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Exploring Science Teachers' Perceptions of Teaching and Learning

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Introduction

The research presented and discussed in this paper is work undertaken as one component of the ESRC-funded 'Talking to Learn, Learning to Talk in Science' project. One of the main aims of the research project is to gather evidence in naturalistic settings on the impact of argumentation in secondary school science education, and in doing so to explore and investigate the hypothesis, developed in previous research, that teaching argumentation as a discursive and epistemic practice can lead teachers to adopt a more dialogic approach (Osborne, Erduran and Simon 2004, Simon, Erduran and Osborne 2006), with benefits for conceptual learning and critical thinking. A second aim is to work with school departments, as opposed to individuals, supporting the development of a professional learning community as a means to attaining sustainable change in practice. To this end the project works with 9 schools in Greater London, 4 intervention schools and 5 control schools. The selection of the schools is purposive to represent a range of socio-economic conditions.

The project extends from March 2008 to December 2010, and this paper reports on the analysis of data, from interviews conducted with the lead teachers in the intervention schools at the beginning of the project (May 2008) to investigate their initial views on classroom pedagogy and their own professional learning. The interviews are repeated at the mid and end points of the project to track any change (or lack of change) in the teachers' perceptions as an impact of their engagement with the project.

The Project- *Aims and Rationale*

The requirement of the new GCSE science programme of study that one half of the course should address 'How Science Works' serves as a signpost to an ideological commitment that teaching science needs to accomplish much more than simply detailing what we know. Of growing importance is the need to educate our students and citizens about how we know and why we believe in the scientific world view – that is to see science as a distinctive and valuable way of knowing.

This change is motivated, in part, by the political need to educate the future non-scientist to be able to engage with and critically evaluate a range of information sources and information types that are relevant to their citizenship and everyday lives. Contemporary science impinges directly upon many aspects of people's lives. Individuals and societies have to make moral and ethical decisions about a range of scientific issues (e.g. genetic engineering, reproductive technologies, food safety) based on information available through the press and other media. Often accounts of new developments in science report equivocal findings or contested claims. Evaluating such reports is not straightforward requiring the ability to assess whether the evidence is valid and reliable, to distinguish correlations from causes, and to assess the degree of risk. Within the context of a society where scientific issues increasingly dominate the cultural landscape, where social practices are constantly examined and reformed in the light of scientific evidence, and where the public maintain an attitude of ambivalence

(Giddens, 1990) or anxiety about science (Beck, 1992), there is an urgent need to improve the quality of young people's ability to interpret and evaluate argument in socio-scientific contexts. This involves a curriculum which foregrounds the epistemic aspects of science, and the need to make the science curriculum more relevant, coherent and engaging. Making this change requires that the teaching of science pays considerably more attention to the evidence and arguments for scientific ideas, and to developing an understanding of the nature of science.

However, such an approach requires not only a transformation in content but, more fundamentally, a transformation in pedagogy. Secondary school science has been characterised as the last authoritative socio-intellectual discipline on the school curriculum with a default pedagogy of transmission, and a tendency to rote learning, copying, and repetition. Where current pedagogical practice across school subjects, and especially in primary schools, is based upon ideas of social pedagogy and small group work that allows students a discursive space to purposefully explore ideas in interaction with each other, a growing body of research suggests that the traditional approach of much secondary school science education is a significant factor in student disenchantment and disengagement with science.

To address this need for change the project has proposed a move towards a more dialogic approach to pedagogy (Alexander 2008), involving principles of social pedagogy and collaborative group work. In particular, this is because it sees the need to engage in critical exploration of ideas as a vital component that assists the construction of new understanding. The rationale for a specific focus on argumentation to address the goal of achieving a more dialogic pedagogy is fourfold.

First, research on pedagogy in secondary science would suggest that the default practice places an overemphasis on the transmission and construction of knowledge over the exploration and evaluation of new ideas. Moreover, evidence from the evaluation conducted for the innovative course *Science for Public Understanding*, the pilot of the 21st Century Science course (Bartholemew, Osborne & Ratcliffe 2004) would suggest that many teachers find the use of a dialogic pedagogy, which would support such practice, challenging. Our previous research on argumentation, which involved collaboration with teachers, has indicated that teaching argumentation is one means of developing many of the features of the dialogic practice identified by Alexander (Osborne, Eduran and Simon 2004, Erduran, Osborne and Simon 2004, Simon, Erduran and Osborne 2006).

Second, the case for the inclusion of argumentation as a form of dialogic pedagogy comes from the increasing evidence that learning to argue and reason is learning to think. There is increasing empirical evidence emerging from the work of social psychologists that the knowledge and understanding of school-age children can be facilitated by collaborative dialogue between peers (e.g. Dillenbourg 1999, Mercer et al 2004, Mercer and Littleton 2007). The work of Howe et al. (1995), and Alverman et al. (1995) with young students has demonstrated that a consideration of plural perspectives about a scientific phenomenon leads to an improved and more secure conceptual understanding – that is knowing why the wrong idea is wrong matters as much as knowing why the right idea is right (Aufschnaiter, Osborne, Erduran & Simon 2006).

Third, as a corollary, our hypothesis is that engaging in argumentation should improve the quality of children's reasoning skills (Erduran, Simon and Osborne 2004, Erduran and Jimenez-Aleixandre 2008). This concurs with our view that one of the main goals of science education is to educate young people in the epistemic and critical information processing skills to think critically within a scientific or associated domain, as discussed above.

Fourth, the dominance of a transmissive pedagogy in secondary science, with the tendency to drill the "facts", is recognised as a factor in student's disengagement. Yet, the need to engage more students in the study of science is a critical element of current government policy which aims to increase the number of students taking physics A-level by 50% above current levels by the year 2014. The use of a dialogic approach extends the normative repertoire of practice commonly used, giving students a more flexible, more contingent and less authoritative approach to both the content and the structure of the typical science lesson. Students then sense that they have more autonomy and more opportunities for self-expression, which research shows are key factors in generating intrinsic as opposed to extrinsic motivation and a sense of 'flow' – both of which are essential for engagement with learning.

Nevertheless, change is always challenging. The choice of model for professional development is important if teachers' practice is to be transformed towards an enhanced use of dialogic practice, and ensuring that change is relevant and sustainable for the practitioners involved. The approach taken on this project draws upon a number of the principles common to action-research and work-based learning: that professional learning takes place within the professional context; that the ability to implement a new approach requires both an understanding of the principles underlying the practice and the perception that the practice is of value, that a change in pedagogy involves a reflexive approach to practice, and finally, that the process involves an active co-operation between researchers and practitioners (Adey, 2004 ; Bell and Gilbert, 1996; Fullan, 2001; Hoban, 2002; Loucks-Horsely, 2003; Spillane, 1999). Hoban's work is particularly important here in identifying a combination of conditions for teacher learning that complement each other in supporting change. A second basic principle of the model adopted in this project, is to support the development of a collaborative, professional learning community, which serves as the context for mutual support and for continued reflection on the process of working with dialogic practice and argumentation in science lessons (EPPI Review 2005). In summary, the research works from the perspective that change is enacted within the complexities of the classroom and school environment, by those who are agents within this environment (Hoban 2002).

Therefore, as its primary focus this research seeks to work with four school science departments over a period of two years to investigate the question of:

1. Whether a cycle of reflective professional development based on the use of argumentation transforms science teachers' pedagogic practice to one that is more dialogic?

We also seek to investigate using a quasi-experimental design:

2. Does engaging in argumentation lead to any observed improvement of students' conceptual learning?

3. What effect engaging in argumentation has on students' understanding of the nature of science?
4. What effect a more discursive pedagogy has on students' engagement with science?

Teacher Interviews-*Purpose and Methodology*

To address the first of the research questions data have been collected from different sources. In addition to the interviews with the lead teachers, notes and audio-recordings have been made at each school of the reflective meetings attended by researchers, and lessons for each lead teacher have been observed, video-recorded and analysed for features of dialogic practice, including the roles adopted for scaffolding argumentation (as reviewed by Jiménez-Aleixandre, 2008). Observations and video-recordings of lessons of other members of the department have also been made on a six monthly basis and analysed in the same way. Together this suite of approaches will enable us to track and describe the teachers' experience and development in dialogic practice at the level of the individual and at the level of the department.

The audio interviews were conducted with the eight lead teachers prior to the professional development program, repeated one year later and will be repeated again at the end of the two years. The initial interviews have been analysed to establish the experience and beliefs of teachers as they embark on the project. Subsequent analysis will explore the changes that take place in their perceptions of dialogic practice and determine their views on the effect of collaborative reflective analysis. The focus of this paper is the analysis of the initial interviews.

The principal remit for the interview at the three stages is to elicit and explore the teachers' personal perceptions, values and beliefs about:

1. the nature of science and of science as a school subject [*Focus-Interview Question 1*]
 2. their perceptions and beliefs about teaching and learning, about how children learn, and how they think argumentation might fit into teaching and learning science [*Focus-Interview Question 2*]
- and
3. to elicit teachers' accounts of their own continuing professional development and how they personally go about learning. [*Focus-Interview Question 3*]

The interview schedule is available in Appendix 1. Three operational principles were identified for the design and implementation of the interview schedule. The first is to attempt to capture the social, political and cultural complexity of a school classroom. To do so, we

draw upon Ivanic and Tseng's (2005) conceptual model of the relationship between teaching and learning. The model is helpful in defining a schema that is empirically based of the main influences and factors that impinge on the classroom context. The model also provides a principled set of boundaries for defining the scope of the context used in this study.

The second and third principles concern the status of the data. One of these principles is to attempt to elicit an account of what teachers actually do in their classrooms rather than an idealised version. This is done by adopting a narrative approach to the task - i.e. asking the teachers to tell the story of their own experience (Bamberg 2007, Georgakopoulou 2006), and by reducing the asynchronicity of the power relations between interviewer and interviewee. The third principle is to find out about teachers' beliefs and values in teaching and learning, by addressing topics, which are familiar within the professional setting, such as asking for a rationale for practice or an elaborated explanation of a statement of practice, from which personal beliefs and values might be inferred.

These principles were implemented in the ways in which the interviews were conducted through a number of strategies. (i) The teachers had a certain amount of autonomy in determining the content and direction of the interview. One way in which this was done was to send questions 1 and 2¹ to the teachers for preview. This allowed the teachers to think through their responses to these questions and to clarify their thoughts. The conversational style of the interviewer was also intended to contribute to this aim. The role of the interviewer was constrained to achieve three objectives; to maintain the flow of the conversation naturally while allowing the teacher to speak as freely as possible, to ensure that the objectives of the questions were met and to ask for elaboration or clarification wherever it seemed required. (ii) The questions in the interview were formulated as an indirect prompt (rather than a direct question), and so carry an implication of politeness, as if making a request. (iii) The main part of the interview (50%) was the teacher's account of a recent lesson of their choosing. This was addressed in two phases. Initially the interviewer preceded the teacher's story by asking about the teacher's perception of the learner group, eliciting explanations of the factors that influence their experience of teaching this group. This is in order to gain an account of the teacher's perception of the factors that define Ivanic's domain 3 ('creation of learning opportunities'). The remainder of the interview on this question allowed the teacher to freely tell the story of the lesson, with prompts for rationale for practice and for explanations of ambiguity.

Minor revisions were made to the interview schedule as an outcome of the pilot study. The interviews were conducted in the schools on an individual basis, in a quiet, private room and were audio recorded. Each interview was approximately 40 minutes in length.

The interviews were transcribed and then coded using Nvivo 8. The coding categories for the analysis were derived from an intensive reading of the interview transcripts initially done

¹ Question 3 – the teachers' approach to professional learning and their perception of the ethos of the department as a locus of professional learning- was not a seen question. This was done to elicit a spontaneous response.

individually by 5 researchers. This was followed by a reiterative cycle of collaborative, cross coding until a final set of 33 codes, within 4 themes (tree nodes) were identified to be used across the cohort. On completion of the coding of the eight interviews, a cross check was conducted for reliability across two researchers. The reliability measure between the two researchers was approximately 88%

The analysis was conducted at the level of the individual, with the output being an extended descriptive profile of each teacher, which was derived from the coding. The first part of the analysis was based on an observation of the distribution of the codes, to establish patterns of dominance or prevalence of themes and codes for each individual. These patterns of dominance were then looked at in greater depth and an interpretation was made of each instance of the coded transcript with reference to its context of use. This information was co-ordinated to arrive at a detailed account of what the teacher had said, including any contradictions and qualifiers to the opinions expressed. Finally, a record was made of all the occurrences of coding for the interview. The purpose of doing so was to capture both those comments which do not fall within the domain of the dominant ideas, and to pattern the nature of the comments made by this teacher, which may not include coding under all the themes and nodes identified for the cohort as a whole.

Overview of Results

The scope and purpose of this section is to provide an overview of the findings of the analysis of the interview, following the procedures for analysis described above. The section begins with general background information on the intervention schools and the lead teachers. A brief discussion of the findings follows. As the analysis is made at the level of the individual, it is difficult to represent the findings for each theme and each teacher in the detail required to represent the manner in which the data was analysed. The discussion in this paper will therefore focus mainly on drawing out ideas within the themes, which are common to more than any two of the teachers to provide an overview. More detailed attention is given to the theme of teaching and learning, which was the main focus of the interview. A full summary of results, organized by theme and detailing the responses of the individual teachers, is given in the Appendix II.

Subjects of the Study

The interviews were conducted with each of the two lead teachers in the four intervention schools.

School A- The school is a mixed comprehensive school, situated in a quiet outer northern suburb of London, but takes a large part of its school population from approximately 3 miles into the city. There are a large number of asylum seekers and new immigrants in the school and there is a good deal of coming and going in sections of the school population, including indigenous travellers, alongside a more stable local population. The school is a performing arts college. **Teacher 1 (A1)** has been teaching since 1994, and has been at School A since

2001 as a teacher of Chemistry She is Head of the Science Faculty and Head of the Department. She is an AST and is also involved in AFL coaching across the borough, and across all subject discipline areas. **Teacher 2 (A2)** is twenty-five years old and in her third year of teaching Biology as her main subject. All her teaching experience (except her first teaching practice during PGCE training) has been based at School A. She has recently and progressively taken on increased responsibilities within the school, including main leadership for the project, and responsibility for KS4.

School B- The school is a mixed comprehensive school that draws upon a largely local population in an ethnically-mixed, predominantly Asian suburb of outer North-West London. Many of the students speak a language other than English at home. At the time of the interview, it is a small community school, but this is set to change with the intake of an expanded sixth form in September 2009 and the first intake of year 7 students in September 2010. The school is a specialist technology college. **Teacher 1 (B1)** is Head of the Department of Science, with a department size of 13 teachers. Her main subject area is Biology. She has been teaching for twenty years, and is now in her mid-forties. **Teacher 2 (B2)** is a teacher of Chemistry and in her late twenties. She is currently second in department. In May 08, she was in her second year of teaching. She has taught in two schools, having moved school in her NQT year in order to get married.

School C- The school is a mixed comprehensive drawing on a local population, in a traditionally deprived area of North- East London. The general ethos of the school is of committed teachers. The school is also a specialist school for science. School C is situated on two split sites, with the lower part of the school dealing with KS3 (Y7-9) on one site and the other year groups on another site. **Teacher 1 (C1)** is the lead teacher for KS3. He is a teacher of Biology and has been teaching at the school since 2005. This is his first teaching post, following a career of 22 years on active service in the British army. He also originates from the area in which the school is situated, and took an Open University degree in Science while serving in the army. At the time of the interview (May 08) **Teacher 2 (C2)** was an NQT in her mid-twenties, having previously taken a degree in Human Biology and a PGCE. C2 has two main responsibilities with respect to curriculum development, in addition to her role on this project. One is to work as part of a team in developing a KS4 cross-curricular project between science, maths and IT. The other is to liaise with teachers teaching KS3 science curriculum on a separate school site to introduce argumentation and critical thinking skills

School D- The school is a voluntary-aided, catholic girls' school in South East London, which admits only practising Catholics. The school draws upon a predominantly Afro-Caribbean population in an ethnically mixed (but largely Muslim), area of London. The school has a good reputation for achievement results and is a specialist technology college. The teachers in the school are mixed gender, but predominantly white. **Teacher 1 (D1)** is a teacher of Physics, and has been at the school for 8 years. She is now in her early to mid-thirties and teaches across all levels of the school, including sixth form. Following a Masters

degree at the Institute of Education, D1 has been involved in a previous King's/IOE research project on argumentation and is currently a lead teacher on the T2L project. At the time of the interview she also taught on an IOE postgraduate course. In May 08 **Teacher 2 (D2)**, who is in her late twenties/early thirties, was in her second full year of teaching and taught all year groups up to GCSE. She taught Biology and Chemistry as her main subjects but also taught some Physics in the school. However, her own background is in Sports Science and she moved into teaching as a second career, taking a PGCE in Science Education at the Institute of Education.

Summary of Main Results by Theme

Theme 1- Nature of science and science education

Five main, common ideas about the nature of science and science education are expressed by the teachers in this study. One idea, expressed quite forcibly by B2 and C2, is that science involves abstract thinking about entities and phenomena which cannot be observed or experienced, such as atoms. Subject knowledge is given a high priority in all the teachers' learning goals for their lessons. However, this view of science is expressed as the requirement for the students to engage in the type of critical thinking and reasoning processes that are perceived as characteristic of the development of scientific knowledge. And so, knowledge is constructed through the interaction of the teacher with the students.

With that group, because they are quite a high ability group, there were sort of several things. Rather than focusing on subject knowledge, it was trying to introduce this looking for the evidence. [C2]

A second point of view, expressed explicitly by B1, B2 and D2, is the view that one of the purposes of science education is to correct the common misunderstandings that many people hold about scientific concepts. These misunderstandings are corrected through the provision of scientific knowledge and through providing accessible explanations of the relevant concepts.

Yes, you know, stuff, really common misconceptions about reflection and what refraction is and you know, why can we see- I don't know, why when you drop a penny into a glass of water when you go and pick it up, you know it is not in the place you think it is. Little kind of magic tricks almost, and you've got to- they've got to be able to explain that [D2]

A third view of secondary science education (A1 and A2) is that science is a practical subject, like technology, that involves understanding of the procedures and the main facts and theories.

The remaining two other ideas shared in common by the teachers in this study concerns science practicals. One idea is that practicals are a way to bridge the gap between the abstract

nature of the subject content knowledge and the contingent relationship of science on data and evidence.

Yes. I mean you sort of try and base it in the concrete don't you. I mean you do the practicals to try and say well look this is what we believe to be true at the moment, and you know, giving you that we are now going to try and base it in something concrete, but even then there's a gap. I mean even when we are doing the iron and sulphur – to make that leap that you know the iron and sulphur, and there is not something else in there. Or there is not something magical going on or the iron and sulphur doesn't turn into a third element or something like that, is quite a jump. [B2]

The last common idea on this theme is that students enjoy science practicals, and so they are helpful in maintaining student engagement and motivation.

Commentary

Perhaps, what can be reasonably drawn from the teacher's views on science education is the emphasis placed on the delivery and construction of knowledge to be acquired by the students. There is also the notion of the need to develop the students' thinking skills- and to try to introduce them to a scientific mode of reasoning. Yet, there is also the underlying understanding that science is a difficult subject. Many of the teachers characterise it as a discipline that draws on knowledge and skills learned in other subject disciplines (see Appendix II). It is, so, often portrayed as a contentful, abstract subject that requires quite high level thinking skills. For some of the teachers, and for B2 and C2 in particular, who strongly hold the view of science as a form of reasoned inquiry, it is difficult to maintain this approach with lower ability groups (see Theme 3:3- concept of ability-AppendixII).

Theme 2- Concept of argumentation

Only 2 of the 8 teachers articulate a clear conception of argumentation. A2 explains that in her view, argumentation is only suitable for socio-scientific subjects, i.e. controversial topics about which students have clear opinions. They can then be encouraged to find evidence to support their opinions in order to engage in argument. C2 presents a more philosophically based account of argumentation as a process of collective reasoning to offer an explanation of anomalous data.

Commentary

What seems most striking about this outcome is that the most of the teachers in this initial interview do not express their view on argumentation. We do not have the information at this stage to explain why this is so. The interview data does indicate that few of the teachers in the study are accustomed to group work in their classes, and where this is used as a teaching and learning strategy, it is often for peer assessment of individual worksheet exercises [C1, D1] or as a means for students to engage in discussion tasks on subject content material prior to a

teacher-led plenary [B1, B2, C2, A2]. However, there does seem to be an anomaly in the implicit understanding that one of the purposes of science education is to teach students to engage in scientific processes of evidence-based reasoning, particularly in light of the curriculum changes towards “How science works” and the relatively low occurrences of accounts of discussion or argumentation-based activities in the accounts of practice.

Theme 3- Teaching and learning

In one sense a number of the teachers’ accounts of their practice can broadly be described as “transmissive”. However, perhaps a more appropriate generic description is to identify their accounts of practice as accounts of a teacher-led, teacher-controlled classroom environment, with variations on how this is implemented, and including for most, a degree of contradiction in their ideas about teaching and learning science and their practice.

For one teacher (C1), in this initial interview, teaching is a process of traditional, didactic, “chalk and talk”. The students are required to listen, to take notes for home revision and are later tested on their memory of the information taught. However, this approach is modified beyond the purely traditional by the perception that children learn differently, and that learning also involves the capacity to apply their knowledge beyond rote learning:

Repetition of teaching. And teaching key things repeatedly in different ways. So it goes to every kid. Every kid obviously learns in entirely different ways. So I can teach them in one way and teach them the same thing slightly differently, using something different. Then it might appeal to them, and if they do different sort of activities. Again that helps them to consolidate their knowledge and once they have got that knowledge I think a lot of children then apply it, and use that knowledge in different unfamiliar situations. . [C1].

For the teachers B1 and B2, a large part of teaching involves teachers structuring and controlling student acquisition of knowledge through structuring the “right” tasks and asking the “right” questions in plenary to direct the student learning in the subject content. But again, this is modified, by B1, who as a proponent of discovery learning, tries to use questions to act as a prompt to students to think their own way through to the answers:

While they have done their experiment, while they were doing the motor, and I was trying, you know, I was going round asking. I was trying carefully to question them as to what was happening and why it was happening rather than to give any answers [B1]

In her NQT year C2 has moved from a transmissive approach towards student-led inquiry:, which is more commensurate with her views on the enquiry base of science (Theme 1 –nature of science and science education):

And also what I found this year is that I started off very teacher based lessons and I found myself being quite drained, cause I was the one pushing them forward all the time, and I felt this was one

lesson where I'd actually changed that around. I actually made them do the work, them finding out the information and then putting their ideas together rather than me leading it all the way. So I thought it was more pupil led. [C2]

In contrast the issue of behaviour management and issues of poor literacy skills that she associates with lower ability students restricts her practice of group work and inquiry based activities with these groups. [Appendix II 3.3]

On the other hand, both the School A teachers are committed to the notion that children are naturally inquisitive, irrespective of ability, and learn most through personal discovery, and peer learning.

I think in science, it's when they... I think it's the same in all lessons. It's when you get them to go wow and they go oh I didn't know that, or I didn't realise that. Or, oh my goodness, yes it's like this, because they have worked something out. .{.....} Yes, when they have made the connections. It is much better when they have made the connections rather than me just say here you are [A1]

However, their lessons are firmly structured around teacher designated learning goals. Testing and measuring the students' performance on these goals at the end of the lesson is taken to a large degree as a measurement of learning, and both teachers clearly identify this strategy as an aid to student learning [Appendix II: 3.1. & 3.2]

The teachers in school D (D1 and D2) in contrast are quite conversant with the practices of group work discussion through exposure in their school department and through contact with research projects. In the lessons described, the students are allowed a good degree of responsibility for directing and determining their own learning within the structures provided by the design of the task and a large part of the activity design also involves peer teaching (Interview D2). However, neither teacher gave any form of rationale for the design or purpose of the lesson in terms of pedagogy or in terms of models of children's learning (Appendix II : 3.2).

Commentary

As described above, there is some variation between the teachers in the implementation of what is essentially a teacher controlled, teacher -led learning classroom setting. There are also apparent similarities between teachers within the same department.

Another common theme, especially among the younger teachers [A2, C2, D2] is the idea that physical activity is a mediator to learning. They term this "kinaesthetic", but none explain how they implement the approach in the lessons they describe.

A fairly significant pattern within the interviews is that although most teachers' views on how children learn can be inferred from the accounts given of their practice, only one of the teachers (A2) discusses children's learning in sufficient detail that this is separated out as a personal dominant idea. For the majority of the teachers in this study, the main emphasis is on how they teach.

This impression tends to be borne out in looking at teacher's explanations of their rationale for practice. Aside from some explicit comments by School A on children's learning, there are two main common student factors that the teacher recognise as influencing their practice: behaviour management and the ability level of the group (Appendix II: 3.2). As comments that referred in some way to the ability level of the class or students were coded separately (Appendix II: 3.3), it is possible to follow this through. In brief, some teachers avoid small group work with lower ability groups on the grounds that these groups tend to present with issues of low levels of literacy and poor levels of behaviour and attention, and so do not have the skills or attitude they see as pre-requisite to peer discussion. Others, (C1 and D1) claim the ability level of the group does not significantly alter their practice. For others still, (A1 and A2) ability is not mentioned as a factor affecting practice.

Theme 4; Professional Development

There is one clearly outstanding common idea in this theme and that is the value unanimously placed on peer observations within the schools. Peer observations are organised by every department as a strategy to encourage sharing of practice, peer learning and to promote an open door policy within the department. For all the teachers in this study, this is a highly successful CPD strategy and leads many to identify their departmental colleagues as a major influence on their practice.

Summary and Discussion

Possibly the most consistent finding across the interviews is that, as predicted, the majority of the teachers interviewed practise a teacher-led, teacher-controlled approach to classroom teaching and learning. Above all, the teachers would seem to expect to control the ideas expressed and so the content of the knowledge constructed. This can be seen, for example, in the control and boundary-setting exerted by the learning and testing of learning goals, preferred by the teachers in School A. Similarly, both teachers in School B describe their preference for teacher-led plenary question and answer sessions, the purposes of which are to guide and structure knowledge and to correct student misconceptions. In School C, while C1, on the one hand, describes his approach as traditionally didactic, on a separate site within the same school, C2 encourages her higher level students to engage in evidence-based reasoning (but would not do so with lesser ability). Yet, both "control" the construction of students' knowledge on the topic by checking on and correcting students' understanding of the subject in plenary sessions.

There may be a link between the teachers' perceptions of science education as a discipline area that is abstract, difficult and contentful and this tendency to control the construction of knowledge in the classroom. However, this has not yet been explored in the analytic work on this project. Nevertheless, the corollary of this approach is a focus on knowledge construction

and not knowledge evaluation. And one of the aims of this project is to explore the extent to which the use of argumentation extends the scope of the lessons towards evaluation.

The exception to this trend is School D, where both teachers describe quite extensive use of student-centred group work. However, again, in these initial interviews, we have not yet had the opportunity to explore the extent to which their students are involved in the evaluation of knowledge.

A second trend, which is emerging from the analysis, is that in this first interview the teachers give relatively little attention to how children learn, or to providing principled rationales and explanations for their practice. Most of the respondents in the interviews spoke quite extensively about how they teach science, but far less about how they think children learn science. This perhaps might be expected, given the controlled manner in which many teach. However, it is a surprising outcome in light of the fact that a large proportion of the interview aimed to elicit accounts of their practice and their underlying rationale.

Associated with this didactic approach to teaching, is the finding that few of the teachers expressed a view on argumentation, and of the two who did so, A2 holds the belief that argumentation is suitable for controversial topics only. Further, it might be supposed that this lack of familiarity with the concept and purposes of argumentation would hinder their understanding of how to use argumentation to help children to learn, and similarly may make its integration within existing schemes of work difficult to undertake at first. Their development with the concept of argumentation and its role in their classroom practice therefore remains a key focus of the research.

Finally, the finding that the teachers unanimously and enthusiastically speak of the value of peer observations, and the opportunities for reflective discussion around these observations, in developing a culture of openness, and of sharing within their departments, seems a good basis for the development of a professional learning community.

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APPENDIX I

Teacher Interview Schedule / interviewer's version

Interviewee's details:

Name:

Position in department/school:

Leadership roles within the school:

Length of service in this school:

Length of service as a teacher:

Name of school:

Date and time of interview:

Part 1: (Seen question - 10 minutes)

What makes a good science lesson? What are the features of a good science lesson?

Part 2: (Seen question - 20-25 minutes)

Can you describe for me a lesson which you taught recently with one of your year 8 or year 10 classes. Why did you choose to organise this lesson as you did? What made this a good lesson from your perspective?

Part 3: (Unseen question - 10 minutes)

- (a) Do you think you have become a better teacher over the time you've been teaching? What have been the main influences and events that have helped you to develop?
- (b) How would you describe your department? What is the ethos of the department as a place for professional development?

Appendix II

Summary of main outcomes of analysis – Teacher Interviews May 08

Theme 1- Nature of Science and Science Education
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- Scientific knowledge is abstract. We need science to explain phenomena that we can't explain by direct experience. Scientific knowledge involves cognitively manipulating abstract ideas of phenomena that exist and are modelled, but which we cannot interact with e.g. an atom. [B2, C1,D2]
- Science is everything. It is an integral part of all natural phenomena. [A2, B1, D1, C2]
- Science education is about learning scientific concepts ² and reasoned enquiry. Scientific knowledge resolves and changes the common misconceptions people have about events and phenomena in their everyday lives [B1, B2, D1, D2, C2]
- Science education is a process of discovery and inductive learning, best learned through practical enquiry e.g. practicals, data collection and data analysis. [A1, D2, C2]
- Science as a subject discipline draws on and utilises knowledge and skills of all other school subjects [B1, B2, D1, D2]

Theme 1/ Subgroup 1- Role of Practical

- Practical are a key way to bridge the gap between scientific knowledge as sets of abstract concepts and the need for a tangible model to interact with. [B2, C1]
- Doing practical experiments enables the learner to understand that science is not black and white, with predictable outcomes, but a process of contingent, evidence-based reasoning. [A1, B2, C1]

² SA2 and RC2 both express views 2 and 3 on the nature of science education. Notably, both teachers also claim to avoid explicit teaching of theoretical concepts, in favour of an applied science, inquiry based approach.

- Science is a practically-based (*procedural*) subject [A2]
- Classroom practicals are good for student motivation and engagement [A1, A2, C2, D2]

Theme 2- Concept of argumentation

- Argumentation is a scientific process through which anomalous data or outcomes are resolved through reasoned argument.[C2]
- Argumentation is suitable for controversial socio-scientific topics only [A2]
- Argumentation requires a good conceptual understanding of the points to be put across [A1]

Theme 3- Approach to Classroom Teaching and Learning

- Students are encouraged to develop their own questions and understandings of the topic in small group work [A1, A2, C2]
- Subject content knowledge is conveyed in teacher-led and teacher controlled question and answer plenary sessions [B1, B2]
- Didactic “chalk and talk” with repetition of content + (*qualifier*) students are encourage to develop their own style of note-taking. [C1]
- Lessons are closely structured around well-defined learning goals and student achievement on the goals is assessed at the end of the lesson. [A1]
- Extensive use of group work and a range of discussion activities, but practised as a learned technique with no underpinning rationale offered [D1, D2]
- Student learning in small groups is not practised with low ability students [B1, B2, C2]

Theme 3/Subgroup 1- How children learn

- Children are naturally inquisitive. They learn through inductive processes of discovery and inquiry. [A1, A2, B1, C2]
- Children's learning is mediated through physical interaction with the objects and processes around which their knowledge is built (these teachers' term = kinaesthetic) [A2, C2, D2]
- .Children learn if they are able to explicitly identify what they are learning. Learning goals should be clear and transparent at the beginning of the lesson and attainment of these goals assessed at the end of the lesson. [A1, A2]
- Value of peer learning. Children learn from each other [A2, C1]
- Children learn differently, and respond variably to different stimuli and media [C1]
- Good behaviour is pre-requisite to learning, as it is pre-requisite to listening. Learning cannot take place without listening. [C1]
- People, adults and children, are capable of independent inquiry and learning when they have sufficient knowledge and mastery of a subject discipline (through expert-novice tuition) to generate their own content-based questions. [B2]

Theme 3/ Subgroup 2-Rationale for practice

- Behaviour management and classroom control [C1, C2, D2]
- Classroom practice and approach depends on the ability of the learning group [A2, C2]
- Use of AFL as a motivating factor in student learning [A1]
- As children learn through inquiry and discovery, the teacher's role is to structure the environment and to model modes of interaction with this environment [A1, A2, C2]

Theme 3/ Subgroup 3- Concept of ability (+ Groupwork/argumentation)

- Higher ability students need to be stretched in their subject knowledge [B2, C2]
- Lower ability groups often present with low levels of literacy In English and challenges to behaviour management, which inhibits the use of small group discussions in favour of a teacher-led plenary [B1, B2, C2, D2]
- Student ability does not fundamentally alter the approach to or the content of the lesson [A1, A2, B1, C1, D1]

Theme 4- Professional Development- Department + Individual

Department /School ethos

- The school and department aim to keep abreast of innovations and new ideas for teaching and learning and are keen to implement these [A1, B1³, D1]
- Head of Department is/aims to be supportive and approachable and is keen to develop the staff judiciously [A1, A2, B1, C1, D1, D2]
- Department has an open-door policy on peer observations, and encourages sharing of ideas, practice and experience [A1, A2, B1, B2, C1, C2, D1, D2*]
- Older members of the department are reluctant to respond to new ideas [D2]
- Policy in the department is mainly determined by senior management [A1, B1]

CPD sessions are regularly scheduled as an integral part of the department/school timetable [A1, B1, B2, C1, C2]

³ A1 and B1 are both Head of Department

Individual professional development

- Peer observations in school (+ feedback) [**A1, A2, B1, B2, C1, D1, D2**]
 - Influence of colleagues within the department [**B2, C1, D2**]
 - Reflecting through writing and personal target setting following an INSET or training programme [**A2**]
 - Exposure to and involvement with external influences (e.g. National Strategy, AST coaching, involvement with research projects) [**A1, B1, D1**]
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