In the second stage, teachers use their pedagogical design capacity to transform the activity design into a plan for an instructional episode. The teacher may significantly modify the activity, and if the activity serves an educative purpose for the teacher, the activity design may significantly influence the teacher to modify their normal practice. Even if the activity is not substantially modified, this stage usually involves further design choices to help teachers craft the lesson, such as deciding how to group pupils, when and how to present evidence, and how different groups might learn from each other. In the case of our study, two teachers co-planned the teaching, with the designer in attendance at the planning meeting. The output is a plan for enactment, which may or may not be formally represented. The final stage is the classroom enactment of the argumentation activity. Design choices at this stage may be triggered by student responses to the activity or unanticipated constraints such as a shortened timeframe, or may arise spontaneously. The design output is the instructional episode itself, as experienced by the teacher(s) and students.

The message from this small-scale study for designers of argumentation activities is that teachers need careful guidance, including clarity of authorial intentions. Unless these are flagged – for example the purpose of sorting evidence into different types, such as economic, social, environmental – teachers may not enact the activity as intended. Whatever guidance is provided, a certain level of pedagogical design capacity is required for teachers to realise the potential of their own design choices even in 'ready-to-go' activities. In our case, Alan problematised student grouping and how to ensure multiple stances, in doing so adding further layers of design to the lesson structure. Heather is less experienced and does not initially pick these out as issues. Thus annotated guidance will need careful construction for inexperienced teachers of argumentation.

Appendix 1

(*KS3 is students aged 11–14 years, KS4 students aged 14–16 years)

The Legacy of the Olympic/Paralympic Games London 2012: The Story of the Sustainability of the Olympic/Paralympic Stadium

Activity Teaching Notes – Second Draft Version

In order to engage students in an argumentation activity looking at environmental impacts and potential sustainability issues, questions need to be raised which encourage them to defend/argue about positions for and against such an endeavour. The outline below is intended for middle–higher attaining students in KS3*. It can be modified for lower attainers (simplifiying statements, reducing the number of statements, using writing frames, using images) and particularly for KS4* (by bringing in 'late evidence', by playing devil's advocate etc.).

Setting the Scene

The London 2012 Olympic and Paralympic Games will take place from 27 July–12 August and 29 August– 9 September respectively, a total of 4 weeks.
Twenty-six sports in the Olympics and 20 in the Paralympics will take place.
The estimates for the final costs of the Olympic Park are, at the time of writing (January 2010), running at between £3 and 9 billion.
The Olympic Delivery Authority (ODA), the organisation responsible for building the facilities and so on, say that London 2012 is aiming to set 'new standards' of sustainability and to 'create positive, lasting changes for the environment and communities'.

Possible Scenario Questions

Does holding the Olympic/Paralympic Games make environmental sense?
Is the Olympic Park being built in a sustainable way?

Learning Objectives/Goals

The learning objectives for the students are to:

- explore the nature of materials being used to construct the Olympic Park;
- recognise the environmental impacts that a project such as this may have;
- distinguish between scientific, environmental, social and economic evidence when constructing an argument;
- construct arguments to justify their position with respect to the progress of the building of the Park from an environmental impact perspective.

(Note: The potential outcomes are in line with current science NC PoS at KS3 and KS4 for How Science Works and Assessing Pupils' Progress (APP) – AF2 Implications and Applications particularly.)

Teaching Sequence (2 Hour Session)

Students begin the activity by looking out over the Olympic site and undertaking the 'what do you notice most/most interesting/spot the . . . .' activity.

- Introduce the argumentation activity – Story of the Sustainability of the Olympic Park (whilst looking out over the site). What impressions do they have of potential environmental impacts and so on?
- Divide students into scientific adviser teams of three.
- Students watch the PP/video sequences to set the scene (when available), possibly with a prompt sheet for noting interesting aspects.
- Distribute and go through the activity handouts, telling the students that their task is to decide whether or not the Olympic Park is being built in a sustainable way (some discussion of what this means will be needed).
- Explain to the students that they should provide reasons for choosing their most important statements, supporting or challenging the sustainability claims being made by the ODA. The group should discuss the reasoning behind their choices and put together a coherent argument. One person in the group acts as scribe; one could put forward positive arguments, the other negative arguments and all to try to anticipate counter-arguments. Alternatively, all the evidence cards could be 'dealt' out so that all three in a group have some and they then go about discussing the various pros and cons and so on (Various prompts/scaffolds can be used if groups need them). Allow 20 minutes for the discussion.
- At the end of 20 minutes, ask the groups to try to decide which pieces of evidence are scientific, environmental, social or economic (some definitions need to be agreed here) and get them to categorise the evidence they are focusing on most strongly.
- The groups of three join another group of three (threes to sixes) and put forward their arguments. Where do they agree, disagree? Which 'strongest' evidence have they chosen? The larger group needs to formulate an agreed argument to present to the rest of the class; they will be able to speak for 2 minutes. Allow 15 minutes for the discussion/decision.
- Ask students to choose a representative who will present their case to the class.
- Run the presentation of arguments (high-attaining students can try to respond to the previous groups as it progresses). Allow 15 minutes for the debate.
- Finish by conducting a plenary discussion on the outcome(s) of the debate. Did groups agree; where/why did they differ? Do they recognise the kinds of evidence that they were drawing upon (scientific, environmental, social, economic)? Try to encourage a class consensus as to whether the ODA's sustainable development claims are justified.

A possible activity sheet for the students is outlined below.

London 2012 – Sustainable Development or Not?

The activity – student version

You are a team of three scientific experts advising on the building of the Olympic Park. The construction is now well underway and you are looking out on to the Olympic Site with your colleagues, trying to decide whether the Olympic Development Agency (ODA) are committed to sustainable development. Just how environmentally friendly is all the building? Is it really justifiable to spend all that money for an event that will only last about 4 weeks in 2012?

Your task

You have to compile a short scientific report for the Government (Department for Culture, Media and Sport) showing whether or not the Park is being built in a sustainable way, with the intention of making the impacts on the environment, and local people, as positive as possible.

You will work as a team of three initially; listen carefully to the instructions, some of which are summarised below.

- Look out over the Olympic Park and/or watch the video/PP presentation to gain a sense of all the building work that is going on at the moment across the Olympic Park.
- Examine the evidence that you have gathered, on the evidence cards, about the use of materials across the Park, the claims of the construction companies, the thoughts of local people and so on.
- Divide up the evidence cards between you. Decide in your team how to build your argument as you decide whether the Olympic Park is being built in a sustainable way. What does 'sustainability' mean here?
- Decide who is doing what – perhaps one of you select all the evidence 'for' sustainability and someone else select the evidence 'against' sustainability; the third person could be the writer, recording your decisions and the building of your argument. Or you could divide all the evidence up randomly first between you and then everyone decide on the pros and cons of some of the evidence.
- Record the start of your argument on Evidence Sheet A.
- Think about the following questions:
  - Where do you agree, disagree?
  - Which evidence is the 'strongest' you have chosen 'for' and 'against' sustainable development? Which evidence is the most convincing to you?
- Using Evidence Sheet B, sort your evidence into 'scientific', 'environmental', 'social' or 'economic' and see which seems to be the strongest – perhaps use different colours to show the different types of evidence.

When instructed you will join another team of three and try to persuade them that your arguments 'for' and 'against' the sustainable development of the Park are good arguments.

Select a spokesperson to present your case.

- In your team of six, try to reach agreement about the strongest arguments 'for' and 'against' that you have, and prepare a short presentation, choosing a spokesperson, to give your overall decision to the DCMS at the end of this session. In other words, you now all have to decide whether the Park is being built in a sustainable way, or not, based on the evidence you have discussed and what you have seen today.

Either write out your own final argument, or use Evidence Sheet C to help you.

Appendix 2

Argumentation Prompts (Adapted from the IDEAS Project, Kings College)

- What makes you think that?
- What is your reason for that?
- Can you come up with another argument for your point of view?
- Can you think of an argument against your point of view?
- How do you know that?
- What is your evidence for . . .?
- Why do you feel that . . . is the most important evidence?

Evidence Sheet C – Your Final Argument London 2012: Sustainable Development or Not?

Our Argument … Team ……
Our argument / position is that ….
Our reasons are that ….
Arguments against our idea might be that ….
We would convince somebody who does not believe us by ….
The evidence we would use to convince them is that ….

London 2012 Olympic Park Sustainability Evidence Cards

Rain water will be collected from the roof of the Velodrome to use to flush toilets inside and to water plants and trees	No materials leave the site if they can be re-used or recycled here
10,000 tonnes of steel will be used in the main stadium compared to 40,000 tonnes used in Beijing 2008	Two camps of travellers (gypsies) had to move when the Olympic Park site was chosen
The dust raised during the building works is a constant potential hazard for local residents	The 80,000 seat Olympic stadium will be reduced to 25,000 afterwards, and the steel will be re-used
60% of all the original materials on the site have been used again or recycled (bricks, cobbles, man-holes)	All the soil on site is being washed at the on-site 'soil hospital' – oil/contaminants are shaken free
Washed soil from the site is being used to landscape the area; 4,000 new trees will be planted	Some old businesses did not want to move from the site in 2005 and 2006
The site was contaminated with metals like mercury (from an old battery factory)	The bridges across the site will be made smaller after the Games and materials re-used
Radioactive material was found on site; it probably came from an old watch and clock factory	The radioactive material on site was sealed and buried under one of the bridges, rather than taking it away
Health and safety is very high on the agenda on the Olympic site	The energy centre on the site will use biomass boilers to generate some of the site's electricity
A new 120 metre high wind turbine will generate some of the site's electricity	The ODA hope 20% of all the energy used in the Olympic Park will be generated from renewable resources
To reduce carbon emissions, 50% of all the building materials being delivered to the site are coming by train	Some waste materials are being removed from the site by boat to reduce carbon emissions
In November 2009, just 2 of 9 sites being monitored for increased dust levels around the Park showed greater than normal levels on 2 days or more	New cycle routes and paths are being built to encourage people to walk or cycle to the Games
All the timber (wood) being used on site is coming from sustainably managed forests	Originally, there were about 500 objections raised to the building of the Olympic site by local people, businesses and environmental groups
Existing wildlife habitats are at risk from being disturbed by the building work for at least 5 years	Contractors are moving thousands of newts and hundreds of frogs to new habitats on site during building work
Part of Hackney Marshes (currently football pitches) will become a huge car park for the Games	People in Clay Lane, Marshgate Lane and Dace Lane (3 local roads) had to be re-housed to make way for the site
Each year 50–75 people die in the UK in accidents on building sites. So far, no one has died on the Olympic site	Allotments originally on the site were moved to another space, but the soil wasn't good enough to grow vegetables there. Some people lost their livelihoods as a result

References

Ben-Peretz, M. (1990). *The teacher-curriculum encounter: Freeing teachers from the tyranny of texts.* Albany, NY: State University of New York.

Beyer, C., & Davis, E. A. (2009). Supporting preservice elementary teachers' critique and adaptation of science lesson plans using educative curriculum materials. *Journal of Science Teacher Education, 20*(6), 517–536.

Brown, M. (2009). The teacher-tool relationship: Theorizing the design and use of curriculum materials. In J. Remillard, G. Lloyd, & B. Herbel-Eisenmann (Eds.), *Mathematics teachers at work: Connecting curriculum materials and classroom instruction*. New York: Routledge.

Clarke, D., & Hollingsworth, H. (2002). Elaborating a model of teacher professional growth. *Teaching and Teacher Education, 18*, 947–967.

Davis, E. A., & Krajcik, J. S. (2005) Designing educative curriculum materials to promote teacher learning. *Educational Researcher, 34*(3), 3–14.

Driver, R., Newton, P., & Osborne, J. (2000). Establishing the norms of argumentation in classrooms. *Science Education, 84*(3), 287–312.

Erduran, S., & Jiménez-Aleixandre, M. (Eds.). (2008). *Argumentation in science education.* Heidelberg: Springer.

Howe, C., & Mercer, N. (2007). *Children's social development, peer interaction and classroom learning* (Primary Review Research Survey 2/1b). Cambridge: University of Cambridge.

Kuhn, D. (1991). *The skills of argument*. Cambridge: Cambridge University Press.

London 2012 Olympic Games website http://www.london2012.com/news/2009/11/london-2012s-green-build-on-track.php. http://getset.london2012.com/en/home

Newton, P., Driver, R., & Osborne, J. (1999). The place of argumentation in the pedagogy of school science. *International Journal of Science Education, 21*(5), 553–576.

Osborne, J., Erduran, S., & Simon, S. (2004a). Enhancing the quality of argument in school science. *Journal of Research in Science Teaching, 41*(10), 994–1020.

Osborne, J., Erduran, S., & Simon, S. (2004b) *Ideas, evidence and argument in science*. In-service Training Pack, Resource Pack and Video. London: Nuffield Foundation.

Sandoval, W., & Reiser, B. (2004). Explanation driven inquiry: Integrating conceptual and epistemic scaffolds for scientific inquiry. *Science Education, 88*(3), 345–372.

Schwarz, C., Gunckel, K., Smith, E., Covitt, B., Bae, M., Enfield, M., et al. (2008). Helping elementary preservice teachers learn to use curriculum materials for effective science teaching. *Science Education, 92*(2), 345–377.

Simon, S., Erduran, S., & Osborne, J. (2006). Learning to teach argumentation; Research and development in the science classroom. *International Journal of Science Education, 28*(2–3), 235–260.

Simon, S., & Richardson, K. (2009). Argumentation in school science: Breaking the tradition of authoritative exposition through a pedagogy that promotes discussion and reasoning. *Argumentation, 23*(4), 469–493.

Slavin, M. (2006). *Olympic Games Monitor website.* Retrieved February 15, 2010, from http://www.gamesmonitor.org.uk/