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Evaluation of Three Primary Teachers' Approaches to Teaching Scientific Concepts in Persuasive Ways.

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3 Evaluation of Three Primary Teachers' Approaches to Teaching Scientific Concepts
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5 in Persuasive ways.
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10 **Context and Purpose of Research.**

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15 In his often cited work 'The scientific model as a form of speech', Sutton (1996)
16
17 argues that science lessons tend to over emphasise the role practical work can play in
18
19 pupils' development of conceptual understanding. Sutton argues that pupils' science
20
21 learning could be improved by spending more time exploring the established scientific
22
23 view discursively, rather than pupils trying to construct personal understanding
24
25 through direct interaction with the phenomena. At the same time he acknowledges the
26
27 problems involved in teaching pupils abstract ideas which at first seem to have little
28
29 relevance to how they normally visualise the world. From this perspective he suggests
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31 that it is not enough to inform pupils of scientific views but rather to persuade them of
32
33 their value.
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41 *To involve someone else in your science is not just a matter of telling them what you*
42
43 *have found; it involves persuading them of the usefulness and validity of the view you*
44
45 *adopt, and the relevance of the evidence you present (Sutton, 1996, p146).*
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51 Sutton characterises science teachers' normal pedagogical practices as 'oscillating
52
53 uneasily between persuading and informing' (p 147). He suggests that there is a need
54
55 to move away from 'telling' or 'informing' to the notion of 'coming to appreciate'
56
57 someone else's model or 'way of seeing' by trying to look at relevant aspects of the
58
59 world through their eyes. Sutton stresses that it is only through 'looking at' and
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2
3 'talking about' the world from scientists' perspectives, will pupils be persuaded of the
4 value of their ideas. His work amounts to a re-description of science learning, which
5 is representative of the shift away from Piagetian constructivism as a theoretical
6 framework for science education. The 'new direction' (Scott, 1998, p46) has its
7 grounding in sociocultural theory and has led to an emphasis on the use of language
8 and context as key pedagogical tools for meaning making.
9

Purpose of research

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11 Theoretical principles such as Sutton's notion of persuasive discourse do not translate
12 unproblematically into everyday classroom practice (Asoko, 2002). Lijnse (2000)
13 suggests that we have to go back and forth between the specific teaching situation and
14 the theoretical ideas to make effective progress. In this way the existing pedagogical
15 knowledge of experienced teachers, together with the theory, can be used to inform
16 the development of context specific small scale pedagogical models (Lijnse and
17 Klaassen, 2004).

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41 The research set out in this paper seeks to develop context-specific pedagogical
42 knowledge based on the translation of Sutton's ideas into practice by three
43 experienced primary teachers. The intention of the research was to evaluate the
44 teachers' practice and identify successful aspects which could be generalised into a
45 pedagogical model. It was thought that this approach had the potential to develop new
46 pedagogical knowledge with its roots fixed within the contemporary practices of the
47 teachers. From this optimistic starting point, the research set out to appraise the
48 teachers' choice of context and patterns of discourse when trying to persuade their
49 children of the usefulness of the relevant scientific concepts. Outcomes of the study
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demonstrate how the teachers' choices of learning contexts fail to emphasise the functionality of the target concepts and as a consequence do not provide any significant exemplification of persuasive discourse. To provide a way forward, the outcomes of the case studies were contrasted with an example of more effective practice taken from Feynman (1999). This enabled the development of a provisional pedagogical model which could be used to assist the teachers to improve their practice in ways consistent with Sutton's ideas. The application of this model by the teachers forms a focus for further research.

The research is set out in three parts:

Part 1 provides a theoretical perspective on the nature of persuasive practices.

Part 2 analyses how the teachers interpreted Sutton's ideas and how they put them into practice.

Part 3 uses a case study taken from Feynman (1999) to explore a way forward and to provide a model which could be used to assist teachers to improve their practice.

Theoretical Perspective.

The Discursive Turn in Science Education.

Sutton's article is one of a growing cannon of research literature (see for example Howe, 1996; O'Loughlin, 1992; Scott, 1998; Soloman, 1994) which serve to interpret aspects of discursive or sociocultural psychology as a theory for science education. This 'new direction' has emerged as science educationists have come to view Piagetian constructivism as too conservative to take account of specific economic,

1
2
3 social, cultural and historic contexts in which knowledge is constituted (O'Loughlin,
4 1992). Steering science education in the new direction has involved what Harre and
5
6 Gillett (1994, p27) have called the 'discursive turn' in cognitive psychology which
7
8 interprets the driving force for development in terms of social and cultural processes
9
10 rather than rational internal procedures (Howe, 1996). This move towards situating
11
12 science teaching and learning within a sociocultural classroom has been greatly
13
14 influenced by the interpretations of the works of Soviet theorists Vygotsky and Bakhtin
15
16 by prominent scholars such as Wertsch (1991). In his hugely influential work, 'Voices
17
18 of the Mind', Wertsch sets out a sociocultural account of meaning making which is
19
20 comprehensive enough to take account of its highly contextualised nature. Wertsch
21
22 argues that the central link between the thinking of the person and the influence of the
23
24 contextual setting in which the person acts is the mediational means the person uses to
25
26 construct meaning. These mediational means can take the form of either technological
27
28 tools or semiotic systems such as language, mathematics and pictures. From this
29
30 perspective, scientific models provide people with mediational tools which they can
31
32 use when interacting with the natural and technological world. Generally, scientific
33
34 models provide visions of the world that are unperceivable and hence provide unique
35
36 and privileged insights into how it works. However, as with other types of complex
37
38 tools, appreciation of their value is dependent on familiarity with the way they
39
40 function and practice in their use.
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53 *Nature of Persuasive Discourse.*

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55 Educationalists such as Ogborn et al, (1996); Scott (1998) have analysed aspects of
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57 pedagogies that promote appreciative understanding of scientific concepts. This has
58
59 given rise to new ways of talking about science learning which shift attention away
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1
2
3 from inductive processes towards the types of social interactions that mediate
4
5 meaning making. For example, Mortimer and Scott (2003) encourage the science
6
7 teacher to stage and script teaching and learning performances through which students
8
9 can be 'introduced to the tools and practices of a school science social language' ...
10
11 and come to 'see how these might be applied to diverse social, technological and
12
13 environmental contexts' (p16). Other evocative vocabulary which match the
14
15 'discursive turn' include the description of scientific models as 'stories' or 'narratives'
16
17 with 'casts of protagonists' and meaning making as a dialogical process through
18
19 which the protagonists (i.e., entities or concepts) are talked into existence (Ogborn et
20
21 al, 1996).
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29 Both Sutton (1996) and Soloman (1994) argue for a description of science learning
30
31 which is indicative of the discursive turn. Soloman suggests that constructivism, in the
32
33 sense it has been used in science education, has always skirted around the actual
34
35 learning of an established body of knowledge and hence has not come to terms with
36
37 how students learn the language of science.
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43 *What constructivism has not described is the process of learning as arrival on a*
44
45 *foreign shore, or as struggling with conversation in an unknown language* (Soloman,
46
47 1994, p16).
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51
52 Soloman's redescription of science as an alien cultural implies that learners cannot
53
54 engage meaningfully in science activity until they have learnt its language. This seems
55
56 to be stating the obvious, but of course learning language is not the same as learning
57
58 words. A word becomes part of a learner's language when he populates it with his
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1
2
3 own intent and adapts to his own purpose (Wertsch,1991). To appropriate a new
4 scientific word, a learner must use his own language as a mediational tool to create an
5 internal representation or mental model of the new word. This involves providing the
6 space within classroom conversation for learners to interpret in their own words the
7 key ideas being taught by the teacher. This view is consistent with Bakhtin's notion of
8 the 'internally persuasive word' which is 'half ours and half someone else's' (cited in
9 Wertsch, 1991, p.79). From this perspective the persuasive power of an argument or
10 point of view does not reside in the speaker's words but in the counter or answering
11 words that they provoke in the listener. In this way meaning making is multivoiced in
12 that it requires at least the interaction of two voices – the voice of the speaker and the
13 interruptive voice of the listener (Mortimer, 1998). It is through the generation of
14 counter words that the listener gains access to existing mental representations (mental
15 models) from which shared meaning of the taught concept can be fashioned.
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36 *Persuasive Discourse Mediates the Modelling Game.*

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38 From a sociocultural perspective, conceptual learning can be seen as a semantic
39 process through which learners gain access to existing mental models which they can
40 use to construct shared representations of a target concept. Learning science can
41 therefore be visualised as a 'modelling game' (Greca and Moreira, 2000) in which the
42 teacher's role is to assist the learner to choose the most powerful counter words with
43 which to fashion a functional model of the taught concept. Functionality is the key
44 quality which commits learners to a particular mental representation.
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4 *The main role of a mental model is to allow its builder to explain and make*
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6 *predictions about the physical system represented by it. It has to be functional to the*
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8 *person who constructs it. (Greca and Moreira, 2000, p3)*
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14 Of course, learners' mental representations of particular concepts do not necessarily
15
16 have to be scientifically accurate to be personally useful (Borges and Gilbert, 1999;
17
18 Norman, 1983). This is why, misconceptions are so often very difficult to address.
19
20 Therefore, key to the success of the modelling game is the commitment to help
21
22 learners produce mental models of target concepts which are both personally
23
24 functional and scientifically valid. Greca and Morera (2000) describe the modelling
25
26 game as an enrichment process of previous models rather than involving complete
27
28 restructuring. It is not necessary that these scientifically enriched models replace
29
30 existing ones, only that the learner is persuaded of the usefulness of the scientific
31
32 model in specific contexts (Driver et al, 1994). The modelling game therefore
33
34 necessarily involves two distinct stages. The first is what Sutton (1996) calls the 're-
35
36 describing' stage. This requires teachers to help pupils to use their existing mental
37
38 models to interpret and create a meaningful internal representation of the target
39
40 concept. Sutton suggests this involves 'talking around the topic until shared meanings
41
42 are developed' (p147). From a mental modelling perspective, talking around the topic
43
44 provokes the generation and externalisation of a 'tool kit' of counterwords with which
45
46 teachers can help pupils fashion their own personal interpretation of model. In the
47
48 second stage pupils need to learn to appreciate the utility of their new model. To
49
50 commit to the model, pupils need to be able to use it productively for the purpose(s)
51
52 for which it was created. Here we arrive at arguably science education biggest
53
54 challenge and its most enduring dilemma. Ever since the introduction of the
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3 comprehensive school system in the 1960's, schools have failed to develop a
4
5 consensus about the purpose of science education (Jenkins,1997; Millar and Osborne,
6
7 1998). A clear view on what science learning should enable pupils to do is crucial to
8
9 the success of the modelling game, and conceivably one of the reasons that it is not
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11 played consistently well in science classrooms.
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22 **Research Methodology**

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27 The starting point for the research was a meeting with three primary teachers in which
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29 we discussed Sutton's article (1996) about the need to persuade children of the value
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31 of the concepts that we teach them. All the teachers were science coordinators in their
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33 schools and taught children of ages 10-11. The teachers are referred to in the paper as
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35 Pam, Cathy and Brenda.
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41 During the meeting the teachers shared their beliefs about effective science teaching
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43 and discussed ways in which children could be persuaded of the value of scientific
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45 ideas. As a result of the discussion the teachers were asked to describe their
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47 understanding of the nature of a persuasive learning setting and to construct a
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49 pedagogical model to guide their lesson planning. Having agreed a framework, the
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51 teachers were asked to plan their lessons independently. They were expected to
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53 continue with their normal curriculum but to adapt their teaching style to
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55 accommodate the agreed teaching model. The researcher was present throughout the
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meeting to answer questions relating to the theory and to help the teachers to generalise their ideas into a pedagogical model.

Data collection and analysis focussed on the teachers' choice of context and patterns of discourse in what they considered to be a persuasive lesson. Each teacher provided written plans of their lesson and video or audio recorded their interactions with a focus group of children. In each case, the children were already used to staff videoing their activities and therefore it was decided that in house recording would have least influence on the nature of data collected. This method helped to maintain the integrity of the teaching and learning setting, but gave the researcher less control over the data collection process.

Analytical Framework.

Transcriptions of the video and audio tapes were produced and analysed to identify, in light of sociocultural theory, interactions which could be described as persuasive. The basic unit of analysis was taken to be an exchange, which is defined as a set of utterances which serve to complete a topic of conversation (Sizmur and Osborne, 1997). The analysis of the classroom exchanges follows Scott's (1998) characterisation of authoritative and dialogic functions of discourse. In brief, Scott describes authoritative discourse as being univocal and with fixed intent. It is a mode of discourse used for transmitting information, which does not encourage the sharing and exploration of ideas. Dialogic discourse is situated on the other end of the discursive spectrum. Dialogic practices encourage learners to generate internally persuasive words in response to the ideas being taught. In a dialogic exchange the teacher helps the learner to access meaningful answering words and use them as tools

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3 to interpret and make sense of the scientific view. An exchange would therefore
4
5 consist of a pattern of authoritative and dialogic utterances, the balance depending on
6
7 the purpose and topic of conversation. If the purpose of a conversation is to persuade
8
9 children of the merit of a scientific view, then it needs to be set in a context which
10
11 serves to emphasize the functionality of the view presented and also helps to resolve
12
13 ambiguities with regard to the meaning of the scientific language (Millar, 1996). This
14
15 is consistent with sociocultural theory which interprets the modelling game as a
16
17 process of dialectical interaction between the pupils acting with modelling tools, the
18
19 activity and the context in which the activity takes place (O'Loughlin, 1992). The
20
21 context in which science learning is set has the power to shape both the nature of the
22
23 pupils's activity and the choice of modelling tools for the relevant task (Lave, 1988).
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25 As the case studies exemplify, the choice of context is crucial to the development of
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27 persuasive pedagogical practices.
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39 **Research Outcomes.**

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42 All three teachers interpreted Sutton's ideas from a techno-utilitarian perspective. For
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44 them a useful scientific view would be one that would help inform an everyday
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46 activity. For example, thermal insulation is a useful concept because it helps us
47
48 understand how to keep things warm and could be applied to a wide range of
49
50 everyday situations. They agreed that useful scientific ideas should present children
51
52 with tools for problem-solving and decision making. The teachers were also
53
54 unanimous that empirical evidence was crucial in persuading children of the validity
55
56 of a scientific idea. Scientific enquiry was considered to be an important part of the
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3 persuasion process, and Brenda and Cathy very firmly believed that children were
4
5 more likely to value the scientific view if they discovered it for themselves.
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10 The teachers were less certain about their role in the persuasion process. There was
11
12 consensus that they needed to listen to the children's ideas and to present the scientific
13
14 view as an alternative (potentially more powerful) way of thinking about an event or
15
16 issue. However, they could not agree on when, within a problem-solving context, the
17
18 scientific ideas should be presented. Pam thought the key ideas should be taught in
19
20 advance and the problem-solving activity should be used as an application of the
21
22 ideas. Brenda and Cathy thought that the problem-solving activity should come first
23
24 and the scientific ideas introduced after the children had been given the opportunity to
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26 discover a solution for themselves. Both approaches were considered to provide
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28 opportunities to demonstrate the value of the scientific ideas.
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36 What the teachers had not considered was how the scientific ideas would be presented
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38 and how the children would learn to use them as cognitive tools. The nature of the
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40 teachers' discussion implied that they thought children learned through either being
41
42 'given the ideas' or by 'discovering ideas for themselves'. Intuitively, the teachers
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44 viewed active learning as a hands-on activity and there was no evidence that they
45
46 considered how they would manage the children's mental activity. It is fair to
47
48 conclude that the teachers viewed explaining as univocal and synonymous with
49
50 telling; in contrast, active learning involved some form of practical work.
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58 Based on the initial discussion, the teachers agreed on the following framework for
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60 planning a persuasive lesson.

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- 6 1. Choose a science-related practical problem.
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- 8 2. Construct a list of scientific ideas which could be used to help solve the
- 9
- 10 problem.
- 11
- 12 3. Provide opportunities for children to evaluate the usefulness of the scientific
- 13
- 14 ideas against their own ideas, when trying to solve the problem.
- 15
- 16
- 17 4. Having solved the problem, children would make a display of the ideas they
- 18
- 19 found to be most useful.
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25 The framework seemed to hold some potential for organising a learning setting which
26 provides children with opportunities to talk about scientific concepts in light of their
27 understanding of everyday reality. The emphasis placed by the teachers on the use of
28 scientific ideas for problem-solving purposes suggests a commitment to developing
29 children's understanding of scientific ideas as tools for thought, rather than just
30 'things' to think about (Sutton,1996).
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41 The teachers' utilitarian commitment is also shared by educationalists such as Jenkins
42 (1999) who calls for an approach to science education that 'relates in reflexive ways
43 to the concerns, interests and activities of citizens as they go about their everyday
44 business' (p9). This is arguably a different epistemology to the cultural and historic
45 one Sutton had in mind when he described the scientific model as a form of speech.
46 However, it is a view of science reinforced by many contemporary teaching resources
47 including The National Curriculum (DfEE, 1999) programmes of study for primary
48 science. We only have to look at the picture of Tom on page 77 in his reflective coat
49 and the caption '*Tom wears a reflective coat. The car lights shine on his coat and then*
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you can see him in the dark' (p77), to get a flavour of the techno-scientific epistemology that permeates the primary science curriculum in England.

Arguably, a teacher's image of the purpose and nature of science will influence the nature of both their pedagogy and the children's learning (Mathews, 1994). Mathews suggests that, to foster a cultural appreciation of science, 'the teacher needs to have an idea of what science is, needs to have a sense of the essence of science, an image of science that is going to be conveyed to classes and which is going to inform decision making about texts, curriculum, lesson preparation, assessment and other pedagogic matters' (p204). In this study, it was the teachers' techno-utilitarian image of science which dominated their practice and consequences of this on the topics and nature of classroom talk were clearly evident in their classroom practice.

Analysis of the Classroom Practice.

Although the teachers had a common framework on which to base their lessons, the nature of the contexts and discursive interactions were sufficiently different to warrant separate analysis. Issues raised by the case-studies are discussed in the context of contemporary practice in primary science education to enable generalisations to be made.

Pam's Lesson

Context

Pam's lesson required the children to modify the design of a Roman house to make it warmer in winter. This complemented recent work which they had done on the Romans as part of their history curriculum. The nature of the learning setting could be described as cross-curricular in that science, history and technology are conceptually linked. The English Primary National Strategy (DfES, 2004) encourages teachers to make links between curriculum subjects and hence Pam's approach could be considered representative of contemporary practice in this phase.

Having decided on the problem, Pam identified a list of scientific propositions which she thought could inform the children's designs. She identified them as scientific resources and posted them prominently on a display board to make them available to the children.

Pam's Scientific Resources

- Insulators prevent heat passing through them
- Some materials are better insulators than others
- Air is a good insulator
- Materials that trap air have good insulating properties
- Warm air rises

The list of scientific resources represents the conceptual content of Pam's lesson and is consistent with the requirements set out in The National Curriculum (DfEE, 1999) programme of study for primary science. For this age group The National Curriculum states that 'pupils should be taught that some materials are better thermal insulators

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3 than others' (p87). There is no reference to an explanatory model which can be used
4
5 to explain why some materials are better insulators than others. In the absence of an
6
7 explanatory model, Pam defines thermal insulators as materials which prevent heat
8
9 passing through them. This is an inaccurate or incomplete proposition as it is only true
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11 with regard to heat transfer by conduction. However, the proposition is presented to
12
13 the children as the key epistemic criterion on which to base their problem-solving.
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20 Pam's lesson lasted 60 minutes and consisted of three key exchanges. In the first she
21
22 established a purpose for science learning by telling a story of Roman domestic life
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24 and the problems the poorer classes faced to keep warm in the winter. The
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26 introductory part of the lesson invites the children to intervene in the lives of these
27
28 Romans by using scientific ideas to mediate solutions to their problems. Arguably,
29
30 this strategy holds potential for children to re-express scientific ideas as tools for
31
32 thought and to use them to mediate their technological activity.
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39 The purpose of the second exchange was to introduce the children to the concept of
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41 thermal insulation as the key useful scientific idea. In the third exchange Pam used
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43 everyday experiences to exemplify the usefulness and validity of her list of scientific
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45 resources.
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51 *Patterns of discourse.*

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53 Discursive practices throughout Pam's lesson could be best described as deterministic
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55 and authoritative. This was perhaps inevitable because, by identifying thermal
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57 insulation as the most useful concept, Pam had predetermined the solution to the
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3 problem. As evidenced by Episode 1, this provided few opportunities for the children
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5 to meaningfully participate in the problem-solving process.
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10 *Episode 1*

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12 Pam: Poor families couldn't afford to have hypocausts built in that way. So have a
13
14 look at page 6 in your history books. On the very left-hand-side you can see a
15
16 townhouse. It's more like an apartment or little block of flats. And here at the top it
17
18 says where poor families lived and they are the ones we want to try and design a way
19
20 that would keep the heat from escaping – keep the heat inside the house. Right let's
21
22 have a look at that first. Why do we think it wouldn't be very warm?
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29 Child: It doesn't have windows.

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31 Pam: It does have windows but it doesn't look as if it has any glass in them. It
32
33 doesn't look like it – it's just small holes isn't it – in the brick. Possibly they
34
35 should have shutters in them. The ones down stairs have shutters do they?
36
37 Some of them do. How else are they designed to keep the heat in? Have a
38
39 look at it and see if you can think of anything else?
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43 Child: It would be colder up there.

44 Pam: They are three storeys up – why do you think it would be colder up there?

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46 Child: The higher up the colder it is.
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49 Pam: Right, as you go higher up the air will be colder. Good boy. Anything else?

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51 The higher up the colder. Does anyone know a word for keeping heat inside?
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57 Pam's solution to the Roman problem was to fill the wall cavities with an insulating
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59 material. Therefore, when Pam asks the children how heat could escape from the
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3 house she is looking for an opportunity to introduce the notion of thermal insulation.
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5 The child's idea of heat escaping through open windows is an obvious reason why
6
7 Roman houses may be cold in winter. Instead of using the remark as a catalyst for
8
9 discussion about how heat travels through convection, Pam side-stepped the child's
10
11 response by quickly asking an unrelated question. Pam seemed then to reinforce a
12
13 possible misconception. The response that 'the higher up the colder it is' is a
14
15 contentious one in this context and one perhaps that could have generated reasoned
16
17 argument about the validity of this view in light of children's experiences and the
18
19 scientific model for convection. As Ogborn et al (1996) points out, dealing with the
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21 difference in views is what drives classroom explanatory practices and from this
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23 perspective Pam seems to have missed an opportunity to scaffold persuasive
24
25 discourse.
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34 This episode highlights two problems primary science teachers face when teaching
35
36 science in cross-curricular contexts. The first is the demand placed on their scientific
37
38 knowledge by the complexity of the learning setting. To respond sensitively to the
39
40 voices of the children the teacher has to adopt a more conceptually flexible approach
41
42 than would be required in more narrowly focused scientific contexts (Jenkins, 1999).
43
44 For many primary teachers, who have limited scientific background to draw on
45
46 (Murphy and Beggs, 2003; Parker and Heywood, 2000; Parker, 2004), the need for
47
48 conceptual agility can reveal quite serious weaknesses in their own scientific
49
50 knowledge. The second problem stems from the nature of contemporary lesson
51
52 planning which is based on predetermined and conceptually narrow learning
53
54 objectives. As evidenced by Pam's practice, teachers can be tempted to discount
55
56 children's responses which divert the conversation away from the key knowledge
57
58
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60

1
2
3 objectives (Levinson and Turner, 2001). This suggests that narrow, inflexible
4
5 conceptual learning objectives can prove to be a drawback when trying to maintain
6
7 meaningful patterns of discourse within cross-curricular contexts.
8
9

10
11
12 In the second and third exchange Pam attempted to provide the children with a
13
14 functional understanding of thermal insulation. The nature of her interactions with the
15
16 children could be best described as labelling language (Sutton, 1992). The purpose of
17
18 labelling is to pass on to the children an unambiguous meaning of the label (Sutton,
19
20 1992) and hence the nature of the interaction is authoritative. As evidenced by
21
22 Episode 2 Pam does this in two steps. Firstly, she defines thermal insulation in
23
24 abstract terms and then she links the definition (label) to familiar objects and events to
25
26 give it some form of physical reality. With regard to meaning making, her labelling
27
28 strategy relies on the children's familiarity with the nature and behaviour of the
29
30 objects chosen by Pam. In effect, she is expecting the children to construct their own
31
32 mental models of thermal insulation based on their experiences with the objects. Since
33
34 the children's thinking is not explored, Pam has little control over their meaning
35
36 making. There is specific evidence that Pam leaves the children unclear about whether
37
38 the purpose of insulation is to stop 'hot air' escaping as suggested by the child or to
39
40 stop 'heat' escaping. If she had encouraged the child to externalise his thinking, she
41
42 could have perhaps took a step towards resolving ambiguities between the scientific
43
44 concept of heat and the physical entity referred to by the child as hot air. As it was,
45
46 the children's utterances were never developed and Pam's exposition remained
47
48 authoritative throughout the exchange. Generally, Pam's exchanges throughout the
49
50 lesson exemplify Sutton's (1992) view that labelling uses language in ways which
51
52 discourage interpretative forms of discourse.
53
54
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4
5
6 *Episode 2.*
7

8 Pam: Does anyone know a word for keeping heat inside?
9

10
11
12
13 Silence (No one answers)
14

15
16
17 Pam then walks to the blackboard and writes the word insulation and asks the children
18
19 to read it.
20

21
22
23
24 Children read the word insulation out loud in unison.
25

26
27
28
29 Pam: Has anyone heard that word before – insulation. What do you think it means?
30

31
32 If something is being insulated what has been done to it?
33

34 Child: Keeping all the hot air in.
35

36
37
38 Pam: Keeping the heat inside and stops it from leaking out. Another word that goes
39
40 with that is thermal.
41
42

43
44
45 She then writes the words thermal insulation on the board.
46
47

48
49
50 Pam: It means to keep the heat inside and stop it from escaping. What kind of things
51
52 can you think of that you would want to keep warm? Anything at all that you
53
54 would know of that you would want to keep the heat inside and stop it
55
56 escaping. What do we want to stop heat escaping from on a cold day?
57
58

59
60 Child: Our rooms

1
2
3 Pam: No – from our bodies. We cover them in clothes. We put more layers as it gets
4
5 colder don't we. What fabric – what material keeps in most heat? Think about
6
7 what you wear in winter.
8
9

10 Child: Wool
11

12 Pam: Wool – do you think that is a warm winter material? I wonder why that keeps
13
14 in the heat? I wonder why we use wool? Come back to that later. Right our
15
16 bodies. We insulate our bodies with clothes. What else do we keep warm?
17
18 Where would you put tea to keep it warm if you were going on a journey?
19
20
21

22 Child: In a flask
23

24 Pam: In a flask – a thermos flask. Again, 'therm'
25
26
27
28

29 Pam points to the word thermal previously written on the board.
30
31
32
33

34 Pam: You want to keep it warm. That's going to be insulated – the flask. We have
35
36 our bodies, we have drinks, what else would be insulated.
37
38
39
40

41 As the lesson went on Pam's labelling strategy invoked a wider range of objects
42
43 which included double glazing and bubble-rap to persuade children that air is a
44
45 thermal insulator. Intuitively, most children are unlikely to perceive air as a substance
46
47 which prevents heat passing through it. Experience tells them that heat passes easily
48
49 through air. Each day they feel the heat from the Sun on their faces as it travels
50
51 through the air. They also commonly experience heat travelling through air when
52
53 using a hairdryer or when they sit next to a school radiator. Of course, science has
54
55 answers to these questions but they are based on powerful explanatory models which
56
57
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1
2
3 are not part of the primary science curriculum. In the absence of their voices we can
4
5 only wonder how plausible the idea that air is a good insulator seemed to the children.
6
7
8
9

10 In conclusion, the persuasive power of Pam's labelling strategy is weak and unlikely
11
12 to provide the children with a functional mental model of thermal insulation.
13

14
15 Through-out the lesson Pam was unable to take advantage of the opportunities the
16
17 exchanges presented for her to scaffold the way children's voices contribute to the
18
19 modelling game and hence the learning outcomes were unpredictable.
20
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26

27 *Cathy's Lesson*

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29
30
31

32 *Context.*

33

34 Cathy set her children a task to design a solar-water heater. In contrast to the other
35
36 teachers, Cathy did not prioritise a list of useful scientific ideas in advance. The
37
38 recording of her lesson consisted of three types of exchanges. The purpose of the first
39
40 exchange was to introduce the task to the children in a way which emphasised the
41
42 importance of science in their everyday lives. The second and third types of
43
44 exchanges focussed on the usefulness and performance of the children's solar heaters.
45
46
47
48
49

50
51 Cathy started the lesson by talking about what scientists do, and tried to impress on
52
53 the children the importance of science in day to day living. However, the language
54
55 used by Cathy served to confuse scientific activity and its products with those of
56
57 technology and had the potential to mislead the children. For example, when a child
58
59
60

1
2
3 remarked that scientists 'invent everything we need'. Cathy validated the child's view
4
5
6 by providing the following response:
7
8
9

10 'Well done, yes. Scientists are involved in our everyday lives. Whatever you see
11
12 around you, the things you use everyday, all these things are here because scientists
13
14 developed ways of making them.'
15
16
17

18
19
20 The belief that scientists make things which improve our lives is a common
21
22 misconception and many primary teachers tend to treat science and technology as a
23
24 unified enterprise (Driver et al, 1996; Harlen & Qualter, 2004). The consequences of
25
26 this naïve understanding of the nature of science can be a conceptually barren
27
28 approach to science learning as evidenced by Cathy's exchanges during the lesson.
29
30
31

32
33
34 In the main part of the lesson the children explored different ways of using a light
35
36 bulb to heat a container of water. They were encouraged to think of ways to improve
37
38 the rate at which the water could be heated. For example, some wrapped their
39
40 container in fur thinking that it would keep the heat in; others used mirrors or
41
42 aluminium foil to reflect more light onto the water container. Decision making was
43
44 based on intuitive understanding of heat and light, and trial and error. Cathy wanted
45
46 them to discover the solutions for themselves as she considered this to be the most
47
48 effective way to learn science.
49
50
51

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59
60 *Patterns of discourse.*

1
2
3 While the children were working Cathy had two types of exchanges with each group.
4
5 The purpose of the first exchange was to emphasize the utility of their science
6
7 learning. The second exchange happened after the children had tested their heaters
8
9 and it was designed to see how well they worked. As evidenced by Episode 1, these
10
11 exchanges were more concerned with establishing the usefulness of the artefacts,
12
13 rather than the value of the conceptual models which underpin the design of solar
14
15 collectors. Consequently, her questions were not designed to provoke the need for a
16
17 useful scientific explanation, but to persuade the children that science produces useful
18
19 artefacts.
20
21
22
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24
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26

27 *Episode 1.*

28
29 Cathy: Right, so tell me, what you are doing here?

30
31
32 Child 1: We're seeing if the tin foil will reflect the light onto the bottle of water to
33
34 make it warmer.

35
36 Cathy: So what is it you're investigating? What are you trying to make?

37
38 Child 1: We're shining the light to make the bottle of water warmer.

39
40 Cathy: But what is the purpose of it? How could we use this in everyday life?

41
42 Child 1: To warm up drinks like orange and tea and that.

43
44 Child 2: If you had a young baby and it was hungry in the night, this is a way you
45
46 could heat up the milk so you don't have to go down stairs.

47
48
49 Child 3: If you need hot water and you are stranded in the forest and you just had
50
51 your car and your tent and you have a light, you could plug it into your car
52
53 and then put a bottle of water over the top of it and it would warm up like
54
55 that.
56
57
58
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1
2
3 The episode illustrates how Cathy's questions served to divert the children's attention
4 away from explaining how their solar heater works to describing its purpose. As we
5 can see, the children readily played the game coming up with some imaginative, if
6 impractical responses. Although the uses the children proposed for their water heaters
7 were unwarranted, they were never challenged by Cathy. In fact, there is no evidence
8 of scientific argumentation being used as a persuasive device in any part of the case
9 study. Referring back to the analogy of strangers arriving on a foreign shore, we must
10 be concerned for the impressions of science Cathy's children developed from this
11 lesson.
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27 Successful completion of the project mainly required the use of technological tools
28 and hence dialogic discourse focused on the performance of products rather than a
29 scientific model. Having completed this project, it is very unlikely that the children
30 would have gained any conceptual insights into the nature of solar energy and the
31 energy transfers involved in solar water heaters. Overall, the learning setting is not
32 only devoid of any conceptual models for children to talk about, but due to the
33 treatment of science and technology as a unified enterprise it also misrepresents the
34 nature and purpose of science.
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Brenda's practice

Context

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52
53 Brenda planned to persuade the children that scientific ideas could be used to make
54 work easier. Her focus activity was a task which required the children to lift a weight
55 of 5N to a height of 1m with the minimum amount of force. Brenda's management of
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1
2
3 the children's learning in the focus session involved setting the task, giving out a sheet
4
5 of paper containing a list of useful scientific ideas, and then to let them get on with the
6
7 task in small groups. At the end of the lesson the children were expected to write up
8
9 their work using a specified format.
10
11

12
13
14
15 Brenda's List of Useful Scientific ideas.

- 16 • Gravity pulls objects to the Earth
- 17
- 18 • Friction is caused when 2 surfaces rub together
- 19
- 20 • Friction can be reduced by using lubricants
- 21
- 22 • The steeper the slope the larger the force of gravity on it
- 23
- 24 • The flatter the slope the less gravity on it
- 25
- 26 • When more than one force is acting on an object the greater force will affect it
- 27
- 28
- 29
- 30
- 31
- 32
- 33

34 Brenda's approach depended on the children using the propositions on the useful
35 ideas list to inform the way they set about the task. The first three propositions had
36 been the focus of previous lessons and therefore should have been familiar to the
37 children. The last three propositions were added by Brenda because she thought they
38 would prove useful when planning a solution to the task. This had required Brenda to
39 reinterpret her own understanding of gravity, similarly to the way Pam had to rework
40 her understanding of thermal insulation. The complexity of the situation revealed
41 weaknesses in her subject knowledge. For example, it is not valid to suggest that there
42 is less gravity acting on an object on a flatter slope or more gravity on a steeper slope.
43 The situation is more complex than this and perhaps beyond the scope of the primary
44 curriculum. This is another situation where the teacher's knowledge is severely
45 challenged by the complexity of the chosen context.
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6 *Patterns of discourse.*
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8 Brenda recorded the exchanges of a group of 5 children who were supervised by a
9 classroom assistant. Brenda was determined not to intervene in the children's group
10 work and her voice wasn't recorded on the tape. The children gave scant regard to the
11 list of scientific ideas and they began to complete the task by exploring different
12 slopes and different surfaces for the ramp. The first exchange contained a range of
13 sensible and potentially productive ideas as evidenced by Episode 1.
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24

25 *Episode 1.*
26

27 Child 1: I reckon we should get a big piece of card to make a slope and
28
29 pull the weight up a slope with a newtonmeter on it.
30
31
32
33

34 They tried this out and found it took a force of 9N to pull the 500g mass up the slope.
35
36
37

38 Child 2: We need to make it a slippery surface.
39
40

41 Child 3: Use paper
42
43
44

45 They tried out the new idea and found it took 3N.
46
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51 At this point there was what proved to be an untimely intervention by the classroom
52 assistant whose job it was to record the children's exchanges. She suggested that they
53 look around the classroom for other things to help them. As a result they found a
54 magnet that seemed to change their perception of the problem. They quickly
55
56
57
58
59
60 abandoned the slippery slope approach and instead decided to focus on ways of using

1
2
3 the magnet. Creatively, they managed to use a fork and the magnet to lift the weight
4
5 without recording any force on the newtonmeter. After a number of trials, they came
6
7 to conclusion that they could lift the load with a force of between 0-1N. However, two
8
9 members of the group were uncertain that they had provided a valid solution to the
10
11 task. An argument then ensued, which continued to the end of the lesson without
12
13 resolution. What started off as a promising setting for the application of scientific
14
15 ideas turned into an argument about the nature of the task.
16
17
18
19
20
21

22 *Episode 2.*

23
24 Child 1: Are you still having a go at that although we have achieved what we
25
26 wanted?
27

28
29 Child 2: No, but we are going to ... it went up to 2
30

31
32 Child 1: This is a science lesson and magnets are to do with science
33

34
35 Child 3: But you were holding the magnet
36

37
38 Child 1: Yeah, but the actual newtonmeter was pulling it up – the fork and the
39
40 magnet were just giving it support to make less force
41

42
43 Child 2: When I was holding the fork and doing it I got loads of force on it
44

45
46 Child 3: But all the force is suppose to be on the newtonmeter
47

48
49 Child 1: Not necessarily. It did actually go to one
50

51
52 Child 2: How come one minute it's zero and then it's one or two?
53

54
55 Child 1: It just happens.
56

57
58 A critical aspect of the lesson turned out to be the unplanned intervention by the
59
60 classroom assistant. What was especially interesting was the level of influence that
her casual suggestion, 'to find something in the classroom to help', had on the

1
2
3 children's perception of the task. Compared with the list of scientific ideas provided
4
5 by Brenda, the magnet proved to be a far more powerful mediational tool. Perhaps
6
7 this is not surprising since everyday practical problems are usually solved by finding
8
9 and using an appropriate technical tool. From this perspective, it could be argued that
10
11 Brenda's list of useful ideas were in the children's eyes the wrong 'tools' for the job.
12
13 Similar to the other case studies, Brenda's lesson turned out to be conceptually weak
14
15 with, again, confusing messages being given to children about the nature of science.
16
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23 **Issues raised by the case-studies.**

24
25 The research set out to examine three teachers' choice of context and patterns of
26
27 discourse when trying to persuade children of the value of scientific ideas. The
28
29 outcomes of the study exemplify how the choice of techno-scientific contexts can
30
31 militate against the development of persuasive practices in the primary science
32
33 classroom. In each of the case-studies the chosen contexts facilitated learning settings
34
35 in which discursive interactions were used mainly to mediate practical tasks rather
36
37 than conceptual understanding. When concepts were explored, they were presented
38
39 authoritatively as labels for objects or events. There were few opportunities for
40
41 children to use their own words to interpret them meaningfully. Generally, the
42
43 influence of any scientific view on the children's activity and meaning making was
44
45 weak. Meaning making was mainly of a technological nature with no evidence of
46
47 discursive interactions which had the potential to promote scientific ways of
48
49 visualising the world. In conclusion, there was no evidence that the children had
50
51 successfully participated in the modelling game and hence none of the teachers'
52
53 pedagogies could be described as persuasive.
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1
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3 Although this is a small study it is important, because it exemplifies the problems
4
5 primary teachers face when trying to adopt persuasive teaching approaches. The key
6
7 issue raised by the case-studies concerns the ability of the teachers to develop contexts
8
9 which serve to emphasise the functionality of a target concept. In each case-study the
10
11 teachers interpreted the notion of useful scientific knowledge from a practical
12
13 perspective and hence chose to set the children's learning in techno-scientific
14
15 contexts. Analysis of the learning settings shows that the activities undertaken by the
16
17 children provided scant reward for engaging with the target concepts. Generally the
18
19 case-studies militated against the modelling game by rewarding physical effort, rather
20
21 than active participation in the discursive exploration of scientific ideas.
22
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32 **Way forward**

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35
36 The case-studies identify a need for clear interpretation and exemplification of
37
38 persuasive approaches to teaching science which can be successfully applied in the
39
40 primary classroom. In this part of the paper, I draw on Feynman's (1999) account of
41
42 his formative science education to exemplify learning contexts which address both the
43
44 affective and effective dimensions of the modelling game and provide suggestions
45
46 about how primary teachers could be helped to stage persuasive teaching
47
48 performances in their classrooms.
49
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55
56 In his book, *The Pleasure of Finding Things Out*, Feynman describes how he was first
57
58 introduced to the world of science by his father on their many walks together in the
59
60 local woodland. On their regular walks his father would take great pleasure in

1
2
3 tantalising Feynman with questions about the animals and plants which they observed
4
5 and with challenges to explain reasons for their behaviour. Feynman describes the
6
7 occasion their conversation focussed on the behaviour of a bird.
8
9

10
11
12 *During the walks in the woods with my father, I learned a great deal. In the case of*
13 *the birds, for example: Instead of naming them, my father would say, "Look, notice*
14 *that bird is always pecking in its feathers. It pecks a lot in its feathers. Why do you*
15 *think it pecks the feathers?" (1999, p181)*
16
17
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22
23
24 Feynman was encouraged by his father to hypothesise what seemed to him to be a
25
26 logical reason and his father would help him test if he was right. For example, in this
27
28 case he hypothesised that the bird was straightening its feathers because it had just
29
30 landed. They then tested this idea by watching a range of birds land and checked if
31
32 they pecked at their feathers. When they found that the birds did not necessarily peck
33
34 their feathers when they first landed they looked for another reason, until it was
35
36 necessary for his father to provide an explanation about the parasitical relationships
37
38 supported by birds. The experience was not designed to produce a declarative
39
40 statement of knowledge about the birds' behaviour but to provide a window through
41
42 which the theme (big idea) of interdependency could be explored.
43
44
45
46
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49

50
51 *..., he went on to say that in the world whenever there is any source of something that*
52 *could be eaten to make life go, some form of life finds a way to make use of that*
53 *source; and that each little bit of leftover stuff is eaten by something (p182).*
54
55
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1
2
3 By introducing a new entity (parasites) into the setting his father enabled Feynman to
4
5 see the same events in a different way. In the beginning Feynman was encouraged to
6
7 construct a narrative involving events and entities which were familiar to him, when
8
9 the account proved unreliable there was a need to introduce a new way of seeing the
10
11 events. In the end he did not discover anything for himself; his pleasure (reward) was
12
13 derived from being actively involved in the telling of a story which stirred his
14
15 imagination.
16
17
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21

22 *Now the point of this is that the result of observation, even if I were unable to come to*
23
24 *an ultimate conclusion, was a wonderful piece of gold, with a marvellous result. It*
25
26 *was something marvellous* (Feynman, 1999, p182).
27
28
29
30
31

32 The value of Feynman's account of his formative science education is the clear
33
34 philosophical perspective it could provide for primary science teachers. That is, the
35
36 purpose of science education is to share with children the amazing visions of the
37
38 world that science has discovered. If shared through rational and evocative dialogue
39
40 children can experience the pleasure of learning science which comes from the
41
42 wonder and awe of finding out that the world is not as we first perceive it to be.
43
44
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48 Of course Feynman was reminiscing about an experience which was unique and
49
50 clearly very special to him. Producing similar intellectual and emotional experiences
51
52 for a class of primary children may not be so easy. However, the message is very clear
53
54 about the value of scientific knowledge. The usefulness of science resides in its power
55
56 to transform the way children see their world. To achieve this, conceptual learning has
57
58 to be set in contexts which require the need for a scientific explanation. Therefore
59
60

1
2
3 matching content to context is the first step in developing a persuasive pedagogy. The
4
5 second is staging the teaching and learning performance in ways which reveal the
6
7 significance and functionality of the new ideas. The context described by Feynman
8
9 involves problemizing content, modelling required behaviour and rewarding
10
11 participation. For example, his father arouses his son's interest in the topic by pointing
12
13 out a puzzling event. He then guides the way Feynman attempts to construct a valid
14
15 explanation for what he has observed. This leads to conflict between how Feynman
16
17 mentally visualises the event and the empirical evidence. This adds tension and an
18
19 imperative to provide a solution. In effect, the puzzling event pushes the functionality
20
21 of Feynman's existing conceptual framework to its limit and hence raises his
22
23 awareness of the need for reconstruction. Cognitive conflict used in this way is a
24
25 feature of constructivist practices and 'a characteristic of much teaching that would be
26
27 considered 'good' by expert observers' (Adey and Shayer, 1994, p62). From a
28
29 sociocultural perspective the puzzling event provides an incentive to engage with new
30
31 forms of conversation which enabled Feynman to redescribe aspects of nature in
32
33 scientific ways (Sutton, 1996). Eventually Feynman's active participation in the
34
35 modelling game is rewarded with the sense of pleasure and satisfaction he gets from
36
37 resolving the puzzle and being able to see the event in a new and more powerful way.
38
39 These strategies which Feynman's father assumed without benefit of learning theory
40
41 are representative of effective discourse based practice identified in range of studies
42
43 (See for example Asoko, 2002; Lijnse, 2000; Ogborn 1996; Watt, 2002).

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54
55 The nature of the children's learning in the case studies contrasts with the above
56
57 account in a number of ways. Firstly, we find that successful resolutions of the
58
59 problems set in the case studies do not require scientific explanations. In each case the
60

1
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3
4 required outcomes can be achieved either through trial and error and/or simple
5
6 practical testing. This is not to say that the outcomes could not have been influenced
7
8 by the application of scientific knowledge especially in Pam's and Cathy's lessons
9
10 where knowledge of heat transfer would have been of value. However, the levels of
11
12 functional knowledge required were beyond the scope of the course and the expertise
13
14 of the teachers. This exemplifies the problems primary teachers face when trying to
15
16 develop persuasive pedagogies in learning environments which are conceptually
17
18 impoverished. The case studies suggest that primary teachers need help to choose
19
20 contexts which have the potential to reveal the functionality of the limited conceptual
21
22 knowledge available to them.
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28

29 The second issue concerns the need for teachers to model and scaffold ways of talking
30
31 which help children redescribe their world. In particular, the conversational nature of
32
33 the talk between Feynman and his father is distinctly missing from the case studies.
34
35 The scientific knowledge presented in the case studies was delivered to the children in
36
37 the form of propositions with few opportunities for dialogic meaning making. This
38
39 contrasts sharply with the nature of the conversation which helped Feynman to
40
41 construct an explanatory narrative which had the power to influence him both
42
43 intellectually and emotionally. The staging of the narrative played a key part in
44
45 persuading Feynman not only of the value of scientific knowledge but also of the
46
47 pleasure its understanding can provide. This is essentially the divide between the
48
49 nature of the learning in the case studies and the nature of Feynman's learning. In the
50
51 case studies the teachers imagined that the sources of pleasure for the children would
52
53 be the hands-on work; in Feynman's case the rewards were a result of new ways of
54
55 talking and visualising the world.
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The final part of the paper explores possible ways in which the teachers could be helped to develop more persuasive pedagogies by adopting a story telling approach.

Towards the development of theme-specific plots

There is a striking parallel between the way the learning experiences are arranged in Feynman's account and the way events are arranged by authors when writing short stories. When viewed in the light of narrative theory, it can be seen that the events described by Feynman have been arranged by his father to arouse curiosity, create tension and provide satisfaction. His father achieved this by initially choosing a context which was right for the theme and also familiar to Feynman. He then set the scene by exposing the behaviour of the protagonists around which the story would unfold. Next he provided a hook (puzzling event) to stimulate Feynman's interest in the theme and the main protagonists, and a complication to create conflict between what Feynman observed and what he perceived. The conflict reached a climax when Feynman was unable to arrive at a satisfactory solution to the problem. At this point his father helped Feynman resolve the tension with an explanation, which not only changed the way Feynman understood the initial event but also changed the way he perceived the world more generally.

It seems to me appropriate that primary science teachers should draw on established story-telling techniques to create persuasive teaching and learning performances. To help them I propose that aspects of narrative theory could be used to develop concept specific pedagogic structures which I have called theme-specific plots. The need to develop theme-specific plots is consistent with Linjse's (2000) work into the value of

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3 establishing didactical structures as the outcome of research on teaching-learning
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5 sequences. Lijnse argues that there is a missing level between learning theory and
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7 how to apply it to teaching specific content in the classroom.
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12 *The missing level is that of describing and understanding what is, or should be, going*
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14 *on in science classrooms in terms of content-specific interactions of teaching-learning*
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16 *processes, and of trying to interpret them in terms of didactical theory (Lijnse and*
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18 *Klaassen, 2004, p538).*
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24 Research into the development of theme-specific plots would attempt to bridge this
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26 gap by providing concept specific pedagogic structures consistent with relevant
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28 aspects of sociocultural theory.
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32 33 34 Structure of a theme-specific plot

35 36 Part 1: Redescribing phase

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38 The first part of a theme-specific plot could be structured in the four stages that are
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40 often used for story writing in schools (Abbs & Richardson, 1990). These four stages
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42 would represent the redescribing phase of the modelling game.
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48 a) Exposition – This stage is designed to arouse the children's curiosity in the
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50 theme and to provide opportunities for children to talk about the theme
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52 from their own perspectives.
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55 b) Complication – This stage creates a theme-based dilemma which requires
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57 resolution.
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- c) Climax – This stage increases the tension and provides the need for an explanation.
- d) Resolution – This stage rewards the active participation of the children with new scientific ways of seeing the world.

Part 2: Application Phase

The second part would represent the application stage of the modelling game. This part would be designed to enable the children to apply their new knowledge in another context to help develop an appreciation of its functionality. In this part children use the new knowledge to construct their own explanatory narratives about relevant events or phenomena.

Application of the above pedagogical structure to Pam's case study questions the potential of her chosen learning context to arouse the children's curiosity and to facilitate discussion. Home insulation is arguably an adult theme and young children are unlikely to have much to say about it. As Feynman's account exemplifies, learning contexts which have the potential for the development of persuasive discourse are those which are familiar enough for children to talk about from their own experience, but also produce puzzling situations which scientific ideas can help resolve. From this perspective, I think string vests provide a potentially more productive context in which to teach children about the thermal insulation properties of air.

Example of a theme-specific plot which could be used by Pam to help improve her practice.

Theme: The thermal insulation properties of air.

Title: Why my old string vest is so special.

Exposition

Teacher brings into class an old string vest and develops a narrative about how her parents made her wear a similar one each winter. Children are encouraged to respond to the narrative and to tell their own stories about what they wear to keep to warm in winter.

Complication

Teacher declares that her parents told her that the holes in the vest would keep her warm. This always seemed a bit daft to her! How could the holes keep her warm? What do the children think? She often wondered if she would have been warmer if she had worn a vest without any holes. Children can hypothesise based on their own experiences. What do they know about other materials which keep things warm? How many of them have holes in them? Children work in discussion groups and should be encouraged to provide reasons for their views. Can any of the groups think of any good reasons why a string vest should keep us warm?

Climax

With assistance from the teacher, children design ways of testing whether the holes in materials play a part in keeping things warm. Remember, a string vest is designed to be worn underneath some outer clothing and this must be replicated in the testing. Children report on the things which they have found out and things which still puzzle them.

Resolution.

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So can holes keep us warm? Of course the short answer is no. It is not the holes that keep us warm; it is the air inside the holes that traps the heat. Teacher can talk about how the holes help create a layer of hot air around the body. Children can talk about other clothes such as woolly hats or jumpers and why these keep us warm. Resolution depends on the children coming to appreciate the insulation properties of air by talking around the theme. To support their meaning making children can make reference to secondary sources of information and models/pictorial representations provided by the teacher.

Application Phase:

To appreciate the functionality of the key ideas children need to make purposeful use of them in another context. In this case children can explore how different animals keep warm. They can focus on animals with feathers and fur. This can lead them to designing and testing different models and developing explanatory narratives about how particular animals have adapted to the relevant climatic conditions. This provides a window through which to explore the important theme of adaptation.

In conclusion it is envisaged that theme-specific plots could help teachers to:

1. Identify appropriate contexts in which to teach specific concepts.
2. Provide insights into how to stage teaching and learning performances in ways which reveal the significance and functionality of the scientific ideas.
3. Understand how context, ideas, events and discourse can be arranged to evoke emotions such as curiosity, tension and satisfaction.
4. Use scientific enquiry methods, dialogic talk and other modelling tools in ways which serve to emphasise the functionality of target concepts.

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3 When talking about successful story writing, Carver (2005) makes a point about the
4 importance of creating unique ways of describing the world and finding the right
5 context in which to express them.
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12 *Some writers have bunch of talent; I don't know any writers who are without it. But a*
13 *unique and exact way of looking at things, and finding the right context for expressing*
14 *that way of looking, that's something else (p32).*
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22 Primary science teachers face a similar challenge. In order to develop persuasive
23 pedagogies they need to be clear about the unique vision of the world which they want
24 to share and the right context for persuading children of the value of that way of
25 seeing. The research indicates that this is a tall task for many primary teachers and is
26 unlikely to be achieved without the development of concept specific pedagogic
27 structures to help them. I suggest that the notion of theme-specific plots provides a
28 potentially fruitful way forward and an interesting focus for further research.
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