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► **To cite this version:**

Shirley Simon, Susan Johnson. Professional learning portfolios for argumentation in school science. International Journal of Science Education, 2008, 30 (05), pp.669-688. 10.1080/09500690701854873 . hal-00513365

HAL Id: hal-00513365

<https://hal.science/hal-00513365>

Submitted on 1 Sep 2010

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Journal:	<i>International Journal of Science Education</i>
Manuscript ID:	TSED-2007-0148.R1
Manuscript Type:	Special Issue Research Paper
Keywords:	argumentation, science education, teacher development
Keywords (user):	



Professional learning portfolios for argumentation in school science

Abstract

This paper reports on the use of portfolios in a continuing professional development programme to advance teachers' skills in their pedagogy of argumentation. The programme adopted a cyclical process of expert input- teacher practice- sharing practice, in order for professional learning to include reflective analysis of growing accomplishment. Accomplishment was initially defined according to previous research and development on the teaching of argumentation, but was redefined during the programme as teachers shared practice and discussed their achievements.

Portfolios were used to help teachers apply their learning, collate evidence of their accomplishment and share reflective analysis of practice with other colleagues on the programme. The paper includes extracts of two teachers' portfolios; these provide evidence of each teacher's developing accomplishment in the teaching of argumentation. Portfolios are idiosyncratic and are constructed according to an individual teacher's motivations, interpretations and situations. Teachers need structure and guidance in creating purposeful portfolios that enhance reflective practice.

Introduction

School science teaching in the UK has traditionally been focused on the content of science – that established body of scientific knowledge that forms the bedrock of the curriculum and school science examinations. Yet recent debates about science education emphasise the importance of the nature of science and the processes of

1
2
3 critical reasoning and argument (Driver, Leach, Millar, & Scott, 1996; Driver,
4
5
6 Newton, & Osborne, 2000; Millar & Osborne, 1998). As future citizens our students
7
8 should be able to engage in decision-making about controversial issues in science, and
9
10 to do so they will need to understand how evidence is used to construct explanations.
11
12 They will also need to understand the criteria that are used in science to evaluate
13
14 evidence. There is a growing need therefore to educate our students and citizens about
15
16 why we believe in the scientific world-view – that is to see science as a distinctive and
17
18 valuable way of knowing. Such a shift in emphasis requires that the teaching of
19
20 science should focus more on the nature of science and on the evidence and
21
22 arguments for scientific ideas, and help students develop skills of engaging in fruitful
23
24 argumentation.
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32 Research shows, however, that only if argumentation is specifically and explicitly
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34 addressed in the curriculum will students have the opportunity to explore its use in
35
36 science (Khun, 1991; Hogan & Maglienti, 2001; Osborne, Erduran, & Simon, 2004a;
37
38 Zohar & Nemet, 2002). Because science education has always been more concerned
39
40 with students' understanding of scientific concepts, adopting different aims in the
41
42 science classroom is notoriously difficult. The normative practice in science is
43
44 predominantly that of transmission (Lyons 2006), the focus being on the delivery of
45
46 science facts and concepts. Yet the teaching of argumentation through the use of
47
48 appropriate activities and teaching strategies can provide a means of promoting a
49
50 wider range of goals, including social skills, reasoning skills and the skills required to
51
52 construct arguments using evidence (Osborne, Erduran, & Simon, 2004b; Simon,
53
54 Erduran & Osborne, 2006). In order to change the emphasis in teaching science to
55
56 incorporate argumentation, teachers need to adopt more dialogic approaches
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2
3 (Mortimer & Scott, 2003; Alexander, 2005) that involve students in discussion, and to
4
5 consider how they themselves interact with students to foster argumentation skills.
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7
8 The research reported here focuses on a programme designed to help teachers
9
10 transform their practice and achieve such a change.
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14
15 Transforming pedagogy requires teachers to share the values of an innovation and be
16
17 prepared to take risks – a venture that is best supported by establishing the practice of
18
19 collaborative reflection within a community of professional learning (Hoban, 2002;
20
21 Loucks-Horsley et al., 2003). Early approaches to teacher development that had little
22
23 sustained impact were underpinned by mistaken beliefs that teacher learning is a
24
25 linear process where teachers' practice could be transformed by prescriptive
26
27 approaches, whereas current knowledge would suggest that a more complex view of
28
29 professional learning is required to bring about sustained change (Fullan, 2001;
30
31 Hoban, 2002; Bell and Gilbert, 1996; Spillane, 1999; Loucks-Horsely, 2003; Adey,
32
33 2004). Hoban's work is particularly important in identifying a combination of
34
35 conditions for teacher learning that complement each other in supporting change.
36
37 These are a conception of teaching as a dynamic relationship with students and with
38
39 other teachers where change involves uncertainty; room for reflection in order to
40
41 understand the emerging patterns of change; a sense of purpose that fosters the desire
42
43 to change; a community to share experiences; opportunities for action to test what
44
45 works or does not work in their classrooms; conceptual inputs to extend teachers'
46
47 knowledge and experience (in this case, ideas about the value of argumentation in
48
49 teaching science); and finally sufficient time to adjust to the changes made. Moreover,
50
51 as Fullan has established, any change is dependent on the introduction of new
52
53 materials, approaches and a challenge to existing beliefs (Fullan 2001). Initiating the
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3 kind of change that was attempted in this project was therefore reliant on teachers
4
5 trying out new approaches, sharing their experiences and reflecting on their own
6
7 practice.
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12 Reflection can be viewed as ‘a purposeful, systematic enquiry into practice’ (Schön,
13
14 1983) with a view to its improvement and which allows for doubt and perplexity
15
16 (Hatton & Smith 1995; Pedro 2005). According to Furlong et al (2000), it is a way of
17
18 coming to know by capturing practical experience in order to learn from it.
19
20
21

22 Reflection involves both doing and thinking, looking back and looking forward and is
23
24 concerned with learning in order to be a better practitioner. Reflection, however, can
25
26 occur at different levels, for example Hatton and Smith (1995) make a distinction
27
28 between different kinds of reflection, including technical (decision-making about
29
30 immediate behaviours or skills), descriptive (seeking what is seen as best practice),
31
32 dialogic (weighing viewpoints and exploring alternatives) and critical (seeing goals
33
34 and practices as problematic). The first three levels of reflection are characterised by
35
36 recounts of personal experience that do not go beyond the self, or which focus on the
37
38 effectiveness of skills without any broader critique, or which provide some reasons
39
40 for action but which are limited to personal judgement. Critical reflection, by
41
42 contrast, is a wider and longer term. It goes beyond the personal to review
43
44 experiences in the light of other forms of professional knowledge such as the findings
45
46 of research and theoretical insights. Lyons (1998) uses the metaphor of weaving and
47
48 threading to illustrate how critical thinking can connect different experiences to bring
49
50 into consciousness teachers’ beliefs and values, in that way critical reflection can be
51
52 ‘transformational’ (Barnett 1997).
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3 To achieve the transformational goal of teachers' professional development thus
4
5 requires an approach to teacher learning that is informed by Hoban's conditions and
6
7 provides opportunities for reflection on practice. A vehicle for such reflection can be
8
9 the building of a portfolio of evidence that can be shared and discussed between
10
11 teachers. A portfolio is often defined as a 'collection of work' or a 'collection of
12
13 evidence' (Paulson, Paulson & Meyer 1991; Snadden & Thomas 1998; Hoel &
14
15 Haugalokken 2004). Just as the collection of any artefact is varied and built up
16
17 gradually, implicit in the term 'collection' is the idea that the material presented
18
19 shows change and development in different contexts over time and is not a product of
20
21 the moment. In teacher education, portfolios have served two purposes: assessing
22
23 performance and supporting professional learning. A learning portfolio allows
24
25 teachers to 'engage in professional dialogue with colleagues', 'to collaborate and
26
27 develop understanding and ideas on teaching and learning' (Klenowski 2002 p25). A
28
29 learning portfolio involves thinking, talking and knowing about teaching; it is self-
30
31 directed and involves a process of discovery (Grant & Huebner 1998). The process of
32
33 coming to understand better the complexities of teaching involves asking questions,
34
35 sometimes difficult ones which challenge the status quo and which query why things
36
37 are the way they are. Sharing and discussing portfolio entries with colleagues in the
38
39 program was perceived as a means of enhancing reflective practice through
40
41 collaborative analysis of evidence (Davis & Honan 1998, Grant & Huebner 1998,
42
43 Lyons 1998, Shulman 1992). The provision of feedback, questions and different
44
45 perspectives by peers and mentors can strengthen the portfolio development process
46
47 through broadening the process of reflection.
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3 The research reported here focuses on the use of portfolios in a CPD programme to
4 enhance the teaching of argumentation in science. The aim of the research was to see
5 whether teachers would develop portfolios of evidence that demonstrated their
6 growing accomplishment in the teaching of argumentation, and their reflective
7 analysis of practice. Teachers were encouraged to gather evidence of how they
8 interpreted the expert inputs of the CPD programme and put them into practice, and to
9 share and document their reflections based on that evidence. It was anticipated that
10 the portfolios would provide a source of data for demonstrating the efficacy of the
11 CPD.
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27 **The CPD programme for argumentation**

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32 The CPD programme for teaching argumentation that was developed through the
33 King's College Weizmann project grew out of previous research on teachers' use of
34 argumentation in science classrooms (Simon *et al.*, 2003, 2006) and from the in-
35 service training materials called IDEAS (Ideas, Evidence and Argument in Science
36 Education, Osborne, Erduran & Simon, 2004b). The CPD programme built in expert
37 inputs from these materials and supplemented these with other professional learning
38 conditions specified by Hoban, including sessions for sharing and reflecting on
39 practice. A series of workshops was designed to incorporate these conditions and our
40 research aimed to explore those features of the programme that would have an impact
41 on professional learning in the context of teaching argumentation in science.
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58 Earlier work on enhancing the quality of argument in school science had focused on
59 ways in which such quality could be determined. A suitable analytic framework used
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1
2
3 in the research was based on Toulmin's (1958) model (see Erduran, Simon &
4
5 Osborne, 2004 for a fuller rationale), which had been used as a basis for
6
7
8 characterising argumentation in science lessons (Russell, 1983) and in other coding
9
10 schemes (e.g. Jiménez-Aleixandre, Rodríguez & Duschl, 2000). Features of a
11
12 Toulmin analysis of argumentation include: the extent to which students and teachers
13
14 make use of data, claims, warrants, backings, qualifiers and rebuttals; and the extent
15
16 to which they engage in claiming, justifying and opposing the arguments of each
17
18 other. The Toulmin framework was therefore a feature of the way in which we helped
19
20 teachers to conceptualise and evaluate argumentation. Previous work had led to a
21
22 distinction being made between *argument* and *argumentation*, argument referring to
23
24 the substance of claims, data, warrants and backings that contribute to the content of
25
26 an argument, whereas argumentation to the process of assembling these components,
27
28 in other words, of arguing. Through providing students with tasks that require
29
30 discussion and debate, teachers can support students in the construction of arguments
31
32 through the process of argumentation.
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41 A concept that was developed with this project was that of an accomplished teacher of
42
43 argumentation. Though the idea of accomplishment was not new, what it meant to be
44
45 accomplished with reference to the teaching of argumentation had to be established.
46
47
48 Previous research with teachers (Simon *et al* 2006) identified how teachers' oral
49
50 contributions demonstrated epistemic goals implicit in their interactions, both in
51
52 whole class and small group settings. For example, the act of asking students to
53
54 provide reasons for their claims reflected a teaching goal that students should show
55
56 the process of justification. An analytical framework that focused on teachers' oral
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1
2
3 contributions resulted in the formation of a tentative hierarchy of teaching goals that
4
5 facilitate argumentation processes. These processes included:
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- 10 • Talking and listening
- 11
- 12 • Knowing the meaning of argument
- 13
- 14 • Positioning
- 15
- 16 • Justifying with evidence
- 17
- 18 • Constructing arguments
- 19
- 20 • Evaluating arguments
- 21
- 22 • Counter-arguing/debating
- 23
- 24 • Reflecting on the argumentation process
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32 It was envisaged that awareness of these argumentation processes would help teachers
33
34 to incorporate them into classroom discourse. For example, that students needed to
35
36 learn how to listen and talk, justify claims etc, before they could debate; and that
37
38 teachers themselves needed to value and learn how to implement group discussion
39
40 and prompt justification before they could orchestrate effective counter-argument
41
42 within their teaching. Such a starting point, together with the IDEAS materials,
43
44 enabled us to begin to define accomplishment in the teaching of argumentation as the
45
46 following:
47
48
49

- 50 • Articulate argument goals and a rationale for teaching argument
- 51
- 52 • Model and communicate the meaning of argument
- 53
- 54 • Develop organisation strategies for group work
- 55
- 56 • Focus on the use of evidence
- 57
- 58
- 59
- 60

- Introduce writing frames to support argumentation
- Encourage counter-argument
- Evaluate arguments
- Become aware of their role as a facilitator in supporting argumentation
- Be reflective on their practice

The CPD programme thus focused on ways in which such accomplishments could be promoted, through a combination of expert input, workshop activities and episodes for sharing and reflection. The expert inputs began with sessions that helped teachers to become familiar with the rationale for teaching argumentation in science, in that for students to appreciate the origins of scientific belief and the nature of science, they must explore some of the reasons why theories have become established and why alternative theories are considered to be 'wrong'. Teachers discussed activities that invite students to evaluate the evidence that is used in such arguments, and became immersed (Loucks-Horsely et al 2003) in these activities themselves in order to appreciate their impact and extend their understanding of the possible teaching goals associated with argumentation. Many such activities were found in IDEAS (Osborne, Erduran & Simon, 2004b), but teachers were also encouraged to find other resources, or to develop activities themselves to suit their own curricular schemes. There was a distinct focus on the ways in which small group discussion could be organised, as the more dialogic approach needed for successful argumentation requires more careful grouping than simply allowing students to discuss. The teachers experienced several different group formats. Video materials and workshop sessions from IDEAS were incorporated that would help teachers to model argument and communicate its meaning to students. Video material was particularly focused on ways in which

1
2
3 teachers could introduce argumentation activities, and support argumentation using
4 oral prompts to help students justify their arguments with evidence, including playing
5
6
7
8 'devil's advocate'.
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11
12 Exercises using Toulmin's framework were introduced with the aim of helping
13 teachers to evaluate argument. Teachers were encouraged to develop criteria for
14
15 assessing the quality of students' arguments focusing on how evidence was used to
16
17 justify claims and how argumentation incorporated rebuttals. To encourage counter-
18
19 argument, teachers were introduced to strategies that they could use to involve
20
21 students in a conflict situation that can stimulate rebuttals (e.g. a pair taking one
22
23 position in an argument works with a pair taking an opposing position). They were
24
25 also introduced to writing frames that helped to support argumentation and provide a
26
27 means for both students and teachers for evaluating argument outcomes. Teachers
28
29 began their engagement with argumentation through attempting to teach science
30
31 content in a way that includes an argumentation element. At each workshop, they
32
33 shared these experiences before experiencing further inputs. The programme provided
34
35 opportunities for the teachers to share evidence that could be included in their
36
37 portfolios, and identify how such evidence demonstrated growing accomplishment.
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48 **Research**

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53 The research reported here focused on the contents of the final portfolios, addressing
54
55 the following questions:

56
57 Do the portfolios show evidence of accomplishment?

58
59 Do teachers themselves identify that evidence as demonstrating accomplishment?
60

1
2
3 Do teachers annotate their reflections on the evidence in the portfolio, if so, how?
4
5
6
7

8 After an initial phase to establish the CPD contents, the programme was undertaken
9
10 consecutively by two groups of teachers, the main aim of each phase being to refine
11
12 the programme for future use. Though each group included four teachers at the outset
13
14 of the programme, pressures of work and inability to be released from school meant
15
16 that only two out of each group of four teachers eventually completed the programme
17
18 and produced a final portfolio. The four portfolios (compiled by Martin, Nancy, Alice
19
20 and Nick) were analysed by searching the documentation for examples of
21
22 argumentation practice, reasons for selecting evidence and different kinds of
23
24 reflective notes made immediately after practice and at a later stage. Evidence for
25
26 accomplishment was identified according to the criteria for generated in the CPD
27
28 programme (listed above), and evidence for reflective analysis was identified
29
30 according to Hatton and Smith's (1995) descriptors of levels of reflection, that is
31
32 technical, descriptive, dialogic and critical. The analysis of portfolios was followed up
33
34 by interviews with the four teachers about the CPD experience.
35
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43 The four portfolios were idiosyncratic and demonstrated accomplished practice and
44
45 reflective analysis in different ways. The portfolios compiled by Martin and Nancy
46
47 were considered by them to be good examples of their practice and to demonstrate
48
49 their progress in the domain, whereas Alice and Nick considered their portfolios to be
50
51 incomplete but a useful source of information about their teaching. To illustrate the
52
53 potential of using portfolios as a vehicle for professional learning, in this case of
54
55 teaching argumentation in science, this paper includes an analysis the final portfolios
56
57
58 compiled by teachers Alice and Martin. The portfolios provide a record of how each
59
60

1
2
3 teacher practiced the skills acquired from the CPD, attempted to transfer these skills
4
5 to different classroom contexts (Joyce and Showers, 1988), tracked their progress
6
7 towards accomplishment and demonstrated their learning in the domain.
8
9

10 11 12 **Portfolio: Alice**

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16
17 Alice was acting head of her science department, which was located in an inner
18
19 London school with a high proportion of ethnic minority students. She joined the
20
21 project in Phase 2, having had some previous experience of teaching argumentation.
22
23 She attended all four workshops, which took place over a period of eight months, and
24
25 experimented with different ideas for argument activities with students aged 11 to 15
26
27 years. She constructed her portfolio over this eight-month period, collecting examples
28
29 of her practice that included lesson plans, resources she had created herself or
30
31 acquired, students' work and her own reflections on many of her lessons. Alice's
32
33 interpretation of her classroom practice was the focus of attention in the portfolio.
34
35
36
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41 Initially, Alice had a rudimentary understanding of the argumentation process from a
42
43 Masters course she had recently completed and had a limited appreciation of how to
44
45 introduce it into her lesson systematically. She had some experience of reflecting on
46
47 her teaching, but this was not very fully developed. After compiling her portfolio
48
49 Alice constructed a table (Table 1) in which she reflected on the evidence she
50
51 accumulated to demonstrate her work in this domain.
52
53
54
55
56

57 [Insert Table 1 here]
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60

1
2
3 Table 1 shows how Alice focused on aspects of her teaching of argumentation that she
4
5 believed provided evidence of her accomplishment. Within the portfolio there are
6
7 more examples that show evidence of her professional learning, but the Table focuses
8
9 on what she saw as her main achievements. The third column demonstrates an
10
11 awareness of how she has achieved accomplishments including how to encourage
12
13 students to use evidence.
14
15

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19
20 During the second workshop of the programme Alice was introduced to the process of
21
22 evaluating argumentation through expert input based on Toulmin's model. She
23
24 subsequently promoted evaluation in her argumentation lessons, and shared her
25
26 reflections on the process with colleagues. In constructing a section of her portfolio
27
28 that showed how she developed her evaluation of students' argumentation, Alice drew
29
30 from different lessons. Her aim was to explore ways in which students' arguments
31
32 could be evaluated so that she could help students to progress to higher levels. Table
33
34 2 shows the Toulmin model Alice used and adapted to help her evaluate students'
35
36 work.
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41
42

43 [Insert Table 2 here]
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46
47

48 Alice wrote the following note – a simplified version of Toulmin's model that she
49
50 could use with students to explain what she was looking for:
51
52

- 53 • Make a claim
- 54
- 55 • What is your evidence? Present how you are substantiating your claim
- 56
- 57 • Warrant – explain HOW the evidence proves the point you are making
- 58
- 59
- 60

- Backing – present some information to BACK your claim
- Explore any shortcomings/where doesn't the evidence fit in?
- Anticipate/explore counterargument

Alice also drew on a model of the Levels of argument that had been derived from Toulmin's model (Osborne, Erduran & Simon 2004a):

[Insert Table 3 here]

She used a simplified version of these levels to help her assess students' work:

Level 1	Claim V claim
	Claim V counter claim
Level 2	Claim + data to back it
	+Warrant
Level 3	Claim +data to back it
	+Warrant
	+May have a weak rebuttal
Level 4	Claim + data
	+Warrant
	+Strong rebuttal
Level 5	Claim + data
	+ warrant
	+ more than one rebuttal

1
2
3 Alice transcribed students' spoken arguments and explained how she then applied
4 these levels of argument as she analysed the discourse. Through discussing this
5 analysis with colleagues she was able to consider how to improve their arguments in
6 the future. Figure 1 shows her portfolio entry for this analysis.
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14
15 [Insert Figure 1 here]
16
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19

20 Alice also applied Toulmin's model when evaluating students' written arguments in
21 other contexts. She used the IDEAS (Osborne, Erduran & Simon, 2004b) resource
22 Snowman, which involves a concept cartoon showing one snowman with a coat
23 (Fred) and one without a coat (Birt). Students are asked to decide which snowman
24 would melt first. Alice included an example of one group's written argument in her
25 portfolio and annotated it (in parentheses). Her analysis demonstrates that she had
26 assimilated her understanding of Toulmin's model of argument and was able to apply
27 it when assessing students' argumentation outcomes, so that she could judge whether
28 students had achieved a high-level argument. The portfolio entry again shows her
29 accomplishment in evaluating arguments (Figure 2).
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46 [Insert Figure 2 here]
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51 Alice also included other annotated entries of students' work to show how she was
52 continuing to apply the analysis to other argumentation outcomes.
53
54
55

56
57 The portfolio, though incomplete in Alice's view, does demonstrate aspects of
58 teaching argumentation that Alice tried to develop in her practice, particularly
59
60

1
2
3 evaluating students' arguments. The reflective annotations range from 'descriptive'
4 where Alice is analysing her own performance and giving reasons for her actions, to
5
6 more 'dialogic', as shown in Table 1, constructed after completing the portfolio. In
7
8 Hatton and Smith's terms, Alice is 'hearing one's own voice' and exploring
9
10 alternative ways of approaching argumentation. When interviewed, Alice stated that
11
12 this CPD experience differed from others in that it centred more on the process of
13
14 reflection and on the search for evidence from her own practice that demonstrated
15
16 progress. She also valued the sharing of evidence with others on the programme;
17
18 'people look at things from a different perspective and help you see things that you
19
20 would not necessarily see yourself'. The portfolio provided a vehicle for enhancing
21
22 her reflective analysis.
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32 **Portfolio: Martin**

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36 Martin was head of a science department in an inner London community school for
37
38 girls (aged 11 to 16 years) when he joined Phase 3 of the argumentation CPD
39
40 programme. He constructed his portfolio over a period of 6 months by collecting
41
42 several examples of his practice including lesson plans, resources he had used,
43
44 students' work and his reflections on the lessons. Martin had a basic understanding of
45
46 the argumentation process out the outset but was keen to improve his practice and to
47
48 introduce argumentation into his lessons systematically. He also wanted to assist
49
50 colleagues in his science department with their professional development. Portfolio
51
52 evidence presented here is from two of Martin's argumentation lessons, one on the
53
54 topic of genetics and variation (students aged 14 to 15 years) and the other focusing
55
56 on volcanoes and earthquakes (students aged 12 to 13 years). Analysis of these
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1
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3 portfolio exemplars offers evidence of several accomplishments and of Martin's
4
5 reflections on practice.
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10 In the genetics and variation lesson Martin had clear scientific and argumentation
11 goals. This was his second attempt at argumentation and he used a powerpoint
12 presentation showing images of variation or mutation with a mixture of environmental
13 and inherited elements to stimulate students' thinking about the role of evidence. The
14 powerpoint was followed by discussion based on concept cartoons about living things
15 and their environment in which Martin was able to implement small group discussion.
16
17 Figures 3 and 4 are portfolio extracts that illustrate his planning and reflection on this
18 lesson. The lesson plan demonstrates careful attention to the objectives, or teaching
19 goals, of the lesson, and that these are content focused, though Martin clearly aimed
20 to implement small group discussion that would encourage talking and listening.
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36 [Insert Figures 3 and 4 here]
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41 Martin's reflection suggests that he was not entirely happy with the content of the
42 presentation and that in future he would include more images on environmental
43 variation. His objective when compiling the slides may not have been very clear and
44 student reaction caused him to rethink his objectives.
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51
52 The second extract taken from Martin's portfolio focuses on his Year 8 class
53 undertaking argumentation on the causes of earthquakes and volcanoes. In this lesson
54 Martin organised group work in two different ways and asked the students to focus on
55 the evidence they were given in the resources. He provided resources that could
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1
2
3 support argumentation and were sufficiently diverse for students to judge the value of
4
5 each piece of evidence. Martin's lesson plan is included here (Figure 5) as it
6
7 demonstrates that he had progressed in his articulation of objectives as 'lesson
8
9 outcomes' and that these included an identification of content goals, epistemological
10
11 goals (the uncertain nature of scientific knowledge), social goals and reasoning goals.
12
13
14

15
16
17 [Insert Figure 5 here]
18
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21
22 Martin's evaluation of this lesson was positive and focused on the students'
23
24 homework, which he included in his portfolio. He added evaluative comments to
25
26 some pieces of student work at a later date and his comments are shown in italics in
27
28 Figure 6. The evaluation of students' work enabled him to focus on their use of
29
30 evidence in answering questions and drawing conclusions.
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36 [Insert Figure 6 here]
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41 Throughout Martin's portfolio there were two levels of reflective comment; the first
42
43 level included those comments made soon after the lesson, which simply reported
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45 success/problems or added some suggestions, and are therefore 'descriptive':
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48 *Technical issues marred start of lesson – powerpoint froze and sound track did*
49 *not play so well.*
50

51
52 *Could have given pupils more thinking time over paired activity to discuss*
53 *causes of earthquakes and volcanoes.*
54
55

56
57 *Forces of nature activity groups worked well – assigned on ability. Roles*
58 *assigned by group. The pen rule for talking was partially effective in*
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60

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3 *controlling the number of people talking. This would need to be worked on. In*
4
5 *groups, discussion was good – and they could easily evaluate the evidence and*
6
7 *draw conclusions to answer 3 questions.*
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10 The second level of reflective analysis comprised comments made after Martin's
11 engagement with the project, when he reviewed his final portfolio. This level shows
12 more specific reference to argumentation processes and how Martin facilitated these
13 in his teaching, these reflections are more 'dialogic' in that they reflect his analysis of
14 argumentation pedagogy:
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24 *The activities in feedback led to use of counter argument and speakers having to*
25 *further justify their predictions and decisions. Pupils got into role well and*
26
27 *discussions were heated and animated. Decisions were defended with zeal. The*
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29 *arguments used were complex in that evidence was used to support decisions.*
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36 Martin's evidence in his portfolio demonstrated his accomplishments in this
37 domain. He used his portfolio to select, accumulate and analyse evidence, all of
38 helped him to confirm the merits of using argumentation in science lessons.
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46 In a follow-up interview Martin stated that he saw the portfolio as a means of having
47 evidence that he was developing his own understanding of argument and that the
48 pupils' understanding and ability to use argument was also developing. He added
49 reflections to remind him of what he had learnt and what he could highlight from
50 pupils' work. He began by including snippets of lessons using argumentation to whole
51 lessons using argumentation: 'As long as I did my evaluations straightaway – they
52 helped me analyse how much I understood about the process of argument and how
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3 much the pupils understood. Evaluating helped me to go on to the next lesson.’ He
4
5 also commented that sharing his portfolio with other teachers was a useful experience
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7 as it helped him articulate his reflections.
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10 11 12 13 **Discussion**

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17 The two extracts from teachers engaged in Phase 2 and Phase 3 of the programme,
18
19 where expertise in argumentation was to be developed with teachers who had little
20
21 prior experience, shows how the portfolio process enriched reflective analysis by
22
23 providing opportunities for annotation of portfolio entries, immediately after practice
24
25 and at a later date. Moreover, the contents of the portfolio and the reflections were
26
27 discussed with other members of the teacher group, so all eight teachers taking part in
28
29 these two phases were able to contribute, share reflections and learn from their
30
31 involvement. Interviews conducted with individual teachers indicated that the shared
32
33 aspect of the work was the most highly valued component of the programme. Though
34
35 this programme was conducted with a small number of teachers it served to refine the
36
37 CPD for argumentation and enable teachers to co-construct the definition of
38
39 accomplishment in the domain. In addition it enabled us as researchers to evaluate the
40
41 role of the learning portfolio in professional development work. Critical to the process
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43 was the cyclical nature of expert input – teacher practice- sharing practice that was
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45 repeated in each Phase.
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55 The value of portfolio development remains uncertain, as only half the teachers
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57 involved in the CPD produced a final portfolio; other teachers put argumentation
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59 activities into practice and collected student work but did not collate these documents
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3 into a portfolio of evidence or write reflective comments. So why do some teachers
4 undertake reflective analysis and others do not? What motivates a teacher to produce
5 a portfolio, and how effective was it for those who engaged more fully in the process?
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8 During conversations in workshops teachers indicated that they needed to be
9 motivated by personal goals in order to construct a portfolio. Teachers having
10 different levels of experience and roles within their schools were motivated in
11 different ways and hence their portfolios were very different. Martin was head of a
12 science faculty and wanted to set up CPD within his school; he intended to use his
13 portfolio to share his own learning experiences with colleagues, he also valued the
14 portfolio from a personal learning perspective. Shared reflective analysis helped both
15 him and less experienced teachers who used their portfolios to identify progress in
16 their teaching. Our analysis of portfolios demonstrated that teachers made progress
17 towards accomplishment in the teaching of argumentation, as evidenced in Alice's
18 and Martin's extracts. However, these portfolios show that focus was different for
19 each teacher in terms of selecting evidence for accomplishment. From documentary
20 analysis and interview data alone, it is not possible to determine the extent to which
21 the teachers progressed in their teaching of argumentation. To study their teaching
22 was beyond the scope of this project, and the portfolio evidence can only be indicative
23 of their practice. Our interpretations of accomplishment arising from the CPD are
24 therefore limited to what can be seen in the portfolios. In addition, the portfolio
25 extracts can only be indicators of how reflective these teachers were as practitioners.
26
27 However, the portfolios do provide opportunities for reflection based on the
28 documentation; it is possible that lower levels of reflection, such as descriptive
29 reflection, are characteristic of immediate response to an event, whereas reflection
30 becomes more dialogic when teachers have had time to think about their pedagogy, its
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3 problems and possible solutions. The analysis of the portfolios of the four teachers
4 who did complete the process (the two included in this paper are indicative of the
5 four) showed evidence of dialogic reflection and each was positive about the role of
6 the portfolio in their personal learning. One might ask why reflections do not reach
7 the higher levels of criticality described by Hatton and Smith (1995). One possible
8 explanation is that the portfolio, as conceived in this project, did not require teachers
9 to look outwards beyond the analysis of their own practice, and to think about wider
10 implications of their changes. A more wide-ranging analysis of levels of reflection
11 was beyond the scope of this study, which focused specifically on recognition of
12 growing accomplishment in teaching argumentation, and the choice of evidence to
13 demonstrate that accomplishment. However, a combined set of analyses could serve
14 to help develop the role of critical reflection in the wider use of learning portfolios,
15 where these become part of accredited courses and professional development
16 qualifications (Turner and Simon, 2007).
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39 Our work with portfolios suggests that they can be used to develop the skills of
40 reflection, self-evaluation and analysis, hence contribute to an individual's
41 metacognitive development. The product cannot be separated from the processes
42 involved in its development. If the main emphasis is on the quality of the product,
43 then tasks may become reduced to a generic level and the intended processes of self-
44 evaluation and reflection will give way to checklists of standards to be reached. The
45 portfolio would be reduced to trivial and superficial purposes (Klenowski, 2002).
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55 However, there needs to be some structure to guide effective use of portfolios and a
56 sense of purpose to motivate teachers. If the portfolio is to be shared with colleagues,
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3 CPD providers and mentors, and is therefore 'on show', the selection and annotation
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5 of evidence becomes more purposeful.
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Table 1. Alice's tabulation of evidence for accomplishment.

Accomplishment being developed	Activities through which accomplishment is practiced	Reflections on evidence for accomplishment
Planning for achieving argumentation goals	<p>IDEAs lesson on Euglena; Energy choice</p> <p>IDEAs lesson on Euglena with supporting prompts</p>	<p>The first lessons that I taught were simply based on the lesson plans provided in the resources without thinking of what I could do to develop their [students'] skills in writing arguments.</p> <p>Further on, other lessons show more careful planning and pre-thought. As a result of the prompts and the way I focused and taught the concept of argument, written outcomes are of better quality (even if they come from lower years).</p>
Reflections on teaching argumentation	<p>IDEAS lesson on Energy project</p> <p>How to introduce argument.</p> <p>PANGEA lesson</p>	<p>No written reflections were made, though my emphasis was on their scientific understanding rather than the development of their argument skills.</p> <p>Both recent lessons show that my reflections focus on how to develop effective arguments and pupils' engagement with the evidence.</p>
Supporting argumentation	<p>Where could Ideas and Evidence be taught?</p> <p>Resources to support</p>	<p>I'm now reflecting on sections of the curriculum where there are interesting, engaging opportunities to teach ideas and evidence.</p> <p>I'm now developing argument</p>

	written arguments, evidence to frame arguments Assessing argument	prompts e.g. questioning, writing frames, key words to support pupils. I'm developing a bank of sites pupils can use to support their arguments with evidence – considering both sides of an argument. Assessing argument.
Pupil performance of argumentation	Snowman Euglena lesson	Pupils' written outcomes have improved.
The meaning of argument	Lesson on introducing the concept of argument	<i>No documented reflection</i>
Resources for argumentation lessons	Lesson plans Writing frames Plenary prompts	Lesson plans from the Net/CD-ROMs, Useful websites Animations/Presentations

Table 2 Toulmin's Model of Argument

Claims	These are assertions about what exists or values that people hold.
Data	These are statements that are used as evidence to support the assertion.
Warrants	These are statements that explain the relationship between the data to the claim.
Qualifiers	These are the specified conditions under which the claim holds true.
Backings	These are underlying assumptions, which are often not made explicit.
Rebuttals	These are statements, which contradict either the data, warrant, backing or qualifier of an argument.
Counter – Claims	These are simply opposing assertions.

Table 3 Levels of argument from Osborne et al 2004a

Level 1:	Level 1 arguments are arguments that are a simple claim versus a counter-claim or a claim versus a claim.
Level 2:	Level 2 arguments consist of claims with either data, warrants or backings but do not contain any rebuttals.
Level 3:	Level 3 arguments consist of a series of claims or counter-claims with either data, warrants or backings with the occasional weak rebuttal.
Level 4:	Level 4 arguments consist of a claim with a clearly identifiable rebuttal. Such an argument may have several claims and counter-claims.
Level 5:	This is an extended argument with claims supported by data and warrants with more than one rebuttal.

Figure 1. Alice's analysis of students' transcribed spoken arguments

In this lesson the focus has been 'Evaluating argument'. I am looking at how argument can be assessed. I have chosen to focus on spoken argument during class discussions. The 'Level of argument' sheet was used to identify claim, data, warrants and rebuttals in pupils' conversations. What follows is an attempt to analyse particular parts of the lesson that I recorded in writing.

Level 1

<i>Fateha</i>	<i>I agree with it</i>
<i>John</i>	<i>No, it's bad</i>
<i>Fahmida</i>	<i>I don't know</i>
<i>John</i>	<i>It's bad, I know</i>

This shows a claim from Fateha. John just disagrees - a counter claim. Fahmida doesn't help. John repeats what he had said before, but still doesn't explain why.

<i>Vincent</i>	<i>I eat GM food and you do too</i>
<i>Sabena</i>	<i>Don't say that, it's not true. Anyway how do you know what I eat?</i>
<i>Vincent</i>	<i>.....said it's in loads of food, like veg.</i>
<i>Sabena</i>	<i>I don't like veg.</i>

Vincent seems interested in discussing a social implication of the presence of GM but Sabena took offence and defended herself. This is another example of a low level argument as it is simply claim versus claim.

Level 2

<i>Jake responded to Vincent</i>	
<i>Jake</i>	<i>So this means it is bad for health because we are eating it</i>
<i>Vincent</i>	<i>Well, I haven't died</i>
<i>Jake</i>	<i>But you don't know if it's doing something inside.</i>

This conversation shows a claim by Jake followed by Vincent backing his claim with 'weak' data – 'Well, I haven't died'.

Level 3 *Fateha* *We can have more food and people need it.*

John *But it's bad because it's not natural*

Fatena *What, plants or genes?*

John *No changing it like that*

Fatena *And it grows quicker*

John *Because you can't change it back*

John has included a rebuttal – 'changing genes' is not 'natural' and implies danger when he adds the data 'because you can't change it back'. However, it doesn't carry much weight. John does not explain fully how his evidence related to his argument, so I assume it to be a Level 3.

Level 4 Luke steps into the conversation between Fateha and John, in support of John.

Luke *Yeh, its like sometimes the changes can do a bad thing, like getting it to be bad for the soil, or it makes it dangerous and if that happens it spreads and you can't stop it.*

Luke reiterates what John said but makes a stronger rebuttal this time.

Level 5 *John* *GM food is not good*

Fateha *I don't think so*

Fahmida *It affects wildlife like insects so it has to be bad because of the food chain, so it will have an effect on the environment like more or less animals. It depends .*

Fateha talks to Rima to get her on side –

Rima *Look, it says that more people can eat because it grows better, I don't know, so then the land will be less*

damaged because you have to grow less. And this is done so it doesn't get diseases and that.

The discussion starts with a simple claim 'it's not good' vs counter claim by Fateha. Fahmida offers data – it affects the environment, and also a warrant – because it affects the food chain causing an imbalance. Rima supports Fateha with a rebuttal – it will affect the land less because you have to grow less and there is less chance of the plant being diseased.

The challenge presented in an argumentation lesson is to make an effective argument – where all its components are present. It is important for pupils to offer reasons – data – to support their claim and, if they do not agree with the counter claim they should be able to work through the other's thinking to find out exactly why it is they don't agree with it.

A good argument is valid and connects the claim and conclusion by using evidence. To evaluate argument I have focused on pupils' conversations during a class discussion.

Figure 2. Alice's annotated student work, and commentary

I think that Birt will melt 1st because....

The sun is hitting Birt directly so he will melt quicker as the sun carries heat energy [claim and data], which means the heat from the sun can be passed through the molecules quicker if the sun is hitting him directly [warrant].

Another reason is that....

Birt is not wearing a coat so when the snow melts to water it can melt and drip off whereas if he was wearing a coat the coat will absorb the water, and water is not a good conductor of heat [backing].

One reason why Fred's argument was wrong in the first place is because....

He says that his coat will trap all the sun's energy [counter-claim], however he doesn't say that the sun's hitting him directly [rebuttal], so it will take more time to trap the sun's energy [backing]. And also when the water melts the coat will absorb it, and water is not a good conductor of heat [rebuttal].

Finally, I think that....

Birt will melt first the main reason is that the sun will hit him directly. Fred will melt last as the sun isn't going to hit him directly even though he's wearing a coat [considering counter-claim].

The argument is introduced with a claim followed by data. The link between the data and the claim is being stated by the warrant, thus making this a strong argument.

The pupils have carefully considered the counter-argument (rebuttal) by stating why it is that the opposing argument does not hold true.

This is a high-level argument – it is an extended argument – the group has considered both sides of the argument, and there is more than one rebuttal present.

Also, they have carefully backed up their ideas with evidence and have explored where the data does not fit into the claim made.

Figure 3 Martin's Lesson plan for Lesson 1 Genetics and variation

Context		
A new topic: in the previous lesson we looked at the PowerPoint show and discussed the role of evidence in making decisions.		
Objectives		
Explain that variation can be caused by genetic and environmental factors		
Explain that genetic variation can be caused by:		
<ul style="list-style-type: none"> • Mutations (as caused by radiation, chemicals, spontaneous) • Fertilisation 		
Explain that mutations are usually harmful but may be beneficial.		
Recognise that there is a debate over the relative importance of genetic and environmental factors in determining some human attributes.		
Intelligence		
Sporting ability		
Health		
Success criteria		
1. Using examples and evidence I can decide if the difference in living organisms is caused by genetic or environmental factors;		
2. I will be able to explain how human appearance and performance is affected by Genetics and the Environment		
Resources		
PowerPoint slideshow, Concept cartoons 7.11, 7.2 and 6.8		
Time	Pupils	Teacher
10 minutes	Starter activity: pupils are given cards with questions on about differences in animals and plants. They need to try to give reasons for this (pair work)	Register
10 minutes	Pupils observe powerpoint and decide on the outcomes of the lesson	

20 minutes	In groups of 4: they look at the concept cartoon The roles are 2 listeners, 1 scribe and 1 questioner – speaker. The speakers give their thoughts on each suggestion with reasons as to why they think they could be correct or not. They must give ideas on how to provide evidence for their choices.	Teacher displays groups on Whiteboard
5 minutes	Scribes feedback to different groups	Teacher gives scribes permission to move.
10 minutes	Whole class discussion on the outcomes	Teacher invites comments
30 minutes	In pairs pupils will research changes in humans. Criteria: genetic – are the benefits for all or a few? Give examples of the changes being made. Focus on health, sport and intelligence. Environmental: focus on health, sport, intelligence	Teacher sets the scene. Humans are changing: the causes are the environment and genetics
10 minutes	Pupils feed back to other pairs: in feedback one pair listens the others talk	
5 minutes	Review success criteria	

Figure 4 Martin's reflection on this lesson.

Powerpoint and audio [discussion] was good – pupils identified different types of variation and contributed concepts heard of and displayed good prior knowledge. The soundtrack provided good discussion about genetics and its possible effect on the planet.

The lesson worked well, in that groups actively involved themselves in the activity. There were 3 different activities linked to variation. The groups were arranged by me and displayed via power point. As not in friendship groups – but random with mixed ability within them this caused initial problems. However the activity went well. Each person had a clear role. At the end the scribes went to a group with their worksheet. The group had time to look at the sheet and then listen to the scribe. Groups then asked the scribe questions.

The argument activity worked well however it should improve as the pupils are not used to this sort of activity. In supporting the groups the underlying problems revolved around getting them to think of evidence that they know of or experiments they could do to disprove their ideas.

To restructure: get pupils to find evidence of human modification by looking at papers, press sites, then looking for arguments to support these changes through their own beliefs, personal experiences and evidence from press and internet.

Figure 5 Martin's Lesson Plan on Volcanoes and EarthquakesLesson Outcomes:**Science content**

Explain why scientists cannot yet accurately predict when earthquakes and volcanic eruptions will occur.

Ideas and evidence

Uncertainties in scientific knowledge. These are especially likely in complex situations [I&E (d)].

Key skills/thinking skills

- Communication: contribute to discussion
- Reasoning: make deductions, and judgements informed by evidence
- Enquiry skills: predict outcomes.

Context:

The class has been studying rocks and in the previous lesson we looked at volcanoes, earthquakes and plate tectonics.

Resources

Prepare for learning – scrolling power point of volcanoes and earthquakes with music – *You make the earth move under my feet.*

Class set of earthquake-volcano worksheets

Time	Pupil	Teacher
5mins	Pupils to watch slide show (on entry)	Register
5mins	Discuss in pairs what they think could be the causes of earthquakes and volcanoes. Come to agreement on the causes	
5mins	Pupils will put forward ideas – have to decide if it can be backed by evidence	Ask pupils for ideas – record on white board
15mins	In each group one person is to read the text for the group. Followed by the questions.	Introduce the activity – set up rules. For forces of

	They are to discuss the answers as a group following the talking rule. The scribe writes down the answers. The scribe moves to a second group to read the answers to them. The group can ask the new scribe questions but must have pen in hand. Pupils get into expert groups	Nature. When talking only the penholder can talk. Ask for comments from groups on questions
5mins	Pupils read through agenda in silence	
2mins		Go through main activity and the agenda and set the rules
15mins	Pupils are to discuss the expert cards – one speaker at a time – they can highlight and/or make notes. Pupils then work through the agenda in the order set. Penholder to speak and pass on pen	Assign roles for group activity
30mins	To complete table and answer questions	Call meeting groups together
10mins	Pupils respond and make contributions to class	Bring class together to discuss questions and answers
		Set homework which is to complete predication question
	Plenary – pupils give way in which scientists make predications	

Figure 6 Martin's Examples of student work from the volcanoes lesson

Student 1

1. Scientists can only say there might be a eruption
2. Scientists can only collect indirect evidence of changes in earth's surface magma near the surface – small eruption of magma inside the volcano – big eruption.
3. Predication can lead to false alarms – rising magma can freeze and stop
4. Volcanoes can erupt without warning

This [is a] good example of using evidence to back up an answer/response to questions

Student 2

We should spend money on preparing the town so it can survive the disaster.
It is better to protect the town because you'll be saving money as if you spend it making predictions you won't have more money to take any action.

This student has made a suggestion but not actually considered and included evidence.

Student 3 Forces of nature

Because they have no warning

Because they can't escape quickly

People would flee the country – evacuation

Death can be prevented in earthquakes by putting more support on houses by making it heavier so the vibrations can't tip it over.

Conclusion

Our conclusion [they would spend money in the following proportions] 15% predicting earthquakes, 15% predicting volcanoes 60% stronger homes

This [is a] good example of using evidence to back up an answer/response to [the] question.