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## Factors influencing the transformation of new teaching approaches from a programme of professional development to the classroom

### Abstract

A programme of professional development was designed consisting of 20 hours of workshops plus in-school activities. The implementation of new pedagogy was supported by teachers bringing examples of their work in the classroom to the workshops for discussion and reflection. The purpose of this study is to explore factors that influenced what teachers took from the professional development programme and how they used it in their own classrooms. It focuses on how the teachers' perceived needs were affected by the programme and how the implementation of new pedagogy was affected the level of in-school support. Data were collected to evaluate the expertise of the teachers early in the programme, their learning through the programme and factors that affected their learning. These data included tape-recordings of selected discussions during workshops, field notes of the workshops, classroom evidence collected by the teachers and portfolios constructed from it, and interviews with teachers after the programme had finished. The results indicate that success in learning from the programme was affected by two key factors: how teachers' perceptions of their needs interacted with the learning opportunities offered by the programme and how the level of in-school support affected the introduction of new pedagogy in the classroom. Unless both factors were positive learning from the professional development programme was variable.

## Background

This study explores the factors that influence the development of expertise in the teaching of scientific inquiry in the UK. The research began with the design of a continuing professional development (CPD) programme for teaching scientific inquiry. The engagement of teachers in this programme and its impact on their knowledge, understanding and practice of inquiry was the focus of the research.

The design of the professional development programme was informed by the vast literature in the area (e.g. Hiebert, Gallimore and Stigler, 2002; Joyce and Showers, 1988; (Marx, Freeman, Krajick and Blumenfeld, 1998; Putnam & Borko, 2000; Showers, Joyce and Bennett, 1987; Stein, Smith and Silver, 1999; van Driel, Beijaard and Verloop, 2001) that indicates effective programmes are those that:

- Engage teachers in collaborative long-term development related to their own teaching and their students' learning.
- Are related to the needs of the teachers in the contexts within which they work and take these contexts into account when developing new pedagogy.
- Provide teachers with support for the implementation of new pedagogy in their own schools.
- Focus on reflecting on how the new pedagogy can be applied effectively within the context of the specific content or curriculum teachers will be implementing.

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4 Such research emphasizes the importance of adapting teacher development programmes  
5  
6 to the needs of individual teachers and recognising that teaching and learning in a  
7  
8 classroom are influenced both by what goes on in the classroom and by factors outside  
9  
10 the classroom. This socio-cultural perspective views science, science education, and  
11  
12 research on science education as human social activities conducted within institutional  
13  
14 frameworks (Lemke, 2001). Additional to these contextual frameworks, Hoban (p.29,  
15  
16 2002) states that 'educational change is a complex process involving many  
17  
18 interconnected elements that have a dynamic effect on one another'.  
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24  
25 A wide range of factors (Loucks-Horsley, Love, Stiles, Mundry and Hewson, 1998;  
26  
27 Hoban, 2002, pp.35-36), both physical and social, influence what teachers take from a  
28  
29 programme of professional development and how they use that in their own classrooms.  
30  
31 Physical factors include class size, the size of rooms, resourcing of the school in terms of  
32  
33 paper, books and scientific equipment. Social factors include the background of the  
34  
35 learners, where they live, the expectations of parents (Hewson, Butler, Scantlebury and  
36  
37 Davies, 2001; Hoban, 2002; Soudien and Colyn, 1992) and expectations of teachers  
38  
39 (Hewson *et al.*, 2001, Ladson-Billings, 1994). These factors impact on the teacher's  
40  
41 pedagogic style, which is in turn influenced by the school's working environment (Fullan  
42  
43 and Hargreaves, 1991, pp.5-6; Hoban, 2002; Wu, 1998) and expectations of the school  
44  
45 management and Principal (Adey, 2004, pp104-5; Bredson and Johansson, 2000; Hoban,  
46  
47 2002; Sebatane, 1994). For example, Watson, Swain and McRobbie (1999) explored  
48  
49 how teachers implemented scientific inquiry and showed that the way in which they did  
50  
51 this was heavily influenced by the demands of external examinations and their use to  
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3 judge the quality of schools. The school itself rests in a wider social setting as part of the  
4  
5 local education authority, which has its own priorities (Hoban, 2002; Guariento, 1997)  
6  
7 and these are heavily influenced by policies at a national level. Teachers bring to this  
8  
9 setting their own particular biographies; experience both in and out of teaching and  
10  
11 educational training (Fullan and Hargreaves, 1991). As a result of these factors  
12  
13 interacting, teachers develop a range of teaching strategies adapted to the particular  
14  
15 environments in which they teach.  
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22 The focus on the teaching of scientific inquiry draws on previous research (Watson,  
23  
24 Wood-Robinson et al, 1999) where the nature of scientific inquiry has been interpreted as  
25  
26 having the following features:  
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- 28  
29 • students have to make their own decisions either individually or in groups: they  
30  
31 are given some autonomy in how the scientific inquiry is carried out.  
32  
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- 34  
35 • scientific inquiry must involve students in using inquiry procedures such as  
36  
37 planning, measuring, observing, analysing data and evaluating procedures. Not  
38  
39 all scientific inquiries will allow students to use every kind of enquiry procedure,  
40  
41 and scientific enquiries may vary in the amount of autonomy given to students at  
42  
43 different stages of the investigative process.  
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46  
47  
48 Inquiry is thus seen as a process by which scientists use their procedural understanding to  
49  
50 answer scientific questions. To teach inquiry effectively teachers need both knowledge  
51  
52 and understanding of the domain of scientific inquiry (content knowledge) and how to  
53  
54 use that knowledge and understanding to help students learn about the processes of  
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3 inquiry (pedagogic content knowledge).  
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8 The content knowledge and understanding of scientific inquiry can be characterised in  
9  
10 terms of the variety of scientific inquiries and the skills and procedures that are used  
11  
12 within these inquiries. Various ways of categorising types of inquiry have been proposed  
13  
14 (e.g. Lock, 1990; Gott and Murphy, 1987; Ruiz-Primo and Shavelson, 1995; Swain,  
15  
16 1991; Taylor; 1990; Watson, Wood-Robinson et al, 1999; Watson, Goldsworthy et al.,  
17  
18 2002; Watson, 2006). Such a categorisation system allows teachers to design curricula  
19  
20 that both reflect the variety of scientific inquiries used by scientists and match the  
21  
22 learning needs of students (see for example of Harlen, 2000). In order to be able to  
23  
24 deploy scientific skills and processes within different kinds of inquiry, procedural  
25  
26 understanding is needed to be able to use the concepts of evidence associated with these  
27  
28 skills and processes (Gott and Duggan, 1995; Millar, Lubben et al.,1994).  
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36 The pedagogical content knowledge and understanding for scientific inquiry is concerned  
37  
38 with the specific techniques that can be used in the teaching of different aspects of  
39  
40 scientific inquiry, and with the processes of interaction in the classroom. The notion that  
41  
42 scientific inquiry is best taught through students learning by carrying out scientific  
43  
44 inquiries is being increasingly challenged (Millar, Lubben et al.,1994; Watson and  
45  
46 Wood-Robinson, 2002) and new teaching and learning strategies are being designed to  
47  
48 teach specific aspects of inquiry explicitly (Foulds, Gott et al., 1997, 1998 and 1999,  
49  
50 Goldsworthy, Watson et al., 1999, 2000; Sang and Wood-Robinson, 2002; Watson and  
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52 Wood-Robinson,1998). The more focused teaching of different aspects allows clear  
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3 educational objectives to be identified and opens the way to incorporate formative  
4  
5 assessment strategies (Black and Wiliam, 1998a and b) in the context of enquiry  
6  
7  
8 (Watson, Wood-Robinson, et al., 2000). Teaching inquiry also involves managing the  
9  
10 learning environment 'to foster a classroom culture in which students play active roles as  
11  
12 science investigators in a mutually supportive learning community' (National Board for  
13  
14 Professional Teaching Standards, 1998, p.29) in order to promote good quality discussion  
15  
16 including evidence-based argumentation (Watson, Swain et al., 2004).  
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21  
22 To design and implement the professional development programme and the research into  
23  
24 teachers' engagement and learning, our study drew on this body of research to identify  
25  
26 what could be termed 'expertise', or criteria for 'accomplishment', in the teaching of  
27  
28 scientific inquiry. A provisional list of such criteria were used in developing a framework  
29  
30 for professional development, which was extended once the development work began and  
31  
32 teachers made their own contributions to our understanding of accomplishment:  
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38 1. understanding the various skills and processes involved in inquiry and progression  
39  
40 in learning them;
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43 2. understanding how the skills and processes are used in different kinds of inquiry;
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46 3. using a range of strategies to help students learn specific skills and processes  
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48 through both part inquiries and whole inquiries;
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51 4. using a variety of different kinds of enquiry for teaching scientific inquiry;
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5. being able to communicate the criteria for judging successful learning of skills and processes to students and assist students in identifying what to do next to achieve the educational objectives within a particular inquiry context;
6. managing classroom discourse so that:
- there is a supportive learning environment in which learning is seen as a collaborative process;
  - it is purposeful and planned with particular educational aims in view;
  - it is constructive, with teachers and students building on each other's ideas;
  - both the teacher and students justify their ideas.

The intention of the CPD programme was to help teachers develop their skills, and become accomplished in teaching scientific enquiry. During each phase of the CPD we reflected on the participants' engagement with the programme and their subsequent development towards accomplishment, by analysing data collected from of a variety of sources (see below). From this analysis we found that teachers progressed in different ways as they engaged in the programme, and that a range of factors were influential in determining the success of the CPD for each participant. Our main research question was:

What are the factors that influence successful transformation from CPD to the classroom in the teaching of scientific inquiry?

From previous research on teacher development cited above, we anticipated that teachers

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2  
3 would have individual experiences and circumstances that would impact on the ways in  
4  
5 which they responded to the professional development programme.  
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### 10 **The context of the study and design of the CPD**

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15 The context for this study was a research and development project carried out at King's  
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17 College London, UK and the Weizmann Institute, Israel in which we developed six CPD  
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19 programmes designed to help teachers become more accomplished in different domains  
20  
21 of science teaching. The purpose of the CPD programme in scientific inquiry was to help  
22  
23 teachers move from a basic level of expertise to a level at which they considered  
24  
25 themselves to be accomplished teachers of inquiry. The development of the CPD took  
26  
27 place with different groups of teachers, each group experiencing a trial run of the  
28  
29 programme and contributing to its further development. The final format of the  
30  
31 programme was reduced from five whole day workshops, spread over several months, to  
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33 four. All the teachers were volunteers who responded to information communicated  
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35 through King's College partnership schools.  
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44 The CPD programme was planned with three key ideas in mind. First, it should  
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46 challenge teachers to develop their own practice by thinking about teaching scientific  
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48 inquiry in ways that were new to them, second, it must take into account differing needs  
49  
50 of different teachers and, third, teachers' learning must be applicable in their own school  
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52 contexts (Stein, Smith and Silver, 1999). The final CPD programme consisted of about 20  
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54 hours of workshops at college, plus additional tasks, which teachers carried out in their  
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3 own classrooms. Each workshop was divided equally between two kinds of activity:  
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5 'expert input' and 'practice-based discussions'. The expert inputs were designed to  
6  
7 present new ideas to teachers and to demonstrate innovative pedagogy for teaching  
8  
9 specific aspects of procedural understanding to students in schools. Teachers were then  
10  
11 encouraged to carry out a variety of tasks in their own schools. The tasks were designed  
12  
13 to help teachers gain experience in using new pedagogy in their school contexts and to  
14  
15 demonstrate their progression towards accomplishing skills in different aspects of  
16  
17 inquiry. These experiences resulted in artefacts such as videotapes, materials written by  
18  
19 teachers and students. The discussions that took place in the workshops were based on  
20  
21 these artefacts and were designed to help teachers share their reflections and explain their  
22  
23 evidence of accomplishment. Artefacts and written reflections were collated into  
24  
25 individual professional development portfolios.  
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34 In order to take into account teachers' needs the CPD programme was planned so that  
35  
36 there were many opportunities to elicit teachers' perceptions of their needs. At the  
37  
38 beginning of the first workshop participants completed a questionnaire in which they  
39  
40 were asked to estimate the competence of pupils in one of their classes with respect to  
41  
42 twenty-seven skills and procedures. We were conscious of the need to build a  
43  
44 community of practice amongst the teachers in order to encourage them to share  
45  
46 experiences about school and so avoided asking them directly about their own teaching.  
47  
48  
49 By identifying skills and procedures where their pupils were weak, we were able to  
50  
51 highlight skills and procedures that could be targeted more effectively. Workshops were  
52  
53 planned in advance, however, the detailed contents of each workshop were kept flexible  
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3 to address the needs of teachers. Analysing the results of the questionnaire was the first  
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5 method of identifying needs and helped the professional development providers select  
6  
7 from a range of possible activities to be used.  
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12 Further activities in the initial part of CPD programme included discussions of the  
13  
14 meaning of accomplishment and a consideration of what evidence might be used to  
15  
16 demonstrate accomplishment drawing on existing video material. When teachers were  
17  
18 meeting for the first time we did not want them to feel threatened by exposing their own  
19  
20 practice to each other. Our main aim was to assess the starting points of individual  
21  
22 teachers and how they responded to ways of teaching inquiry with which they were not  
23  
24 familiar. Teachers were introduced to a range of teaching approaches selected from the  
25  
26 AKSIS materials (Goldsworthy, Watson and Wood-Robinson, 1999, 2000) and  
27  
28 encouraged to select one for implementation in their own classrooms and to video-record  
29  
30 themselves. The teachers were encouraged both in the workshop sessions and in less  
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32 formal settings (e.g. over coffee) to discuss the teaching approaches they had chosen.  
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41 Subsequent meetings in the programme involved teachers sharing examples of their own  
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43 work in response to the tasks they chose in first workshop. Our aim was to help teachers  
44  
45 challenge their own perceptions about teaching inquiry. Viewing their video-tapes  
46  
47 formed the basis of reflective analysis and rubrics were introduced for evaluating the  
48  
49 quality of discussion in inquiry lessons. Evaluation focussed on:  
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51

- 52 • whether classroom discussion was constructive
- 53
- 54 • how pupils built on one another's ideas
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- whether a supportive environment was created
- whether pupils were encouraged to be reflective by describing and explaining their thinking
- the openness of the inquiry as shown by the extent to which decisions in the inquiry process were made by the teacher or the pupils.

By reviewing evidence from their classrooms over the four workshops teachers were able to construct a portfolio. The final meeting of the programme involved teachers sharing their portfolios, explaining the activities that they had used and how these illustrated their personal development. Discussion amongst the group focussed on reflecting on how the portfolio showed evidence of achievement of the various accomplishments listed earlier in this paper.

### **Research design and data sources**

The aim of our research study was to investigate how the factors influencing successful transformation interact for different teachers in different school settings and contexts. We particularly focussed on how the needs of the teachers were addressed within the CPD programme and how teachers' interactions with colleagues in school affected the implementation of their new pedagogy. Ten teachers attended the workshops through consecutive Phases of the CPD trials.

In order to address our research question we used a variety of data sources including:

- field notes of meetings and audio/video recordings of discussions held during the

1  
2  
3 professional development meetings;

- 4  
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6 • portfolio materials: written and video materials that teachers collected to  
7  
8 demonstrate their progression in teaching inquiry;  
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11 • interviews: individual interviews of teachers;  
12  
13 • school visits.  
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18 The data were collected throughout the implementation of the CPD programme, and the  
19  
20 processes of data collection and analysis were iterative. Each phase of data collection and  
21  
22 analysis informed subsequent data collection. The methodological approach was  
23  
24 qualitative, and involved a combination of action research, survey and case study  
25  
26 approaches (Denscombe, 2002). The action research aspect is characterised by the  
27  
28 influence of analysis on subsequent CPD design and related data collection, the survey  
29  
30 approach by questionnaire data and interview protocols, and the case study approach  
31  
32 through the thematic analysis of each teacher's engagement and response to the CPD.  
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35 The research outcomes take the form of descriptive narrative accounts, and are the  
36  
37 product of data reduction, by two researchers, based on the criteria for developing  
38  
39 accomplished teaching of scientific inquiry.  
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46 Biographic details gleaned from teacher interviews and teachers' discussions in the  
47  
48 workshops and informal settings provided a starting point for building descriptions of the  
49  
50 teachers and their progression in learning to teach inquiry. Details included how long  
51  
52 they had been teaching, whether they had any post of special responsibility for science in  
53  
54 the school and their reasons for attending the professional development programme.  
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3 These included their perspectives and practices about the use of inquiry in their  
4 classrooms; the extent of their participation in the professional development programme;  
5 their school circumstances and, in particular, how professional development was viewed,  
6 supported and shared by the school and the science department. Finally, we explored how  
7 teachers perceived their practices changed as a result of the programme of professional  
8 development.  
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20 Teachers' portfolios provided an insight into programme implementation in their  
21 classroom. Materials included written or video taped pieces of evidence arising from  
22 tasks that were completed in school, such as lesson plans, lesson observation, self-  
23 evaluation and pupils work. Six of the ten teachers completed portfolios by the end of  
24 the CPD programme. Within the portfolio, the materials were analysed by the teachers  
25 and were cross referenced using criteria for accomplishment. Teachers selected evidence  
26 they felt showed their progression in relation to each accomplishment. These materials  
27 also formed the basis of extended teacher discussions about the nature of evidence that  
28 would demonstrate accomplishment. The discussions were recorded forming part of the  
29 workshop records.  
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46 The end-of-programme-interviews were tape-recorded, transcribed in full and analysed  
47 for key themes by two researchers. Themes included: how teachers thought the  
48 professional development programme had affected them, their previous experience and  
49 their roles within the school, their reactions to and participation in the professional  
50 development programme and the support mechanisms in the school. The interviews  
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3 allowed us to clarify ideas that had developed from the other data sources, and look more  
4  
5 closely at individual teachers rather than the whole group. We were interested in how  
6  
7 teachers developed away from the group.  
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12 Information about school support and culture was recorded in field notes associated with  
13  
14 the workshops and during school visits. We drew on events such as non-attendance to  
15  
16 sessions due to requests from senior management, teachers sharing ideas with their  
17  
18 department and a wider awareness of the project when we visited schools. We collected  
19  
20 information about the cohesive ways of supporting staff within the science department,  
21  
22 how senior management viewed professional development, characteristics of the students  
23  
24 and the socio-economic setting of the school.  
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### 32 **Analysis and results**

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36 These different sources of data were combined to produce a profile of each teacher and  
37  
38 how he or she responded to the professional development programme. Thematic  
39  
40 categories of information were tabulated so that both researchers could build profiles of  
41  
42 the teachers by collating and cross-referencing inferences from all these data sources. The  
43  
44 categories included reason for participation, support in school, time issues, initial view of  
45  
46 teachers own practise and/or view of pupil ability, awareness of change in practice,  
47  
48 evidence of change and view of the portfolio. The conceptual framework for this thematic  
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50 analysis was based upon our definition of accomplished practice, and identification of  
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52 themes from the data sources that impacted on that accomplishment. The final table of  
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3 profiles shows contextual factors and summaries of professional learning for the ten  
4  
5 teachers (Table 1). Cross-referencing of inferences from the data sources was undertaken  
6  
7 by both researchers to confirm profiles for each teacher. The data sources were revisited  
8  
9 several times during the construction of profiles in order to clarify emergent themes and  
10  
11 check that all the information had been thoroughly processed.  
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14 [Insert Table 1 here]  
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20 Looking at the ten teachers described in Table 1 it can be seen that although the contents  
21  
22 of the workshops were common for all participants, what they learnt varied considerably.  
23  
24 There was some commonality with many teachers reporting improved ability to reflect  
25  
26 and look critically at own practice, use of an increased the range of strategies to help  
27  
28 students learn specific skills and processes and awareness of a greater range of scientific  
29  
30 inquiries. Some outcomes were, however, not so directly related to the core aims of the  
31  
32 professional development programme as encapsulated in the listed ‘accomplishments’  
33  
34 and were more specifically related to the needs of individual teachers such as:  
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41 Helen: Ideas about how to improve professional development in my own science department.  
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45 The varied response of the participants to the professional development programme raises  
46  
47 the question of what it is about the particular participants and the circumstances in which  
48  
49 they work that has caused such a varied response. The ten teachers in our study were  
50  
51 drawn from a wide variety of schools, had a variety of different roles in their schools and  
52  
53 a wide range of levels of experience as science teachers. Amongst this small number of  
54  
55 teachers we could not detect any systematic effect of any of these factors on what teacher  
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3 learnt from the professional development programme. However, two factors that seem to  
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6 have been crucial in influencing teachers' responses are:

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- 8 • how the course interacted with their perceived needs;
- 9
- 10
- 11 • the interactions between the teachers and their school circumstances.
- 12

### 13 14 15 Addressing teachers' needs

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20 The reasons for teachers being on the professional development programme appear to  
21  
22 have been critical in how they responded to the programme. Some teachers were there  
23  
24 primarily to improve themselves (e.g. Helen, Charles and Liz). In discussions they  
25  
26 tended to focus on what a teacher should be able to know and do to be an accomplished  
27  
28 teacher, whereas other teachers (Mila and Milton) were less focussed on their own  
29  
30 learning and tended to discuss their pupils rather than themselves as teachers.  
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36 For example when Helen was asked what she had learnt from the programme she said:

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41 I am not the world's best teacher at teaching inquiry. The programme has been useful because I have  
42  
43 picked up more approaches of how to go about teaching inquiry. This is particularly useful to me as  
44  
45 head of department.  
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48  
49 In contrast Mila, in answer to the same question, did not think she had gained much  
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51 knowledge but thought her pupils would be able carry out better evaluations:  
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3 ...my knowledge is pretty much the same. I understand what they're all about and so on, and what  
4 they're trying to achieve, but what CPD has done is clarify the components - and the sub-components  
5 more importantly - and the result of that is how to break it up and focus on particular bits in order to  
6 develop their evaluation of plans and their evaluation of data.  
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11  
12 Teachers who were focussed on their own learning tended to adopt a more reflective  
13 approach. This led to a deeper level of engagement with the programme. These teachers  
14 reflected on their needs as teachers of inquiry and used what the professional  
15 development programme had to offer. When trying out tasks set in the workshops in  
16 their own schools they tended to adapt the tasks to make them fit in with what they were  
17 doing already. For example, after workshop 2 teachers were asked to try out in their own  
18 classrooms one of the new inquiries introduced in the workshop. Charles took the  
19 inquiry 'Mystery powders' and reworked the inquiry so that it fitted in with some work  
20 he was already doing with his year 9 class on classifying chemicals. Similarly Liz took  
21 activities designed to teach specific aspects of inquiry and integrated these with whole  
22 inquiries that she was already carrying out. None of the teachers who were less focussed  
23 on their own learning (e.g. Mila and Milton) went through this process of adaptation and  
24 transformation of the tasks. When tasks were done they were seen as add-ons to the  
25 normal practice. For example, Mila used the 'Mystery powders' inquiry but this was not  
26 integrated with the normal scheme of work. The professional development was seen  
27 more as a set of 'tips for teachers' or activities that could be added on to what was  
28 already happening.  
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56 Teachers were agreed that one aspect of the professional development programme that  
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3 affected their perceptions of their needs was the 'expert input'. For teachers who came to  
4  
5 the professional development programme with a desire to improve their practice in  
6  
7 teaching inquiry, the expert input showed them how this could be done. It lifted them out  
8  
9 of their normal routines and showed them how things could be different:  
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15 Fahima: I didn't really have a clear idea about enquiry... if there wasn't, you know someone, to kind  
16  
17 of guide you along the way, you could get very kind of caught up in everything that you already do.  
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20  
21 Liz: I definitely think an expert input was necessary because it just gave us new ideas...  
22  
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24  
25 Mila: I think that helps, because otherwise I would have been... a bit lost, not quite sure what I was  
26  
27 meant to be doing... Learning what other people are doing is useful, but I think your input... was  
28  
29 probably more important.  
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33 Similar by Peers, Diezmann and Walters (2003) reported that materials provided by the  
34  
35 professional development provider showed 'an alternative vision of science education'.  
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40 The quotations from the teachers above show that the 'needs' of the teachers were not  
41  
42 clearly defined. Whatever their starting points, the stimulus provided by the 'expert' was  
43  
44 helpful in clarify directions in which they could develop and they welcomed this clarity  
45  
46 of direction. The first workshop was important in this respect in that one aim was to try  
47  
48 to paint a picture of what an expert teacher of inquiry should look like. Teachers were  
49  
50 asked to write down the characteristics of an expert teacher of scientific inquiry, to  
51  
52 discuss what they had written with one another and finally to compare their own  
53  
54 characteristics with a list which we had generated. Analysis of the written documents  
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3 and the tape-recorded discussions showed that this part of the workshop was useful in  
4  
5 establishing the learning aims for the programme of professional development. The  
6  
7 teachers' own analyses of what was meant by accomplished teaching of scientific inquiry  
8  
9 tended to be constrained by the particular circumstances in which they were working, so  
10  
11 for example, at the beginning of the professional development programme only one of the  
12  
13 ten teachers thought that teachers should be able to teach using a variety of different  
14  
15 kinds of inquiry, although when this idea was introduced to them, teachers readily  
16  
17 accepted the range of inquiries currently used by them was very limited. Similarly, only  
18  
19 two teachers mentioned being explicit about learning objectives (accomplishment 5) and  
20  
21 only half of them mentioned that teachers needed to have a range of teaching strategies to  
22  
23 teach specific aspects of inquiry. Again, when these ideas were introduced to teachers,  
24  
25 they readily accepted them as valuable goals and worth working towards. The teachers'  
26  
27 perceptions of their needs were thus modified by the professional development  
28  
29 programme itself.  
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39 As well as setting the direction for the learning, the expert was also seen as important in  
40  
41 helping to acquire a deeper understanding of new pedagogic approaches: to help teachers  
42  
43 to go beyond knowing what to do in the classroom to understand why a particular  
44  
45 approach is being used:  
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50 Charles: Some of the exercises were quite refined and the expert was able to explain ways of using the  
51  
52 material...particularly what point we were trying to get to with the material. Whereas if I'd just been  
53  
54 handed the material, I'd have said: 'Oh yeah, this is pretty interesting', and I could have used it in a  
55  
56 completely different way to what was intended...  
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3 Int: So, the actually showing of the materials and showing how they might be used?  
4

5 Charles: Yes, but also explaining the teaching point, or what understanding or skill that the material is  
6  
7 trying to get at.  
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11 The expert was also seen as important for challenging teachers: by probing  
12  
13 understandings and reacting to individual needs:  
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18 Helen: I think, if you have got a couple of teachers who can talk, you could have a lot of ideas, but I  
19  
20 think where the expert, where you, come in, is: you have seen a lot a teachers and you know what they  
21  
22 can do and you know the questions to ask. Like when you were doing it with John and doing it with  
23  
24 me, you knew what questions to ask and pushed me a bit further.  
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29 The role of the 'expert' helping to support the development of individuals could be seen  
30  
31 in the first two workshops in discussion of the quality of teaching in videos. In the first  
32  
33 workshop teacher viewed a ten-minute clip of a lesson showing an accomplished teacher  
34  
35 of inquiry. They were then asked to discuss the quality of the talk in the classroom  
36  
37 (accomplishment 6) and to identify the criteria by which they judged quality. The first  
38  
39 reaction of the teachers was to make mainly negative judgments about the teaching and to  
40  
41 suggest how it could have been done better. Teachers were not good at identifying the  
42  
43 criteria used to make the judgments and this was particularly true of Mila and Milton,  
44  
45 from our six exemplar teachers. After framing the discussion to consider the criteria for  
46  
47 judging the quality of dialogue in the classroom, the expert introduced three rubrics  
48  
49 designed to evaluate different aspects of the dialogue and teachers used these to evaluate  
50  
51 the quality of the dialogue whilst watching the video again. The activity of watching  
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53 videos was repeated in workshop 2, but this time using videos that teachers had made in  
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3 response to the task set in workshop 1. This time the discussion was more focussed and  
4  
5 was based on the rubrics provided in workshop 1. Teachers' comments on one another's  
6  
7 videos tended to be less judgmental and more descriptive, identify which criteria for good  
8  
9 discussion were being met and which not. This left teachers with a clear picture of what  
10  
11 needed doing to improve the quality of inquiry dialogue in their own classrooms.  
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17 Whereas the expert input was seen by all the teachers as helping to clarify their needs,  
18  
19 the 'school-based discussions' were seen as important in providing the concrete support  
20  
21 that they needed in order to apply their learning from the workshops in their own schools.  
22  
23  
24 The school-based discussions were another aspect of the programme that made it  
25  
26 adaptable to teachers' needs by exploring how new pedagogic practices might be adapted  
27  
28 to their own classrooms. The discussions provided teachers with ideas for approaching  
29  
30 the teaching of different aspects of inquiry along with practical advice on how to manage  
31  
32 them in the classroom.  
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39 Fahima: I think it's really good when you talk to other teachers. It's just about sharing ideas... seeing  
40  
41 how other people do enquiry in their own schools and then using that information to kind of feed back  
42  
43 into your own work. For example, if someone recommended a particular activity and said: 'Oh yeah, I  
44  
45 did this activity and it was really good', then I would come back to school and try that because I would  
46  
47 think: 'Oh yeah, OK you know, they thought it was really good so I'm going to try that and see how it  
48  
49 works for me'.  
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53 Charles: That is very useful, because you're sharing ideas, sharing experiences, discussing ways of  
54  
55 doing things, going over problems people have had: picking up a very useful technique for doing  
56  
57 something. So I found discussing with the other teachers beneficial.  
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6 Interactions between the teachers and their school circumstances  
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10 An obvious factor that was related to teacher learning in the professional development  
11 programme was the level of involvement in the programme. Of the six exemplar  
12 teachers' above four (Helen, Charles, Fahima and Liz) attended all or all but one of the  
13 workshops and all except Liz completed a portfolio of evidence and reflection. In  
14 contrast Mila attended three out of five and Milton two out of five sessions and neither of  
15 them completed a portfolio.  
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27 The quality of support and interaction between the teacher and the school, the science  
28 department and science colleagues was important in determining the effectiveness of the  
29 professional development programme. Teachers who came from schools where there was  
30 strong support for teachers in their professional development were on the whole more  
31 successful than those who came from schools where support mechanism were weak or  
32 non-existent. Three aspects of the interaction between the school and the professional  
33 development programme were important.  
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46 Firstly, it was necessary to obtain the support of senior management in schools to allow  
47 teachers to attend the professional development programme during school time, but  
48 having obtained this support, schools were varied in their commitment to the professional  
49 development programme and at some schools other priorities were allowed to over-ride  
50 the commitment to the professional development programme preventing teachers from  
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3 attending all the sessions.  
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8 In three of the schools events occurred that were deemed to be more important than the  
9 professional development programme and prevented the teachers from attending. These  
10 events included both unanticipated events and anticipated events such as examinations.  
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12 At Mila's school an incident with pupil behaviour arose and this resulted in Mila missing  
13 one of the professional development workshops:  
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22 Int: Do you think people in your school made it easier, or hindered you in participating in the  
23 programme and making changes to your teaching?  
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28 Mila: They haven't made it easier, but we can do what we want. Everyone knows that I'm doing  
29 this... and nobody's saying no...  
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34 This ambivalent attitude from the school was not just one-sided, but was also held by  
35 Mila herself. When discussing what happened in school as a result of the incident Mila  
36 said:  
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43 Mila: Andrew was saying: 'go', and I said: 'no, I can't go because I should be going'. But... I knew  
44 that... there would be reports and things to write. And then, it was quite major. The head was the one  
45 who was making it out to be major, but Lillie got hit, and Mat got hit, and I got pushed around, like  
46 seriously pushed around.  
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53 The low level of school support was probably a factor in the weak participation of Milton  
54 in the professional development programme. It was obvious from the outset that senior  
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3 management had doubts about releasing him from the school to attend the programme  
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5 and that mechanisms for sharing amongst the staff in the science department were weak.  
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7 Milton had no experience of teaching inquiry and so in the absence of school support it is  
8  
9 perhaps not surprising that he dropped out after the first two workshops.  
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15 The second aspect of school support that was found to be necessary was whether there  
16  
17 were formal or informal mechanisms to enable teachers to feedback what they had learnt  
18  
19 from the professional development and to discuss with science colleagues. Liz's school  
20  
21 went as far as facilitating her to attend the programme but beyond that there was no in-  
22  
23 school support and there was no opportunity to discuss what she was learning with  
24  
25 science colleagues. In contrast in schools of Helen, Charles and Fahima there were  
26  
27 effective informal or formal mechanism for discussing the learning from the professional  
28  
29 development programme with other members of staff. For example talking about his  
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31 school Charles said:  
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38 They've all been very supportive. When I've been away for the day, colleagues from my department  
39  
40 will provide cover... My head of department is very happy for me to teach in whatever way I feel fit,  
41  
42 within the constraints of obviously making sure my classes are covered the material they need to have  
43  
44 come across, and however I get there, he doesn't really mind. And if I haven't quite covered a few bits  
45  
46 of it, he's not that stressed about it...  
47

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50 Int: Would he see what you're learning of any benefit to him, or is that expecting too much?  
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54 Charles: Possibly. I mean, he's been teaching for fourteen, fifteen years and yes, he has seen some of  
55  
56 it as beneficial, although to completely change what he does I don't think is very likely. Although  
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3 particular exercises I've developed, a mini-investigation I've put together, he may take that and put  
4 that into his teaching.  
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9 The third aspect of school support was support for implementation in the classroom.

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11 Again in the schools of Helen, Charles and Fahima there was support for changing  
12 classroom practice:  
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18 Fahima: Within my department I think they were just really keen, and actually the head of the school  
19 as well was really keen for me to go. My head of department was very interested in what was  
20 happening... What encouraged me was talking to the head of physics... and being able to say: 'OK,  
21 you know, I'd like us to incorporate some more scientific enquiry. This is my idea. Where do we go  
22 from here? How can we put it in?' and stuff like that. And that was really helpful...  
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31 In contrast Munby, Cunningham and Lock (2000) describe the negative effects on  
32 professional development when members of the science department feel that there is  
33 insufficient space in the curriculum to experiment with new approaches.  
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40 Another aspect of the development of new practice in the classroom was in carrying out  
41 the tasks needed to develop the portfolio:  
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47 Int: Some people have been unable to complete the portfolio by the end of the course. What are the  
48 factors that encouraged or discouraged you from getting the portfolio completed?  
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53 Helen: For me, I was encouraged to complete it because I found it useful for reflecting on what I am  
54 doing in class when teaching enquiry.  
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3 However, the portfolio did take time: both planning time and time in the classroom.  
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8 Int: Right, OK. Are there any other factors that have affected getting the portfolio completed or not?  
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11 Charles: Yes. Working within an existing scheme of work, which I have to follow and also the  
12 time constraints, because it's obviously quite easy to teach things...the way you did last year. It  
13 doesn't require much thought or time or planning. But if you want to then say: 'well, I'm going to  
14 teach this in a different way', it often means re-planning large parts of the course.  
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21 This time requirement was in competition with many other demands in the schools. Ones  
22 mentioned by teachers were administrative duties such as organising teachers to cover  
23 absent colleagues, an Ofsted inspection, examination demands, marking coursework and  
24 one teacher whose busiest time of the year coincided with the professional development  
25 programme and lasted from September to February! Whether the professional  
26 development programme or the school time demands was given precedence was strongly  
27 related to the level of school and departmental support.  
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#### 41 **Discussion**

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45 Two factors appear to have been particularly influential in determining how much  
46 individual teachers learnt from this professional development programme. The first was  
47 the extent to which teachers perceived the programme as addressing their needs as  
48 teachers and how teachers were able to interact with the programme to take what it had to  
49 offer themselves as teachers. The second factor was the level of support from the school  
50 and how the teacher was able to interact with colleagues and make changes in the  
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3 classroom. These factors have been carefully extracted from the range of data sources,  
4  
5 though other factors may have been influential in teachers' responses. There may have  
6  
7 been limitations in the ways in which individual teachers' needs were reported, or in the  
8  
9 information they provided about their experience and situations. The results are  
10  
11 dependent on teachers' accounts of themselves and their beliefs.  
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17 Significant learning was made by all the teachers who saw the professional development  
18  
19 programme both as an opportunity for teacher change *and* who worked in schools where  
20  
21 there was strong support (e.g. Helen, Fahima and Charles). For teachers where neither of  
22  
23 these conditions existed, there was little learning (e.g. Milton). If the teacher saw the  
24  
25 professional development programme as an opportunity for teacher change *but* worked in  
26  
27 schools where support was weak, success of the professional development programme  
28  
29 was less certain (e.g. Liz), and finally if the teacher did not see the professional  
30  
31 development programme as an opportunity for teacher change but nevertheless has some  
32  
33 school support success was also less certain (e.g. Mila).  
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41 Similar factors were identified by Adey (2004, p.97): the 'teachers' stance' towards the  
42  
43 professional development and the 'school ethos'. In the detailed case-study of three  
44  
45 teachers, two had a positive stance and worked in supportive environments, resulting in  
46  
47 substantial development of their pedagogy. The third teacher had a positive stance but  
48  
49 worked in an environment where support was weak and this impeded her professional  
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51 development.  
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3 If transformation of teachers' practice is envisaged then there also needs to be an  
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5 interaction between what is being learnt in the professional development programme and  
6  
7 the context in which teachers work. In the current study the mechanisms incorporated  
8  
9 into the professional development programme to identify and address individual teachers  
10  
11 needs were on the whole successful, but what was less successful were the procedures for  
12  
13 supporting teachers in their schools. There was a strong emphasis on supporting teachers  
14  
15 in schools through the development and discussion of the portfolio, but this was not  
16  
17 sufficient to compensate for weak or non-existence in school support from science  
18  
19 colleague and senior management.  
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27 Rather than adopting a new curriculum or pedagogic strategy, teachers often adapt the  
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29 strategy in response to an interaction between the new curriculum or pedagogic strategy  
30  
31 and the situation in which they work (Scholtz, Watson and Amosun, 2004). An  
32  
33 evolutionary perspective helps to interpret why teachers responded in different ways to a  
34  
35 curriculum innovation designed to change their pedagogic practice (Johnson, Monk &  
36  
37 Hodges, 2000; Monk, Johnson, Swain, 1998). Such a perspective assumes that the range  
38  
39 of pedagogic strategies that teachers use in their classrooms is selectively retained  
40  
41 because they survive in particular classroom conditions:  
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45  
46 Teachers are not generally irrational opponents of change but they rationally weigh alternatives  
47  
48 according to the realities they perceive (Crossley & Guthrie, 1987).  
49

50 The conditions that have been identified as necessary in the particular programme of  
51  
52 teacher development that has been described in this paper are related to the level of in-  
53  
54 school support. Huberman and Miles (1984) identified the quality and quantity of  
55  
56 assistance that users of an innovation received once change was in process as being the  
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3 most significant factor in determining the success, or not, of an innovation. Similarly  
4  
5 Placier and Hamilton (1994) identified several conditions that need to be in place to  
6  
7 support teacher learning. These conditions were present for the most successful of the six  
8  
9 exemplar teachers described. The conditions are a positive working environment such as  
10  
11 flexibility and willingness to experiment and so allowing teachers autonomy to change  
12  
13 their practice. There should also be collegiality amongst staff and willingness to change.  
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20 The limited success of our professional development programme in bringing about  
21  
22 change in all the teachers indicates that further consideration needs to be given to how  
23  
24 support for introducing new pedagogy into the classroom can be strengthened. A  
25  
26 possible way forward is indicated in the study by Dillon, Duschl et al. (2002). They  
27  
28 described a professional development programme with many features that were similar to  
29  
30 the programme discussed in this paper. In the programme of Dillon, Duschl et al. (2002)  
31  
32 teachers identified and carried out a piece of research about science pedagogy in their  
33  
34 own schools. An additional feature of their programme, that could have enriched the  
35  
36 programme discussed in this paper, was a partnership between the higher education  
37  
38 institution and the local education authority. Within the programme science advisors  
39  
40 from the local education authority were involved in identifying local priorities and  
41  
42 interests for professional development, identifying teachers and schools to be involved in  
43  
44 the programme and ensuring that the school was were committed to supporting teachers  
45  
46 in carrying out their research in school. At least two staff members were always present  
47  
48 at the workshops run in this programme and a special role of the local science advisors  
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50 was to support the teachers in their in school work, including their negotiations with their  
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3 managers. Without such close ties between the providers of professional development  
4 and the schools in which teachers work, our study indicates that at best successful change  
5 in pedagogy will be rather hit and miss and that if teachers are not well motivated to  
6 change success is unlikely.  
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15 Not all professional development programmes are of the kind described here (Stein,  
16 Smith and Silver,1999). Many professional development programmes do not attempt to  
17 change transform practice but simply provide information to bring teachers up to date  
18 with such things changes in the syllabus or the details of summative assessment practices.  
19  
20 Professional development programmes with limited aims such as these do not require  
21 extended time-scales to change teachers or in-school support. If, however, the aim is to  
22 transform teachers' classroom practices, it is important to consider how this can be  
23 supported within the school.  
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Table 1 Profiles of teachers taking part in the inquiry CPD

Teacher	Summary of change	Biographical details	School details	Participation in the CPD
Fahima	Fahima introduced more openness to her inquiry work allowing more pupil discussion, was more aware of what constituted good quality discussion in inquiry and was trying to get the students to be more reflective in their answers. She extended the range of inquiries to include a wider variety and was beginning to use strategies for the explicit teaching of procedural understanding.	Experienced teacher. No position of responsibility. Keen to learn.	Suburban school – mixed gender, ethnicity and social class. School support for CPD, expectation that teachers feedback.	Attended 4/5 workshops. Completed all in-school tasks Completed a portfolio.
Charles	Charles' portfolio showed that he had learnt and used new pedagogical approaches for teaching specific aspects of inquiry. His interview showed that he had moved away from a position where he only taught using whole inquiries, to thinking of inquiry lessons in terms of specific and limited objectives. The portfolio also included a more extended range	Novice teacher. No position of responsibility. Keen to learn.	Private boys' school. Very strong support in department for CPD. Culture of sharing of practice.	Attended 4/5 workshops. Completed all in-school tasks. Completed a portfolio.

	of kinds of inquiry that he used in his lessons. A video-tape that he produced showed that he had changed his questioning style to emphasise explanation more.			
Helen	Helen saw the professional development programme as providing insight and strategies that she could use to help her develop her department. Her portfolio illustrated a variety of ways in which she used explicit teaching of aspects of inquiry. She believed it was important to have clear and limited objectives for each inquiry lesson. In spite of an advanced starting position, she felt that the CPD programme had been very valuable, particularly time to reflect on her own teaching.	Experienced teacher. Head of Science. How to improve dept. Keen to learn and motivate her staff.	Mixed comprehensive in small town. Strong culture of sharing of CPD in the department.	Attended 4/4 workshops. Completed all in-school tasks. Completed a portfolio.
Priti	Priti had a good knowledge of skills and processes used in inquiry. During the project she developed a wider range of strategies for teaching inquiry and a greater variety of different inquiries, including more those which were more open. She became aware of	Few years experience. No position of responsibility. Keen to learn.	Mixed comprehensive in mixed social class area. Strong culture of sharing of CPD in the department.	Attended 3/4 workshops. Completed all in-school tasks. Completed a portfolio.

	collaborative aspects of inquiry.			
Liz	Through the professional development programme Liz started to teach specific aspects of procedural understanding and widened the variety of inquiries that she used. She felt that she had improved her ability to reflect critically about her own practice. She had also realised that her present practice in inquiry lessons was very teacher-directed and was trying to hand over more control to students.	Experienced teacher.  No position of responsibility	Mixed gender comprehensive in mixed social class area.  Good relations in science department but no mechanism for sharing of practice or CPD.	Attended 5/5 workshops.  Some in-school tasks done.  No portfolio as she thought it was 'incomplete'.
Jack	Jack became more aware of the role of discussion and collaboration in inquiry, but demonstrated no other changes in his knowledge and understanding or teaching of inquiry.	Experienced teacher.  Head of Department	Urban girls' comprehensive.  No evidence of sharing practice within science department.	Attended 3/4 workshops  Completed most tasks.  Did not present a portfolio
Mary	Mary developed her knowledge and understanding of the skills and processes of inquiry. She was aware of a range of strategies for teaching inquiry, but without recognising the need for explicit objectives.	Experienced teacher, second in department.	Suburban comprehensive school in working class area.	Attended 2/4 workshops.  Did not present a portfolio.
Pamela	Expressed a view that she already had good knowledge of teaching inquiry.	Experienced teacher.	Inner city girls' school.	Limited engagement in CPD.



Milton	Maybe raised awareness, but limited evidence of change.	New teacher, limited experience.	Mixed gender suburban comprehensive. CPD low priority in the school, no encouragement to attend or feedback to colleagues.	Attended 2/5 workshops. No tasks or portfolios completed.
Mila	Mila tended to view her practice as exemplary but did not appear to have a good grasp of the criteria by which practice in this field could be evaluated. She claimed to be teaching aspects of inquiry through explicit teaching during normal theory lessons but it was not clear exactly what was being taught. She did, however, include a greater variety of inquiries in her lessons.	Experienced teacher. No position of responsibility.	Mixed gender urban comprehensive. CPD had low priority within the school.	Attended 3/5 sessions. Completed one in-school task. No portfolio presented.