Final Report: Researching Effective CPD in Mathematics Education (RECME)

February 2009

RECME
Researching Effective CPD in Mathematics Education

National Centre
for Excellence in the
Teaching of Mathematics

www.ncetm.org.uk

Acknowledgements

The RECME Research Team would like to thank all the teachers, CPD organisers, academics, colleagues and others who participated in this project. We would also like to thank the Research Advisory Group[1] of the NCETM for their critical engagement and support throughout the project.

We have been overwhelmed by everyone's willingness and openness to share their thoughts, ideas and opinions. We have been impressed by the goodwill and professionalism of all. It made working on this research project exciting and a true joy.

The NCETM is indebted to the RECME research team: Jenni Back (researcher), Els De Geest (project director), Christine Hirst (researcher) and Marie Joubert (researcher and report editor), and to Rosamund Sutherland for her role as advisor to the project team.

[1] See Appendix 1

Executive summary

Background

The Researching Effective CPD in Mathematics Education (RECME) project was set up under the umbrella of the National Centre for Excellence in the Teaching of Mathematics (NCETM) in England.

The overarching aim of RECME was to provide advice, guidance and recommendations for the NCETM, in order to inform future plans and to point to the types of evidence that could demonstrate that continuing professional development (CPD) is informing teachers' practice and students' learning. The specific aims of the project were:

Aim 1: To characterise different types of continuing professional development for teachers of mathematics (to include both formal and informal experiences).

Aim 2: To investigate the interrelated factors that contribute to effective CPD for teachers of mathematics.

Aim 3: To investigate evidence of effective CPD for teachers of mathematics.

Aim 4: To establish the roles of research in professional development for teachers of mathematics.

Aim 5: To investigate the influence of the NCETM portal on professional development for teachers of mathematics.

Approach adopted

The study investigated 30 CPD initiatives representing different models of CPD for teachers of mathematics, in different locations of England, taking place in the academic year 2007/2008. Overall, about 250 teachers in pre-primary, primary, secondary, further and adult education settings were involved in these initiatives. The study investigated the organisation of the CPD and two teachers from each initiative were interviewed and observed in their classrooms. These were designated 'focus teachers'. The full data set comprises responses to questions for organisers, notes from observations of CPD meetings, online questionnaire responses, observation notes, interviews with the focus teachers and data gathered from a summer residential event which involved discussion with teachers and leaders about key issues in the research.

It is rare to find large scale research such as this in the area of CPD for teachers of mathematics and it is common to find that research in this area is undertaken by people who could be seen as stake-holders in the CPD initiatives being studied. The research of the RECME project, because of the approaches it adopted, has been able to provide perspectives and insights that are sometimes missing from research concerning professional development for teachers of mathematics. In particular, we suggest our major contribution has been in developing the twin perspectives of looking at CPD 'from the outside' (our view) and 'from the inside' (privileging the teachers' voice). We believe we have produced interesting and notable findings that have the potential to inform the policy and practice of CPD not only in England but also elsewhere.

Summary of findings

Characterising the landscape of professional development for teachers of mathematics

The initiatives fell into three categories:

- **courses** – those initiatives having a number of meetings, defined intended participant learning (although this could range from quite specific to very broad), and clear leadership in terms of a course tutor or leader. The majority of the courses offered optional accreditation from a Higher Education Institute at post graduate level.
- **within-school initiatives** – where all participants came from the same school. One of these offered optional accreditation.
- **networks** – meetings for groups of teachers from different schools or colleges who gathered to provide mutual support for one another. The material the participants engaged with was largely chosen to address the interests and concerns of the participants as developed over time. None of these led to accreditation.

Opportunities

Courses mostly introduced participants to new ideas and knowledge, within-school initiatives tended to provide support for teachers through working together, and networks provided opportunities for teachers to meet colleagues from other institutions and share ideas with them. The different types of CPD initiatives can therefore be seen as providing different learning opportunities.

Leadership

The leaders of courses and some networks had responsibility for shaping the organisation and areas of focus of the CPD initiative and therefore had the potential to exert a major influence on the way the CPD developed. Some networks, however, were working towards models of distributed leadership. Leaders in the within-school initiatives seem to be equally important; they initiated, planned and led the CPD activity and these initiatives were sustained by the commitment of the leader.

Reasons for taking part

There were two initiatives in which teachers participated in order to gain a qualification to teach mathematics and one in which teachers chose to take part because they felt they were not suitably qualified to teach A Level mathematics. In other initiatives however, teachers were invited or encouraged to participate, or became aware of the opportunities and decided to take up these opportunities. It could therefore be argued that most of the teachers taking part in the RECME CPD initiatives were teachers who were keen to learn and develop their teaching.

Areas of focus

All initiatives attended to aspects of mathematical knowledge for teaching mathematics combining, in various ways, mathematics, approaches to teaching mathematics and knowledge about students' conceptions of mathematics. In addition to the areas of focus described above, some initiatives attended to integrating ICT into teaching and learning mathematics, to reading and discussing research and professional literature and to communicating information.

Bringing about change

In initiatives that aimed to introduce participating teachers to new approaches to teaching mathematics, there was usually an expectation that the teachers would try out these ideas in their classrooms and, in many cases, trying out new ideas was followed up with feeding back to the rest of the group at a subsequent CPD session or reflecting on the trial in a journal. Some initiatives recognised that it might be difficult for teachers to make changes and provided support, for example, by suggesting that participating in CPD gave them 'permission' to try new ideas, by making reporting back a clear expectation or by providing help in the classroom.

Some initiatives, rather than introducing teachers to new knowledge and ways of teaching mathematics, focused on supporting teachers in embedding approaches to which they were already committed. For example, one within-school initiative developed sharable resources to support new kinds of mathematical classroom tasks.

Influence on individual teachers

Taking part in a CPD initiative influences individual teachers in different ways. The ways in which different teachers respond to the same CPD initiative seems to relate closely to the context in which they work, their personal professional circumstances, their values and their beliefs about teaching and learning mathematics.

Factors that contribute to effective CPD for teachers of mathematics

When asked to explain the ways in which their CPD initiative was effective, some teachers responded in terms of the factors contributing to the way the CPD was organised.

Leadership
Leadership of the CPD was identified by teachers as of key importance and they especially valued leaders with wide knowledge and understanding of current practice.

A practical approach
Teachers valued practical advice that was directly applicable to the classroom, including resources and banks of resources that they could use with minimal adaptation. In many cases they valued having attention drawn to the use of practical equipment and ICT resources which support mathematical thinking and reasoning. They appreciated CPD that was grounded in classroom practice.

Stimulation, challenge and enjoyment
Teachers valued CPD that was stimulating, enjoyable and challenging. Challenge within CPD was not a comfortable experience for some teachers; appropriate support from the CPD initiative was often provided.

Time
Time was mentioned as a big issue for most participants and they valued the time that their involvement in the CPD initiative gave them to focus on their professional practice. This often involved release from the classroom, standing back from their day-to-day practice and reflecting on their practice.

Networking
The opportunities for networking with colleagues from the same or different schools that involvement in CPD gave the teachers were highly valued. Teachers valued meeting colleagues with very similar work settings as well as appreciating opportunities to work with teachers from other phases or settings. They also emphasised the value of the incidental conversations that took place within CPD sessions.

In addition to teachers' views on factors contributing to effective CPD, observations and interviews suggest that the following factors may be important in CPD initiatives:

Areas of focus (mathematics)
In CPD for teachers of mathematics, it seems to be important to pay attention to mathematics, to ways of teaching the subject and to students' mathematical conceptions. Many teachers seemed to enjoy doing mathematics and thinking about connections within it. Engaging in mathematical activities may have encouraged teachers to consider what it feels like to be a student, hence making them more sympathetic to students' needs.

Students' learning of mathematics
CPD initiatives that engaged in cycles of planning teaching and predicting student responses to particular mathematical activities, followed by teaching and reflecting on the actual student responses, seemed to provide teachers with ways in which to talk about student learning. It seems to be particularly difficult for CPD initiatives to address the issue of how children and students make sense of mathematics. We argue that this is because it requires extended thought and work, which might include cycles of predicting students' responses, close observation of students' mathematical activity and discussion about such activity. In day-to-day teaching it is often very difficult for teachers to observe students closely and to find opportunities for reflection. Some of the initiatives provided opportunities for teachers to attend to students' and children's mathematical thinking: through the use of video of students' responses in mathematics lessons; through teaching 'real' children in CPD meetings; through stepping back and observing children, making notes about what they did, and then as a group, discussing these notes.

Encouraging reflection
Initiatives that encouraged teachers to become more reflective often engaged them with research and professional literature related to teaching and learning mathematics. It seems that it is important to provide teachers with opportunities to read and think about ideas from research.

Expecting and supporting change
Where CPD initiatives wanted teachers to try out new ideas in the classroom, it seems that different approaches to encouraging them were effective. In some, there was a clear expectation on the part of the course leader that teachers would try out new ideas in the classroom, and this expectation appears to have provided the motivation to change. In addition, in some initiatives there was some pressure to report back to the group and/or to write reflective diaries, which may have provoked teachers to make changes. In other initiatives, considerable in-school support was provided for teachers to try out new ideas in the classroom.

Supporting the embedding of change
In initiatives that were set up to help teachers embed change, discussion at CPD meetings of the approaches teachers were taking in the classroom seemed to reassure them and encourage them to continue using these approaches. At these meetings, the teachers also worked together to develop new ideas and resources to support them in embedding changed practices.

Evidence of effective CPD for teachers of mathematics

eachers provided explanations about why they thought their CPD initiative was effective in terms of their own learning, changes in their attitudes and changes in classroom practice.

Teacher learning

Teachers reported learning in three main areas: mathematical knowledge for teaching, increased awareness both of their own classroom practice and of their students' responses, and learning new information. Few discussed their own mathematical learning and learning about students' mathematical conceptions and when they did, tended to provide non-specific examples. Some teachers discussed learning about ways of teaching mathematics, mostly referring to structuring tasks and activities.

Change in teacher attitudes

Teachers reported that their CPD was effective because it had given them confidence. Some comments related to confidence to try out new things. For example, one teacher said that 'it has built my confidence in using handheld technology within the classroom' and another that she felt confident to try out new things. Some teachers related the effectiveness of their CPD to becoming motivated, feeling inspired, challenged and refreshed, and to renewed enjoyment of teaching mathematics.

Increased passion and energy

Effective CPD appeared to increase teachers' passion and energy to persevere in developing their practice, to keep working on professional development, to keep trying out ideas in their classrooms – even with other pressures of work or life. This energy release took place sometimes as a result of making sense of old and new experiences, sometimes from experiencing something which fitted with the teacher's sense of themselves as a teacher, sometimes realising that it would be possible to do what they wanted to do.

Changes in practice

Teachers suggested that changes in classroom practice provided evidence for the effectiveness of their CPD. Many expressed the view that their teaching had improved and some elaborated on this by suggesting, for example, that they now put the students' needs first, and that they allowed their students more control over, and input into, lessons. Other teachers reported that the CPD was effective because they had tried out new ideas in the classroom, but we can only speculate as to whether such change in practice would be sustained.

Student learning and changes in ways of working

Teachers tended not to report improved student learning or changes in ways of working as evidence of the effectiveness of their CPD. However, when questioned, teachers reported such improvements by referring to students' work, what students said and improved attainment. These improvements seemed to be important in convincing teachers that they should sustain the changes they had made to their practice. Teachers often reported that students' attitudes had improved since the teachers had participated in the CPD activity, with students being more willing to share knowledge and collaborate, to engage in discussion and communication about mathematics and to persevere in tackling difficult tasks. It was often reported that these changes improved the atmosphere in the classroom and led to increased confidence and motivation on the part of the students.

The roles of research in professional development for teachers of mathematics

Research-involved' CPD included:

- research-informed CPD, where research findings explicitly inform the organisation and planning of the CPD
- research-inspired CPD, where research findings are used implicitly rather than explicitly
- participants reading professional and research literature
- participants using resources that have been developed based on research
- participants being part of a research project
- participants carrying out research as part of their CPD (often called action research).

Benefits of research

Overall, using research seemed to offer teachers effective means of becoming aware of different perspectives about teaching and learning, to gain confidence about their own thinking, to be confident about the validity of new ideas to try out in the classroom, and to give status and credibility to the CPD initiative itself and to the teacher. From the data it is clear that in the CPD initiatives that involved a research aspect, the teachers were asked to think and reflect about the research that was presented in the CPD. Teachers valued such opportunity to think and reflect positively. Teachers participating in some CPD expected to learn research skills and ways to implement research findings in the classroom. Barriers to undertaking research were similar to other barriers and concerned lack of time and the tensions this causes, lack of opportunity to do research in the classroom and finding reading research too challenging.

Influence of research

Research sometimes influenced CPD initiatives for teachers of mathematics directly, and this could include involvement of HEIs (Higher Education Institutions) which encouraged participants in the initiatives to read research literature and sometimes to carry out their own research. HEIs work in a variety of ways in contributing to CPD: offering courses themselves; working in collaboration with local authorities to provide tailor-made CPD; working with outside funders; through research projects and networks. Research also seemed to influence CPD more indirectly, for example a CPD initiative using resources that have been developed based on research.

The pragmatic use of research

Research was used in a pragmatic way, whether it was relevant to the aims of the CPD or to identified issues in the teachers' professional practice, or whether it was used as a focus for professional development. Whereas in this process the original meaning of the research and its findings may have been reconstructed, research was nevertheless being used as a starting point or vehicle for exploring issues identified as problematic or interesting by teachers.

The influence of the NCETM and the portal on professional development for teachers of mathematics

Many of the teachers reported that the NCETM had influenced their CPD in various ways through its organisation of events and conferences and through supporting teacher enquiry projects as well as the outreach work of the Regional Co-ordinators.

Teachers reported that the NCETM portal was valuable in providing information and opportunities for communication.

Providing information

The teachers were positive about the ways in which the portal had contributed to their professional development, providing them with ideas and information and enabling them to learn from other teachers. In particular, they reported that the Courses and Events section provided them with valuable information about conferences, meetings, speakers, contacts and networks. They used this section to identify events to attend, which provided them with opportunities to meet like-minded people, policy makers and researchers. The News section allowed the teachers to keep up to date with current developments in mathematics education. The Resources section provided practical help for classroom practice and the Mathemapedia provided important links to the research world.

The Research section related to the teachers' interest in a particular topic or project. They reported that learning about research findings could provoke them to reflect on other ways of doing things in the classroom, for example, questioning in the classroom.

Overall, the teachers reported finding the information on the portal useful but they indicated that the large quantity of information now found on it was hindering their ability to find something relevant.

Communication and interaction

Valuable networking opportunities were offered by the Communities part of the portal, which also provided a means for sharing ideas, practice and knowledge, seeing different perspectives, and getting support. 'The Self-Evaluation Tools' (SET), offered teachers an interactive opportunity to assess their own mathematical knowledge in teaching. Some teachers suggested that it could be useful for those who lack confidence.

Recommendations

Recommendations for policy makers

Policy makers should:

- recognise the role of the leaders of CPD and provide professional development opportunities for this group of people through mathematics teachers' professional associations and other appropriate providers such as the NCETM
- provide support for teachers to develop the knowledge and skills to take a lead in offering CPD for their fellow teachers
- support the provision of a range of models of CPD so that teachers have opportunities to engage in different kinds of CPD at appropriate times in their career
- recognise explicitly the wide-ranging ways in which research impacts on CPD for teachers of mathematics and the ways in which research is valued by practitioners
- recognise that all teachers should have opportunities to experience a wide range of pedagogic approaches and to develop strategies for evaluating them and selecting those that work for them and their students as appropriate.

Recommendations for developers and providers of CPD for teachers of mathematics

Developers and providers of CPD should:

- take into account the experience and expertise of teachers and build on these as opposed to adopting a 'deficit model'
- encourage teachers to try out new ideas in the classroom by giving them 'permission' to do so
- build adequate time into the programme for teachers to try out new ideas and reflect on their learning
- consider the support, both intellectual and emotional, that teachers need in order to cope with adjusting to learning that challenges them intellectually and professionally
- include stimulating and challenging mathematical activities within the CPD programme
- include opportunities for teachers to develop knowledge about mathematics and ways of teaching mathematics within the CPD programme. This should include focusing on theoretical concepts when appropriate
- pay explicit attention to students' mathematical learning, acknowledge that this is not easy and build in time and opportunities within the CPD for teachers to develop their capabilities to recognise and talk about mathematical learning. This could involve the dissemination of relevant supporting research findings
- take into account a combination of factors, including teacher learning, change in teacher attitudes, the extent to which engagement in the CPD seems to evoke passion, changes in teachers' practice and changes in student learning within processes of self-evaluation
- be explicit about research underpinning the design of the CPD and the ways in which changes in classroom practice are likely to influence student learning.

Recommendations for the NCETM

The NCETM should:

- identify and nurture teachers who could lead within-school initiatives
- continue to provide support for existing networks
- develop networks for teachers in all phases, also recognising that some teachers might value cross-phase networks
- investigate ways of achieving the benefits of networking in non-physical networking settings through on-line networking, so that teachers' opportunities to network are not limited by geographical and time constraints
- support teachers to engage in teacher research
- offer routes for teachers involved in teacher research to become more involved in educational research, for example through developing further links with the British Society for Research into Learning Mathematics (BSRLM)
- continue and strengthen the combined approach of face-to-face and electronic communication and interaction
- continue to act as a gateway of information on CPD for teachers of mathematics
- continue to build relations with other stakeholders in the field, such as the professional associations and bodies, local authorities, higher education institutions, the National Strategies and promote collaboration between these bodies.

Regarding the **portal**, we recommend that the NCETM:

- continue the development of the Resources section, presenting and labelling the resources to emphasise how they have been used by other teachers, so that the focus of the resources is on CPD.
- provide signposting for teachers looking for resources to point them towards collections of resources elsewhere on the Internet
- set up a Research News section to widen the research information available for teachers
- develop strategies to give teachers a purpose for engaging in the Communities and Blogs section
- develop the Mathemapedia, encouraging teachers to contribute and provide ideas about how the theoretical notions presented within the Mathemapedia can be used in classroom practice
- develop tools to help teachers recognise and reflect on evidence of student learning
- investigate ways in which to develop the self-evaluation tool, building on research about students' conceptual development.

Recommendations for schools and colleges

Schools and colleges should:

- encourage teachers to take advantage of a range of different kinds of CPD relevant to their particular interests at different stages in their career. Encourage teachers to use the NCETM portal to develop their practice and to find out what is available
- encourage all teachers of mathematics to become engaged in mathematics-specific CPD
- support teachers in choosing CPD appropriate for both their individual development and the collective development of the school/college
- encourage and support teachers to try out new ideas for teaching and learning mathematics with students and to embed approaches they are beginning to adopt
- provide time for participation in CPD within teachers' contractual hours
- value what teachers are learning through participating in CPD and encourage them to share new knowledge and understanding within the wider school community.

Recommendations for the research community

Research is needed to:

- investigate different approaches to engage teachers with students' conceptual development in mathematics
- investigate the barriers to engagement with CPD
- investigate CPD aspirations of teachers who do not currently participate in CPD
- investigate how CPD can increase passion and energy to stay engaged with CPD and teacher learning. This may be particularly important with respect to the new Masters in Teaching and Learning qualification being proposed for teachers
- identify teachers' responses to opportunities for academic accreditation and the factors that influence decisions to take up or reject these opportunities
- follow up the focus teachers in this study and explore their continuing professional development over a longer period of time, to investigate the long term effects of their involvement in the CPD initiatives
- investigate factors contributing to successful on-line networking for teachers of mathematics.

Message for teachers

We hope you enjoy reading the report and find it interesting to find out about what other teachers have done and about the wide variations in initiatives of CPD. You might like to encourage your colleagues to read the report as well. Some of the key findings and all the case studies can be found on the RECME pages of the NCETM portal.

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1. Background to the study

1.1. Introduction

In 2002, the Advisory Committee on Mathematics (ACME) produced a report (ACME, 2002) on Continuing Professional Development for teachers of mathematics. One of the conclusions was that '[we] wish to see more professional development for teachers that seeks to broaden and deepen mathematical knowledge and to integrate this with study of pupils' learning and with teaching approaches.' (page 8)

The NCETM was established both in response to the recommendations of ACME and to those made in Professor Adrian Smith's report 'Making Mathematics Count' (Smith, 2004). It was launched in 2006, with the broad aim of enhancing mathematics teaching and learning, in schools, colleges, universities and other organisations through high-quality continuing professional development. In particular, it aims to raise the professional status of all those engaged in the teaching of mathematics so that the mathematical potential of students will be fully realised. All teachers and lecturers of mathematics, together with national and international organisations concerned with mathematics education, are considered stakeholders in the NCETM.

The philosophy underpinning the NCETM is based on the notion that understandings and knowledge growth concerning the CPD of mathematics teachers are most valuable when they are co-constructed by teachers, researchers and other stakeholders. This notion is described in detail by Triggs and John (2008) who use a model of multi-layered communities in which knowledge flow is omni-directional. They suggest that this approach can overcome the identified 'gap' between research and practice.

The NCETM is committed to research on professional development for teachers of mathematics, and commissioned both the RECME project and a number of small scale research projects. Their vision is that the findings of these projects will feed into the ongoing development of the NCETM in order to meet its aim of providing excellent advice, resources and professional development for teachers.

1.2. Introducing RECME

The RECME project was a short term (15 month) project with a data collection period from January to July 2009. Unusually for research in this area, it investigated a large sample of different CPD initiatives in England to develop an understanding of the landscape of CPD in the country. Further, none of the researchers could be seen as stake-holders in any of the initiatives. Finally the five researchers brought a range of perspectives to the research and the project was designed to draw on the different strengths of the individual researchers.

The RECME project bases its philosophical approach on that of the NCETM, and extends towards a model of distributed leadership, which moves away from a 'top-down delivery' model of working:

> Taking this view [of distributed leadership], leadership is about learning together and constructing meaning and knowledge collectively and collaboratively. It involves opportunities to surface and mediate perceptions, values, beliefs, information and assumptions through continuing conversations. It means generating ideas together, seeking to reflect upon and make sense of work in the light of shared beliefs and new information; and creating actions that grow out of these new understandings. It implies that leadership is socially constructed and culturally sensitive. It does not imply a leader/follower divide, neither does it point towards the leadership potential of just one person. (Harris, 2003:314).

The notion of distributed leadership implied calling on the knowledge and expertise of mathematics educators in research, in policy and in practice. In the early stages, a Research Advisory Group[2] (RAG) was formed, whose members (about 20) were selected on the basis of their research reputations, and on the educational sector in which they conduct their work.

A review of the literature concerning professional development for teachers of mathematics was commissioned and the RAG played an active consultative and advisory role in the development of this review.

1.3. Developing the project brief

The first and possibly most important question the RAG addressed was putting together a 'definition' of CPD for teachers of mathematics. It was seen as important to be clear about what exactly they saw as CPD, to provide a starting point for the review of the literature. The following broad 'definition' was developed:

> CPD for mathematics teachers should stimulate teachers to re-think, to experiment, to make fresh distinctions and to probe those distinctions to explore how they are informative in enabling choices related to teaching and learning.

The sorts of questions the RAG developed were concerned with the context, content and process (Harwell, 2003) of CPD. For example, they thought it was important to understand the institutional and contextual settings in which programmes of CPD took place, to take account of the content of the programmes so they could understand the

[2] See Appendix 1

kinds of professional capacity being developed; and they were interested in the forms of interactions afforded, the forms of experimentation evoked and the stimuli provided. A further branch of questions was concerned with the short- and long-term changes that might occur as a result of CPD programmes, with a focus on what counts as evidence of change and particularly what constitutes evidence for effective CPD.

The RAG advised that the project should begin by studying a sample of about 30 initiatives. This, it was felt, would provide a wide enough range of types of CPD in the various education sectors. The relatively large number of initiatives would provide a broad overview of the nexus of factors contributing to a joint understanding of what CPD is. These initiatives represented different models of CPD in mathematics education, in different locations, and aimed at about 250 teachers of students in pre-primary, primary, secondary, further and adult education settings.

1.4. Aims

The overarching aim of the study was to provide advice, guidance and recommendations for the NCETM in order to inform future plans and to point to the types of evidence that could demonstrate that CPD is informing teachers' practices and students' learning. The specific aims of the project were:

Aim 1: To characterise different types of CPD for teachers of mathematics (to include both formal and informal experiences).

Aim 2: To investigate the interrelated factors that contribute to effective CPD for teachers of mathematics.

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Aim 5: To investigate the influence of the NCETM portal on professional development for teachers of mathematics.

1.5. Outline of the report

The remainder of this report is organised in the following way:

- **Chapter 2** provides an overview of the study in terms of the approaches adopted and methods chosen.
- **Chapter 3** analyses the CPD initiatives in the study in terms of the organisation of the CPD, which includes discussion of the purposes for which the CPD was set up, how meetings are organised, the areas of focus and ways in which the CPD encourages and supports change. This chapter addresses aim 1 (characterising CPD).
- **Chapter 4** presents six case studies of CPD initiatives. These include descriptions of how the CPD is set up and analysis of the responses of two individual teachers taking part in the CPD. This chapter addresses aim 1 (characterising CPD) and aim 2 (investigating the interrelated factors that contribute to effective CPD).
- **Chapter 5** investigates factors contributing to effective CPD by analysing teachers' perceptions about what makes effective CPD. It also addresses aim 2 (investigating the interrelated factors that contribute to effective CPD).
- **Chapter 6** investigates the sorts of responses teachers provided as evidence of effective CPD, including teacher learning, changes in teachers' classroom practice and improved student learning. This chapter addresses aim 3 (investigating evidence of effective CPD).
- **Chapter 7** investigates the roles of research in CPD, including the effect of 'research-involved' CPD on teachers, evidence of research underpinning the planning and organisation of the CPD and the involvement of HEIs in CPD. This chapter addresses aim 4 (establishing the roles of research in professional development for teachers of mathematics).
- **Chapter 8** investigates the role of the NCETM, and particularly the role of the portal, in the CPD of teachers of mathematics. This chapter addresses aim 5 (investigating the influence of the NCETM portal on professional development for teachers of mathematics).

Enjoyment of task → feel they are not working (BUT not all!)

- Tasks were open with different approaches
- Motivated by the fact that it was 'display work'.
- Display worried some pupils that 'it wasn't all right'.
- Low ability pupils explaining to each other very powerful (more so than teachers sometimes!!)
- Unsure whether it can be used as new learning????
- What do you do with work afterwards??

2. Approaches adopted

In the first phase of the project (April 2007 to July 2007), the Research Advisory Group (RAG) together with the NCETM Regional Coordinators, invited their contacts, including teachers, local authority advisors and providers of CPD for mathematics teachers, to contribute to a database of CPD initiatives which was built via an on-line questionnaire on the NCETM portal. Potential contributors to the survey were also alerted and invited to contribute through an advertisement in the national professional press (Times Educational Supplement) and on the NCETM portal's homepage, and through invitations emailed to members' list of professional and research associations (Association of Teachers of Mathematics, Mathematical Association, Association of Mathematics Education for Teaching, British Society for Research into Learning Mathematics).

2.1. The sample

From the contributions to the questionnaire, some CPD initiatives were contacted and invited to become part of the RECME project. The most important criterion for selection and inclusion in participation was the indication of a willingness to engage in the research and to work together with the research team to develop co-constructed accounts of the CPD and the teachers' responses to it. A further eight selection criteria were used to obtain a cross-section of the existing landscape taking into account regional variations; criteria highlighted in the emerging literature review, for example different types of CPD such as lesson study, working on students' conceptual development; different structures, for example within school, across school, led by government agencies, with university involvement; different foci, for example subject knowledge of the teachers; different approaches to communication; educational sector, i.e. early years, primary, secondary, further education, adult education. Of key importance was the currency of the CPD: the initiatives had to be ongoing during the academic year 2007-2008 to allow for 'live' research to take place. The on-line questionnaire received 173 replies with examples of the CPD experiences of mathematics educators. Of these, 137 were interested in participating in an NCETM major research project. These entries were then filtered further according to the nine criteria above to get a spread of initiatives. This left 46 possible sample initiatives who were contacted and asked additional questions such as whether the CPD would be ongoing between January and July 2008, whether they would be interested to be part of the RECME sample and whether they could commit to the responsibilities this would entail. In this way, 15 initiatives became part of the RECME sample.

These 15 initiatives did not cover the whole picture of available CPD in England according to our selection criteria and so the team identified gaps in the sample and sought initiatives that 'filled the gaps' by asking RAG members and the NCETM directorate to suggest such initiatives. Examples of such gaps were the lack of any initiatives that were linked with 'large' professional development organisers such as, for example, the National Strategies, the Gatsby Foundation, London Challenge, SSAT and professional development, initiatives from the FE and adult education sector (of which we had very few responses from the on-line questionnaire) and more initiatives from the primary sector. Approaching initiatives in this way gave the project another 15 initiatives; the full sample included a total of 30 initiatives.

The table below (Table 1) shows the detail of initiatives and their recruitment to the project as well as some detail related to the selection criteria.

Table 1 Origin of the sample

Phase Origin of sample	Early years	Primary	Secondary	FE/adult	Cross phase	Network/course/ within-school
From on-line questionnaire (n=15)	1	2, 3, 4, 5	11, 12, 13, 14, 15, 17, 18, 20		29, 30	Network: 1, 4, 30 Course: 15, 17, 18, 20 Within-school: 2, 3, 5, 11, 12, 13, 14, 29
Suggestions rom RAG (n=9)		6, 8, 10, 9	16, 19, 21, 24 12, 15, 19, 33	25		Network: 16 Course: 6, 19, 21 25, 24, 10 Within-school: 8, 9
Suggestions from NCETM directorate (n=6)		7	22, 23	26, 27, 28		Network: 26, 27, 28 Course: 7, 22, 23 Within-school: none

A full list of the initiatives, together with a short description of each, can be found in Appendix 2.

2.2. Theoretical perspective

We adopt the perspective that all human activity, including the learning of teachers, is historically, socially, culturally and temporally situated (Vygotsky, 1978). This suggests that the experiences and contexts of teachers will have a major influence on their learning and implies a need to pay attention not only to the situation, the opportunities and the context of sites of learning (in our case initiatives of professional development), but also to the individuals (teachers of mathematics) taking part in professional development.

Another key aspect of our theoretical perspective lies in the way in which we have chosen to co-construct our accounts and reporting with the participants in the research whether they have been leaders, organisers or teachers. This stems from a belief that any account we offer will be coloured by our own preconceptions and experiences and by working with the people we are researching we hope to develop accounts that reflect the initiatives in ways that make sense to the participants themselves as well as to us. This has meant that we have offered our field notes, papers and writing back to the people we were researching for their comments and corrections and in many cases the feedback they have given us has been invaluable and illuminating. It also supported our aim of including a stronger teacher voice and helped us to produce socially robust knowledge.

2.3. Data collection

As a result of these underpinning philosophical perspectives, we needed to collect data about both the 'big picture' (the initiatives) and detailed pictures (the participants). Our data have been gathered from a wide variety of sources to include descriptions of CPD initiatives as well as the detail of how individual teachers responded to the CPD that they engaged in. These sources offered us qualitative and quantitative data and we argue that this mixed methodology is appropriate by emphasising the size of our sample of 30 CPD initiatives, involving over 250 teachers, which offers the potential to consider quantitative data collected from this large sample, as well as to explore the details of individual cases through qualitative methods. In the following paragraphs we elaborate the research tools we used, outline the justification for their use and offer a brief explanation of the data they generated.

2.3.1 Launch event

At the beginning of the project we held a launch event to which we invited all the organisers of the CPD. The purpose of this was to share our plans with the participants and to gather some ideas from them about the research questions. Two representatives from each of the initiatives that had agreed by that time to participate in the RECME project were invited. Participants were asked to discuss and reflect on what is CPD, what is effective CPD, where could we find evidence of effective CPD. The discussions were audio-taped and field notes made.

2.3.2 Pre meeting data gathering from organisers

Descriptions of the initiatives were collected from the organisers of the CPD. These descriptions were posted on the RECME pages of the NCETM portal. We also sent a list of questions to each organiser asking for information about aims of the CPD, dates of meetings, structure of meetings, number of participants, duration of the CPD, what takes place in meetings, funding/costs, support and communication structures, recruitment procedures, leaders of the meetings and methods of evaluation. For some initiatives not all this data was available or relevant. The purpose of this was to gather basic factual data about the organisational structures and ways of working of all the initiatives.

2.3.3 Visits to meetings of CPD initiatives

For each initiative we observed at least one professional development meeting and took observation notes. The purpose of these visits was to supplement the data gathered from the questions for the organisers (above) and to gain some additional qualitative data about the actual CPD sessions.

2.3.4 Online questionnaire

The purpose of the questionnaire was to gather data about individual teachers and their responses to the CPD in which they were involved. The questionnaire included closed questions with a choice of answers, as well as many open questions. It was answered by teachers from many of the initiatives (but not all) and was completed on-line. It generated both qualitative and quantitative data from 92 responses. The respondents consisted of teachers and organisers and some teacher/organisers. A paper version of the questionnaire is included in Appendix 3.

2.3.5 Visits to individual teachers: lesson observations and interview

From the participating CPD initiatives we selected case study teachers with the help of the organisers and we visited 49 teachers in their schools, observing a mathematics lesson and interviewing them. This helped us to develop our understanding of the context in which they worked, and we interviewed them to provide data about their reactions to the CPD. The interview schedule included questions about professional background, perceptions of their professional identity, their thoughts on the observed lesson, influence of the CPD on the way they taught, motivation to take part and remain involved in the CPD, their CPD histories and how they felt about the CPD. The interviews were audio-recorded and field notes made. These visits and interviews gave us data that supplemented the data gathered from the questionnaire and enabled us to develop detailed case studies about individuals' responses to CPD.

2.3.6 Summer residential

We also invited all the case study teachers to a summer residential event at which we worked with them on collaboratively developing our ideas about various aspects of the data that we felt were problematic. This generated another rich source of data and involved about half of the case study teachers. This took place in the summer term of 2008. It was a 24-hour event (from one afternoon to the next). When these could not attend another teacher from the initiative was invited. Spare places were offered to the organisers of the CPD if they were not one of the invited teachers already. Over the 24 hours, the participants worked as co-researchers on four topics that the research team had identified as requiring more data and more insights. The questions we considered with them were:

- What is challenge/discussion/sharing knowledge?
- What counts as evidence of student learning?
- What is passion and is it related to CPD?
- What are the 'affordances' (opportunities and constraints) of different CPD initiatives?

The data that we gathered from this enabled us to unpack some of the issues which had emerged as problematic at that point in the research. It also gave us some useful insights into the responses of teachers to involvement in the research.

2.3.7 Follow up interviews with teachers using the portal

Four teachers, who were users of the NCETM portal, were identified in order to answer our last research question in more detail. These teachers all participated in at least one of the CPD initiatives we were studying. From the interviews with these teachers four case studies were developed which illustrate how teachers use the portal.

2.4. Analysis

The data were analysed using quantitative and qualitative methods as appropriate. For the qualitative data, a grounded approach on the basis of systematic reading and re-reading of notes about visits, data from the questionnaire and interviews was adopted. Together with the research literature (see Joubert and Sutherland, 2008), this reading and re-reading led to the development of a framework that took account of the complexity of the professional development (presented at the beginning of Chapter 4) as well as the influence the CPD had on the individual teachers involved (explained at the beginning of Chapter 5).

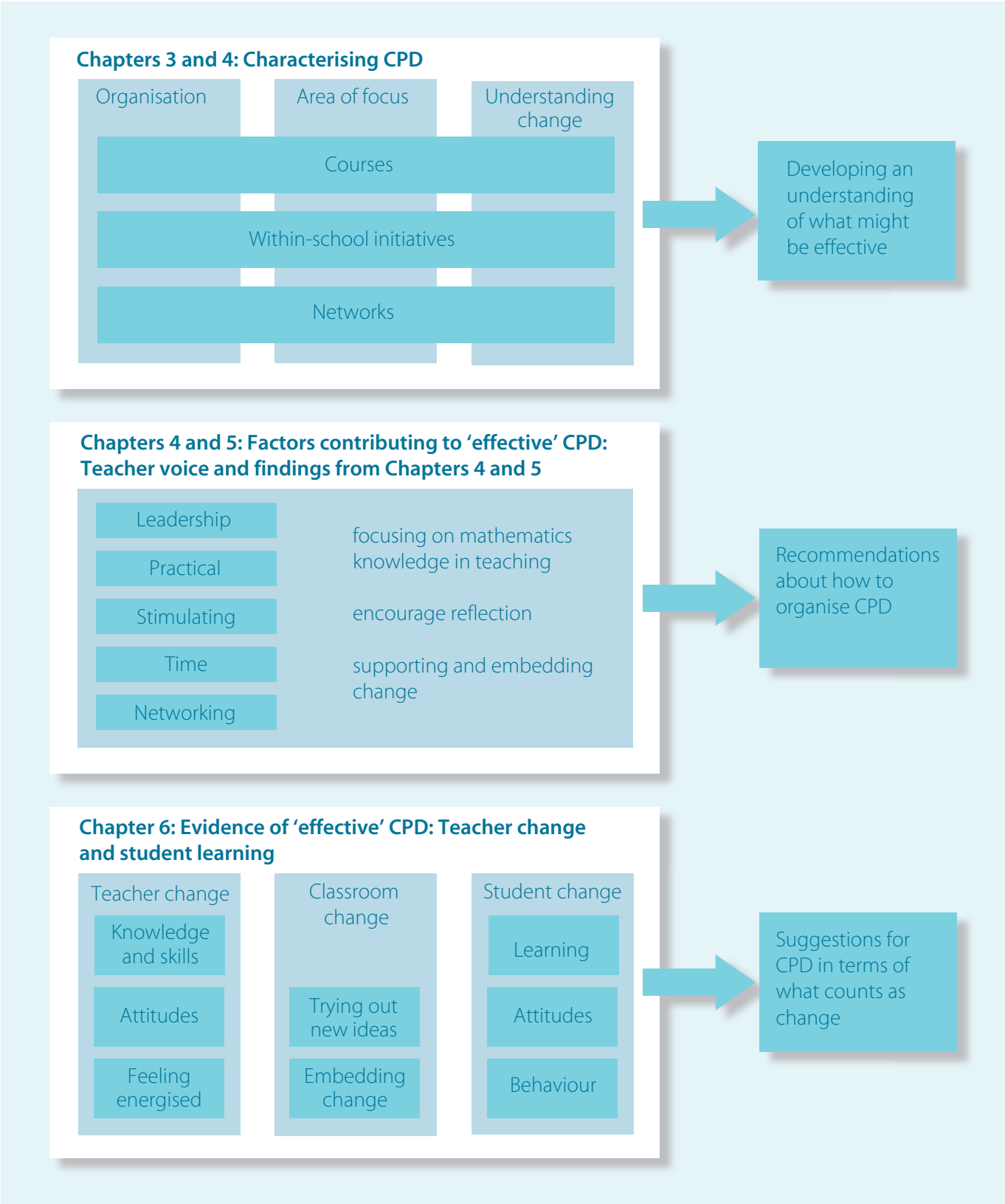
The systematic reading and re-reading of data led to the emergence of conceptual categories drawn from all the different data sets. We used a complex iterative process: all our field notes were written up and sent back to the relevant teacher or organiser for comment. In the cases where no or little research literature could be found on the concept that was emerging from the initial coding, suggestions were fed back to the teachers and organisers in the summer residential to make sure that they concurred with our interpretations and coding.

The research community also played a part in this iterative process. Throughout this project regular meetings took place with the Research Advisory Group (RAG) to which we reported and shared ongoing developments and ideas. We also presented at BSRLM day meetings that took place during the time the project was running to share our current thinking and research ideas, findings and methodologies and to get feedback from the research community.

The other iterative element came in the form of the triangulation of the data in the analysis: we triangulated between the data sets which came from different occurrences; different interpretations of experiencing CPD; and the research literature. In the coding and analysis we were further informed and guided by research literature and findings. In the cases where no or little research literature could be found to support our conjectures, we endeavour to explicate the perspective we have used in our presentation of the findings in this report. Further validation of the research findings comes from the critical review of this report by members of the RAG and NCETM.

The diagram below (Figure 1) illustrates the structure of the presentation of our findings regarding the characterisation and effectiveness of CPD (Chapters 3, 4 , 5 and 6) and links with the research questions.

Figure 1 Diagrammatic representation of characterising CPD and effective CPD analysis chapters



Other Nobo Pads available include:
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3. The CPD landscape: an analysis

This chapter analyses the sample of CPD initiatives in terms of their organisational structures, the areas of mathematics knowledge in teaching on which they focus and their approaches to encouraging change.

3.1. Different organisational structures of the CPD initiatives

The 30 initiatives taking part in the study fell into three groups[3]:

- courses – those initiatives having a number of meetings, defined intended participant learning (although this could range from quite specific to very broad), and clear leadership in terms of a course tutor or leader. The majority of the courses offered optional accreditation.
- within-school initiatives – where all the participants came from the same school. One of these offered optional accreditation.
- networks – meetings for groups of teachers from different schools or colleges who get together to mutually support one another. They are ongoing and the material the participants engage with is largely chosen to address the interests and concerns of the participants as they develop over time. None of these led to accreditation.

Table 2, below, lists the initiatives in each of these groups and indicates the phase in which the teachers work.

Table 2: Phase and types of the full sample

Phase	Courses	Within-school	Network	TOTAL
Early Years Foundation Stage[4]			1	**1**
Primary	3	5	1	**9**
Cross Phase		1	1	**2**
Secondary	9	4	1	**14**
Further Education[5]	1		3	**4**
TOTAL	**13**	**10**	**7**	**30**

Courses

Three of the courses were for primary teachers, nine were for secondary teachers and one for teachers in FE. In all, the teachers came from more than one school. Ten courses had from 11 to 20 participants, two had from six to ten and one had more than 20.

[3] These are the models for CPD in the sample, but are not the only models for CPD (see Joubert and Sutherland 2008). Example of other models include self-study, mentoring, coaching and enquiry approaches.

[4] In the UK, the Early Years Foundation Stage (EYFS) was introduced in September 2008 and refers to the stage of education for children aged up to five years. In this report we use EYFS to refer to this phase. The revised curriculum for EYFS includes guidance on the kinds of learning opportunities that should be offered and the developmental progression that might be expected. In the context of EYFS settings children are offered many learning opportunities to engage in *problem solving, reasoning and numeracy*. However, unlike the *communication, language and literacy* section of the curriculum which emphasises the importance of mark-making, *problem solving, reasoning and numeracy* does not. The 'learner centred' approach of the Foundation stage curriculum contrasts with a more teacher directed approach that is sometimes characterised by heavily structured and teacher led approaches, for example worksheets and following a template to create artefacts.

[5] Further Education (FE) students include post-16 students on vocational courses, adult learners and post-16 students studying A Level mathematics. In the sample, however, most of the A Level mathematics students attended secondary schools and these initiatives have been counted as secondary.

All had a set number of meetings: seven had between one and five, two had between six and 10 and four had more than 10. The length of meetings varied: four had meetings lasting between two and four hours (two of which took place as 'twilight'[6] sessions), four had whole day meetings and five had meetings that ran over two days.

Six courses were organised and led by Higher Education Institutions (HEIs) and took place in universities. One was a Masters course and the others were modules of Masters courses and could lead to accreditation at Masters level. The Masters modules and course required reading and assignments, and the full Masters course also required an original research project. Choice of the precise topic of the research project was left to the individual teachers with advice and input from the course leader as necessary and appropriate. One course was organised by a commercial enterprise and led by a university tutor. Participants were able to opt for working towards a Masters unit accredited by the tutor's HEI. Four courses were organised by local authorities. Two of these were National Strategies 'training'[7], the third was a course in which participants could work towards a Masters level accreditation[8] and the fourth, although it was led by a university tutor, did not lead to accreditation. One was a course (two day-long meetings) organised and led by a participant teacher which did not lead to accreditation. The last was a course organised and jointly led by a university tutor and a local authority mathematics advisor and not leading to accreditation[9].

Two primary and two secondary courses focused on generally improving mathematics teaching and learning. Teachers taking part in these courses tended to take part because they wanted to improve their teaching on a general level rather than because of any defined actual or perceived need. Three secondary courses focused on extending the teachers' mathematical knowledge (and two of these were 'Mathematics Development Programme' (MDP) courses[10]) and teachers participated in these in order to develop their mathematical knowledge and, in the case of the MDP courses, to become qualified to teach mathematics. One course focused on the use of handheld computing devices in teaching and learning mathematics and the teachers were invited to take part. It is unlikely that any of them saw participation as meeting a particular 'need' to learn about this device. One course was about the development of Information and Communication Technology (ICT) skills and participants took part by invitation. There was a course which aimed to develop teachers in the role of subject leader, and teachers taking part tended to see this course as an opportunity to prepare for this role rather than as satisfying any particular need in their current role. One primary and one secondary course were run as part of National Strategies curriculum support and development. These courses are perhaps set up to provide and disseminate information rather than addressing any particular teacher needs.

For some courses, participants were expected to perform some specific task or tasks between meetings. In some cases these were called 'gap' tasks[11]. For one course the task was to produce some ICT resources and for another it was to cascade the learning from the CPD course to the various participants' departments. In all but two courses, the tasks involved doing something new in the classroom although this was implicit in some cases. For courses leading to HEI accreditation, tasks included the academic work described above. One of the leaders of a Masters module described the changes she would expect in this way:

> *The teachers on our course would be implementing a change in their practice designed as a result of their engagement with theoretical constructs derived from mathematics education literature and reviewing its effect.*

Teacher change is discussed more fully later in this chapter (Section 3.4).

[6] After school meetings, typically beginning at the end of the school day, are commonly known as 'twilight' sessions in England.

[7] See http://nationalstrategies.standards.dcsf.gov.uk/ for more on the National Strategies.

[8] This course is described more fully in Case Study 2.

[9] This course is described more fully in Case Study 1.

[10] The mathematics development programme for teachers is aimed at teachers teaching mathematics to pupils aged 11-19 without a mathematics degree or Initial Teacher Education (ITE) specialism in the subject. See http://www.tda.gov.uk/about/newsletter/feb2008/improve.aspx

[11] The term 'gap' tasks will be used throughout the report to refer to activities that the teachers were asked to engage with between their CPD sessions. These gap tasks might involve trying out an activity with students in their classrooms, looking at students' work or reading something related to the CPD, possibly a research article.

Courses: Remarks and conclusions

All courses had a set number of meetings. There was a wide range of models for organising these meetings in terms of the number of meetings, their duration and when and where they took place. To attend most of the courses meant time away from the classroom, which had implications for schools, and some teachers remarked that it was difficult to get away for a variety of reasons, including the difficulties of finding cover and the pressure of examinations. For example, one teacher reported that she could only attend when she was not teaching and another said:

> *I cannot afford time off teaching with less than 2 weeks to go before my students go on study leave - especially given the strike.*

In many cases, the courses had specific content to be 'covered' and some courses might claim to be replicable because the course is one of a number of courses within a larger programme. For example, one local authority course was one of five similar courses provided to different teachers within the same local authority. We argue that each course is unique because the local contexts and teachers are different. Case Study 2 (see page 47) describes such a course, and observations of the meetings suggest that an important influence on the way each meeting developed was the leader of the course. In particular, it seemed that, although the course content was provided for him, he emphasised aspects of the course which could be seen to reflect the philosophical underpinnings of the course, such as promoting discussion between teachers while they were engaging with mathematical tasks. It seems to us that the leaders of a course should understand and subscribe to the philosophical principles underpinning the course because otherwise they are likely to deliver the course without conveying the messages about teaching and learning mathematics implicit in the course's design and content.

Other courses, such as the one described in Case Study 1 (see page 31), were more flexible concerning their content and were organised in a way that allowed the course leader to adapt the material the teachers engaged with in response to the teachers' interests and to current developments (such as the introduction of the new National Curriculum[12]). We suggest that in these courses, the roles of the leaders are crucial as they are likely to have major influences on the structure, organisation, group dynamics and content of the courses.

Some of the courses were designed to provide teachers with mathematical knowledge for teaching and it seems that teachers attended these courses to become qualified to teach mathematics at particular levels. It may be that, in these cases, gaining accreditation was the main reason the teachers participated. For other courses, however, it seems that teachers attended not because they perceived a specific need, but because they were invited, because they saw attending the course as an opportunity or because they were encouraged to do so. For example, of the four teachers described in the two case studies of courses[13], two were invited, one wanted to take advantage of an opportunity and one was encouraged (and, we suggest also saw attending the course as an opportunity.)

The range of schools or colleges from which participants were drawn meant that teachers could learn from one another's experiences. Sometimes the institutions involved were geographically relatively close but in other cases they could have been anywhere in the country. Observations of course meetings suggest that teachers frequently discussed their experiences in their own schools and talked about what they or their colleagues did in the classroom. We suggest that it may be important for teachers to meet with colleagues from different institutions as this allows them to talk to people with different professional experiences and hence expose them to new ideas.

Generally courses tended to introduce new ideas and knowledge and some courses focused on specific areas of mathematics knowledge for teaching. In some cases, particularly where the courses led to accreditation, teachers did not seem to understand why they needed to engage with specific subject matter. For example, two teachers on different courses questioned the value of studying mathematics at a level beyond the level of the students they were teaching and did not seem to be committed to the notions underpinning the course.

Others found difficulty with completing academic assignments and claimed that they did not know what was expected of them.

Many courses encouraged participants to make changes in their practice by introducing new types of activity, using different teaching methods and so on. Implementing some of these changes might require time-consuming preparation (for example, introducing handheld computing devices into the classroom, or using more open and investigative tasks) and we suggest that for participants to make changes which involve significant time commitment, a) some support is needed perhaps in terms of time away from the classroom or access to resources and b) the participants have to become committed to the ideas underpinning the change and to see the effort of making the changes as worthwhile (which relates to a).

[12] In the UK, a new National Curriculum was introduced for students in the first year of secondary school in September 2008

[13] Case Study 1, page 42 and Case Study 2, page 47

In some cases, teachers did not introduce the suggested changes at all, or even partly, but they did introduce other changes which were perhaps less time consuming to prepare. An example of two contrasting approaches to introducing change is described in detail in Case Study 1 (see page 42), where one teacher used 'gap' tasks in her classroom and the other made different changes which were not as time-consuming to prepare. For example, he started not writing the lesson's learning objectives on the board and at the end of the lesson asked the students to work out what the learning objectives might have been.

Some teachers suggested that it was difficult to implement change because the students did not like the changes or because school priorities (raising attainment for example) meant that teachers felt under pressure from school or departments to teach in ways that were well established within their institution. Once again, we suggest that teachers may need support to make changes in these circumstances but the support in these cases might be, for example, mentoring or encouragement from another professional.

Within-school initiatives

Five of the within-school initiatives took place in primary schools, four in secondary schools and one in a middle school. Nine are on-going and the tenth is in the process of refocusing to work with feeder primary schools. Five met weekly, three met two or three times a term and two met on an ad-hoc basis.

In all the secondary schools and in the middle school, the initiative was organised and led by the mathematics subject leader and involved the whole department. The approaches to leadership varied, as the vignettes below illustrate. In the first of these vignettes, there is a sense that the leader, Dave, had a plan for the session, and he ran the session to cover the material he planned to cover. In the other vignette, however, there is a sense that, although the head of department, John, was organising the session, he was not leading it as much as allowing the discussions to develop according to the teachers' interests.

Vignette 1: Leading the meeting with a plan

The five teachers met in one of the mathematics classrooms. Dave (the leader/facilitator) began by saying that he wanted them to get into two groups to discuss different ways to group a set of triangles. After about five minutes he asked the two groups to report on what they had done. He asked them to suggest how a Year 8 class might respond to the activity. He then said they were going to have a look at the video of Sandy teaching and he stopped it at a particular place to ask them all what they noticed. After this he led the discussion about approaches to teaching pattern matching, asking the teachers in turn to go to the board and attempt to solve problems.

Vignette 2: Developing a shared plan

The three members of the department met after school in the mathematics office. All had brought along some student work. The head of department, John, started by asking the others what they wanted to talk about, and Jason said that he wanted to tell them about something that had worked well. Mike discussed some of the student work he had brought along, which led to a debate about the advantages and drawbacks of his approach.

Two of the primary initiatives were led by an Advanced Skills Teacher (AST)[14]. In one, the teacher worked with two teachers in her own school who had previously attended some CPD and the AST's role was to help them embed the new approaches to which they had been introduced at this CPD. In the other, the AST was based in a secondary school but in this initiative worked with teachers in a feeder primary school to encourage mathematical reasoning and problem solving, using tasks taken from the 'Nrich' website[15].

Two primary initiatives were led by the headteacher. In one, the headteacher set aside some time at weekly staff meetings to discuss how to develop the curriculum so that it was more engaging for all pupils. In the other, the headteacher worked closely with the two Year 6 teachers to implement new organisational and teaching strategies and then the two teachers reported back to the whole staff in weekly staff meetings.

The final primary initiative[16] was organised by the headteacher and was led by an external expert and promoted the use of materials designed to encourage investigation, enquiry and discussion in the classroom.[17]

All within-school initiatives broadly aimed to improve the teaching and learning of mathematics, with two adopting a 'lesson study' approach[18], one developing resources that (as the organiser said) 'encourage pupils to engage actively in learning mathematics', one developing strategies to encourage pupils to develop writing and explanation skills, and one introducing and using the Mathematics Enhancement Programme (MEP)[19]. In all cases apart from one, these initiatives were set up to develop the department or school, not because of an identified 'need' but rather to explore approaches to teaching mathematics. In the exceptional case, the headteacher reported that she initiated the CPD in response to an identified need to raise attainment in the school improvement plan.

There was an expectation in all these initiatives that teachers would put their learning into practice between meetings, either by trying out new ideas in the classroom (for example using different/new materials or implementing a collaboratively planned lesson) or by sustaining or embedding changes already made in their practice (for example, to encourage pupils to develop writing and explanation skills).

Within-school initiatives: Remarks and conclusions

The within-school initiatives were organised in a variety of ways, and they all involved meetings between teachers. The extent to which the whole school supported the initiatives varied. In one example, the school provided meeting time for the department which was scheduled into the school timetable. In others, teachers reported that it was sometimes difficult to meet because all the teachers involved needed their classes 'covered'. In another initiative, according to the head of department, the senior management team provided no support and the teachers in this initiative said that they were very disappointed. All members of the department left the school for other teaching jobs by the end of the academic year. We suggest that the school has an important role to play in making it possible and easy for teachers within the school to meet.

As with courses, the role of the leader of the initiative can be seen as crucial. In all but one of the within-school initiatives, the CPD was initiated, planned and run by the leader although in almost all cases there was some level of consultation with the other teachers. These initiatives relied heavily on the leader and to a large extent they were sustained by the commitment of the leader.

In all these initiatives, teachers participated because it was expected of them, as members of the department or whole staff. Observation of these meetings suggest that the teachers valued these meetings for a number of reasons. The first is that, because they worked in the same context, they worked from a base of shared understanding, and second, they shared many of the same day-to-day concerns. Third, because all were working towards the goal of adopting a common approach, the whole department would develop (rather than just the individuals) and the students in the school may have accepted new ways of working more easily. There is an argument that within-school initiatives can be limited because the teachers are not exposed to new ideas, but most of the within-school initiatives in the sample drew on outside expertise (such as described in Case Studies 3 and 4, and in one initiative where an AST worked with teachers in a primary school) and research literature (such as, for example, one of the lesson study initiatives where the leader frequently studied the research literature concerning lesson study). Hence we argue that most of the within-school initiatives in the sample were not limited by a lack of new ideas.

In most cases, the participants were committed to the ideas behind the initiative and the CPD can be seen as supporting teachers in embedding new ideas in their classroom practice. However, observations of meetings suggest that some teachers were less enthusiastic about changing their practice and about the CPD itself than others and once again the role of the leader appeared to be very important in encouraging these teachers.

[14] Advanced Skills Teachers are 'teachers who have been recognised through external assessment as having excellent classroom practice'. They are given additional payment and increased non-contact time in order to share their skills and experience with other teachers, within their own school and from other schools'. See http://www.standards.dfes.gov.uk/ast/

[15] http://nrich.maths.org.uk. The Nrich website describes its aims in the following way: 'Nrich aims to enrich the experience of the mathematics curriculum for all learners, offer challenging and engaging activities, develop mathematical thinking and problem-solving skills, show rich mathematics in meaningful contexts and work in partnership with teachers, schools and other educational settings'.

[16] This initiative is described more fully in Case Study 3, see page 52.

[17] (BEAM)

[18] Lesson study approaches are based on Japanese Lesson Study and follow the model to a greater or lesser extent. In all, teachers collaboratively plan a lesson, one of the teachers teaches this lesson and is videoed, and then the group discusses the video. The lesson plan may be iteratively developed. One of these two 'lesson study' initiatives is described more fully in Case Study 4, see page 56.

[19] The introduction to the MEP materials explains: 'The Mathematics Enhancement Programme (MEP) aims to raise standards in mathematics by promoting a more teacher-focused teaching philosophy, together with the provision of suitable teaching resources'.

Networks

One network was for EYFS teachers, one for primary teachers, one for secondary teachers, one for a mixture of primary and secondary teachers and three for teachers in FE. In two of the latter, the participants were teachers of vocational students and in the third the participants taught a mixture of students, with some teaching numeracy to adults, some teaching A Level and further mathematics and some teaching students on vocational courses. In all, the teachers attend by invitation. Teachers tended to attend not because they felt they needed to, but because they valued the opportunities the network provided, and tended to come to network meetings when it suited them – although some teachers suggested that they valued coming to meetings so much that they would be reluctant to miss any.

All networks are ongoing. In the time frame of the RECME study, four networks met termly, and the others met two or three times a term. Of those that met termly, three had whole-day meetings and one had afternoon meetings. All the others had meetings lasting between two and four hours, taking place as 'twilight' sessions.

The network for EYFS teachers formed part of a group of initiatives that were complex and had three strands all of which had been initiated by two researchers Melanie and Lizzy. The first strand of the group was part of a national Children's Mathematics Network for foundation stage and Key Stage 1 teachers and practitioners. It was founded by these researchers and had its own designated website for teachers and practitioners (**http://www.childrens-mathematics.net/**). A central feature of the researchers' philosophy is to support and encourage local grass roots teachers' and practitioners' network groups as an effective means of CPD that focuses on children's mathematical graphics[20]. Their aim is to develop a national network throughout England. Their work is independent and unfunded. The local 'CM Network group' consisted of teachers and practitioners from a number of different settings and schools (Foundation Stage and Key Stage 1) who met termly. One of the teachers in this group had previously attended a two one-day course led by one of the researchers, Melanie. The courses introduced and explored aspects of research on children's mathematical graphics, and those attending were encouraged to consider setting up a local group of their own. The intention was that the teachers and practitioners should 'own' their CPD, by taking responsibility for organising all aspects of the meetings. The researchers do not attend the meetings of the group unless they are invited (as guests)[21]. This CM Network aims to support teachers in taking control of their learning and professional development and during the first months of the network group, the researcher provided support and guidance by telephone phone and email.

The second strand was led by the other of these two researchers, Lizzy, who was also the headteacher of a Children's Centre providing care and education for children up to the age of five. She provided CPD activities for her staff as part of their normal weekly staff meetings. These weekly meetings focused on considering the activity in which the children in the Centre had engaged in the previous week. Different practitioners on the staff brought examples of the children's work and activity to share with the rest of the staff and a particular emphasis was placed on the children's mathematical activity.

The third strand involved the other researcher, Melanie, who was collecting data for her PhD study on children's mathematical graphics. As part of their normal practice, three teachers from the children's centre became involved in the research. They made observations of the children's symbolic play and their mathematical graphics. This research was collaborative with the researcher and teachers co-constructing their understanding through shared dialogue and reflections about the observations and the children's meanings, and discussion about points raised in articles and papers the researcher provided throughout the year. Melanie suggested that their involvement in the research acted as CPD for the teachers, who learnt from their discussions with the researcher about the children's mathematical development and reflected on how they might best support it.

[20] Mark making in mathematics has been identified in recent years as significant for children's understanding of written mathematics in a similar way to children's early mark making in the realm of writing ((Worthington & Carruthers, 2003) Children start to attach mathematical meanings to some of the marks they make in play, when supported by sensitive adults who understand and value their marks and representations and this emergent mathematics is analogous to emergent writing. They are not expected, as one of the case study teachers expressed it 'to learn about shapes by colouring them in on a worksheet' but to explore the shapes that they can make and create themselves and to consider their properties in meaningful situations. To encourage children to develop their own mathematical thinking, teachers offer them many opportunities to make their own marks or graphics, which are called mathematical graphics, to their mathematical ideas. The most significant aspect of children's mathematical graphics is that they support children's mathematical thinking and help them understand the standard, abstract written symbolism of mathematics (including written calculations) at a deep level (DCSF, 2008)

[21] This initiative is described more fully in Case Study 5, page 60.

Two of the FE networks had been set up and organised by NCETM Regional Coordinators. Both aimed, in the long term, to create self-sustaining support groups for teachers. The NCETM Coordinators led the meetings together with outside experts. Both promoted 'active learning' approaches and encouraged teachers to use materials recommended by the network (because they are seen to support active learning) in their classrooms[22]. The third FE network described itself as an 'active learning set'. It aimed for teachers to support one another in embedding new learning from a previous CPD course, and in particular in using specific materials[23].

The cross-phase network brought together teachers from four primary and two secondary schools. Within the network they met once a term to discuss lesson study approaches, to review how the teachers implemented lesson study between the meetings, to discuss academic articles, to do mathematics and to build collective understandings of a variety of topics related to the teaching and learning of mathematics which were shared through communication via the Internet. This network had been initiated and was led by an NCETM Regional Coordinator.

In all the networks described above, there was an expectation that participants would put their CPD learning into practice between meetings either by trying out new ideas in the classroom or by sustaining or embedding changes already made in their practice.

Finally, two of the networks (the primary and secondary ones) worked with university tutors on the development of materials for use in mathematics classrooms. They tended to be loosely led by the university tutors, by which we mean that the tutors planned some structure for the meeting but they were very flexible. In both there was an explicit expectation that teachers should use the materials being developed in their classrooms. In the meetings they discussed their experiences, often adding recommendations for improving or adapting the resources.

Networks: Remarks and conclusions

Most network meetings took place away from the participants' schools or colleges. For those that took place during the day, the same sorts of issues arise as for courses; the need for support from the school or college and the need to spend time away from the classroom. For some teachers, such as Helen in Case Study 6 (see page 66), attending the network meeting took place in their own time for which they were not paid. For some people this may have meant that they chose not to attend the meetings; as one learning support assistant said: 'I'm doing it on a voluntary basis. I don't get paid for going to it'. This sort of problem seemed to occur particularly for teachers working in FE, who were frequently employed on a part-time basis. We suggest that FE colleges have an important role in supporting these teachers to make it easier for them to attend the network meetings, and possibly working out ways of including time given by learning support assistants involved in CPD in their contractual hours.

In some networks the leader adopted a role similar to that described in the courses; they planned and led the meetings, and frequently chose the material they wanted the participants to engage with, although it seems they frequently invited the teachers to do so. For example, in one network, the teachers always read some research literature, and although the leader asks the teachers to suggest what they would like to read, he reported that in practice he chooses. It seems that that, as with courses, these leaders' role is crucially important.

In other networks, as described above, there was a goal to move towards a model of distributed leadership, but this was often not achieved because of the difficulties associated with distributing responsibilities and roles.

An important point about the cross-phase network, is that the teachers said they valued working with teachers in other phases. The fact that they had to describe their work explicitly meant that they developed new insights into how they worked and what they did in the classroom.

Interview data from participants in the networks indicates that the meetings were very important for teachers in FE and adult education. These teachers seem often to feel isolated in their colleges and other work settings and coming together to discuss mathematics teaching and learning is well received. We suggest that they could also have an important role for primary and secondary teachers and that cross-phase networks might have some interesting benefits.

[22] 'Active' learning is an approach in which students engage in discussing and explaining ideas, challenging and teaching one another. For a more detailed explanation see pages 7-10 of the Improving Learning in Mathematics (often abbreviated to ILM) (DfES, 2005). These curricular resources are also designed in such a way that engaging with them and using them in the classroom could lead to professional learning for teachers.

[23] Thinking Through Mathematics (NRDC, 2007) resources which are based on the same principles as the ILM materials (see footnote 22) and grew out of them.

3.2. CPD meetings

During the observed CPD meetings from all 30 initiatives, the participants worked with a variety of mathematics teaching resources, such as textbooks, resource files[24] and mathematics software. Other resources were used to support the teachers in thinking about the teaching and learning of mathematics in their classrooms, such as students' work, video of classroom teaching episodes, policy documents and research reports and papers. The majority of initiatives used students' work in their meetings, and almost all used policy documents. About half used curricular resources, with some specifically working on creating resources. A minority used mathematics software, other new technologies (such as interactive whiteboards), research reports and video. Physical apparatus that supported mathematical thinking and include resources such as multilink cubes, bead strings, number lines and others were used. This was particularly so in the primary initiatives, where practical work and practical resources were key elements in helping the teachers to mediate mathematical concepts for their pupils.

The CPD initiatives were organised to include opportunities for many different activities, such as discussion, making presentations, listening to other participants or the leader/facilitator, brainstorming and making posters. Doing mathematics either alone or in groups, listening to other participants and the leader/facilitator, sharing knowledge and discussing student work took place in the majority of initiatives. Making presentations to the group took place in half with brainstorming and making posters taking place in a minority.

All initiatives combined a variety of ways of working. For example, in Case Study 2 (see page 47) there is a description of an activity on fractions that was tackled by small groups of teachers. It served as an opportunity for them to engage with the mathematical topic but it was also suitable for use in the classroom. As part of the latter focus, it served as a model for classroom organisation which encourages discussion within small groups and provides learners with challenging tasks that emphasise making connections within mathematics and reasoning as well as on obtaining the correct answer.

[24] Such as the ILM and Maths4Life materials, see footnotes 22 and 23

3.3. Areas of focus: New knowledge and skills

This section discusses the subject matter participants engaged with in the CPD, where the data are taken from observations of meetings and interviews with the teachers and organisers. The areas of focus include:

- mathematics
- students' and children's mathematical conceptions
- ways of teaching mathematics[25].

These three areas are sometimes collectively termed 'mathematics knowledge in teaching'. Other focus areas include research, the development of ICT skills, training about implementing new policies, departmental issues and disseminating information. Almost all initiatives included a combination of these..

3.3.1 Mathematics

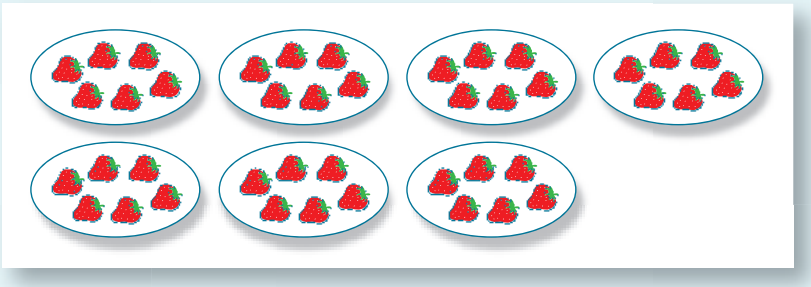
Most initiatives paid explicit attention to mathematics (see for example, Case Study 4, page 56, where the participants worked on quadratic equations), almost always relating this to the teaching and learning of mathematics. In some initiatives, this mathematics was at the same level as the mathematics encountered by the students in the classroom, and in some it was at a higher level.

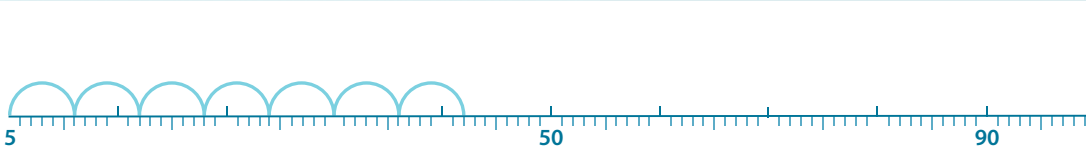
The vignette below provides an example of the mathematical content addressed in one initiative. The network at which this took place was, at this stage, led by Tom.

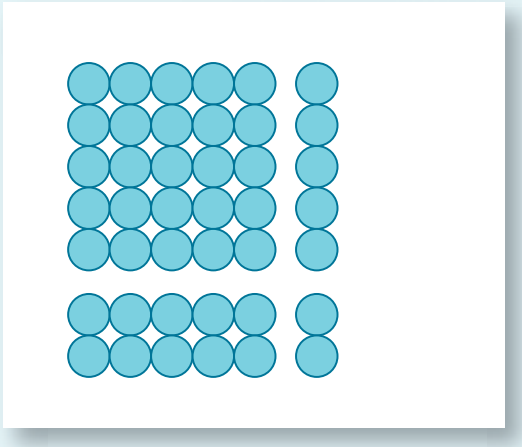
Vignette 3: Representations for multiplication

Tom went through some examples of different representations of numbers and discussed how some are more appropriate in one set of circumstances and others in other circumstances. He provided some examples, together with the sorts of questions a teacher might ask about the representations, and suggested how these sorts of questions might promote reasoning in the students. He displayed three different representations of the multiplication 7x6 for discussion.

[25] See Joubert and Sutherland (2008) The NCETM self-evaluation tools (SET) are underpinned by the principle that teachers' knowledge falls into three types; mathematics content knowledge, mathematics specific pedagogy and embedding in practice. We see mathematics specific pedagogy as including both students' mathematical conceptions and ways of teaching mathematics but we consider it important to separate the two for analytical purposes. We do not consider embedding in practice as an area of focus, and we address it in Section 3.4.







Which of these representations allow us to best reason the properties of multiplication

multiplication and divisional\Multiplication through arrays B.exe

Slide 31

In the vignette above, the participants became engaged in discussion about multiplication, and it was common to observe discussions about mathematics in many of the initiatives. In many, participants became involved in doing mathematics themselves; altogether we observed participants doing mathematics in 17 of the initiatives, either at the same level as their students or at a higher level. Examples include working on fractions (primary teachers) and classifying triangles, trigonometry, calculus and statistics (secondary teachers).

Some initiatives addressed connections within mathematics such as connections between fractions and decimals (primary teachers) and multiple representations of functions (secondary teachers) and understanding the structures underlying mathematics.

3.3.2 Students' mathematical conceptions

We suggest that in the context of a study about CPD, addressing knowledge about students' mathematical conceptions means exploring student learning and evidence of student learning. This section begins with a vignette in which the leader of the CPD, Cath, asked the teachers to watch some video footage and to look out for evidence of student learning.

Vignette 4: Examining student learning – vectors in the secondary school

> Cath said that Derek (one of the teachers) had brought along some video recordings. Derek explained how he had organised the filming and that he had used three cameras in his classroom. The lesson was about vectors and approximately half of the students had not been introduced to vectors before. The video was about his teaching this group of students, and he gave the others a text book and asked them to work on questions related to 3D vectors. The teachers watched about five minutes of video. Comments from the group included the opinion that this video was better than 'officially video recorded classrooms' because 'you can see the enthusiasm, it's not stilted'. Another remarked that the active approach the teacher took was a good way of teaching. Cath asked if they could see any evidence of student learning. What would count as evidence?

Cath, the leader, commented later that teachers find it very difficult to focus on student learning rather than on teaching. We think this is an important point and we believe that understanding students' mathematical conceptions, or the way they make sense of mathematics, is tied up with being able to discuss student learning. Further, we argue that it is crucially important for teachers to develop understandings of student conceptual development (Watson & Mason, 2007) but we suggest that, as Cath remarked, this is difficult to achieve. Despite this difficulty, the data include a variety of examples of approaches adopted by various initiatives. Some of the CPD leaders made it clear that, by asking teachers to do mathematics, as described above, they were putting teachers into the position of students and we are aware that this approach is sometimes adopted in order to help teachers understand how students make sense of mathematics.

The vignette in the previous section provides an example of a leader of a CPD initiative encouraging teachers to think about and discuss the sorts of meanings students would construct from each of the various representations of multiplication, and how they might affect the development of their understanding of the concept of multiplication.

A second example is drawn from an initiative that developed resources for extended units of work. In the teachers' discussions which formed the central part of their meetings, they considered carefully how the students might interpret the tasks and what mathematical meaning they might draw from the tasks through engaging with them. Approaches to a particular topic were discussed and individual teachers took on the role of working on resources between meetings. The resources were tried out with students and then developed further in the light of the teachers' feedback.

The approaches outlined above pay implicit attention to students' conceptual development but it was seldom made explicit. Our observations of CPD meetings suggested that specific examples of students' responses were not often considered in depth.

Another (more explicit) approach used by some initiatives was to ask teachers to bring along examples of students' work and to discuss how this work developed and what difficulties the students appeared to encounter. In some cases, these discussions referred to research literature, such as in Case Study 2 (see page 47), where Roger the course leader explained that the tasks on the topic of fractions that the teachers used in the CPD session related to some of the common misconceptions about fractions described in the books that they had received as part of their course materials. The teachers were expected to read something of the background from these books, to try out the activities in their classrooms and undertake a detailed analysis of some children's responses, then bring their analyses to the next meeting to discuss with the group. Observations of meetings in which students' work was discussed showed that teachers tended to focus on what the students did rather than their learning or conceptual development, and the earlier part of the observed meeting in this case supports this. However, we would suggest that this is because analysing students' work is very difficult and that this difficulty is often compounded by the teachers' inexperience in doing so.

The initiatives that seemed to be successful in engaging teachers in such analysis devoted a lot of time to it and made it a central focus of their work, for example, as seen in Case Study 5 (see page 60). The section 'At the intersection' below (Section 3.3.4) provides three further examples of approaches CPD initiatives took to addressing this area of focus explicitly. All the examples described there engaged teachers in cycles of prediction, trying out, observing, reflecting, which seem to us to be of significant help to teachers, especially when they include observing students as they engage in mathematical activity.

3.3.3 Ways of teaching mathematics

The vignette 'Representations for multiplication' on page 30 also describes how the initiative attended to teaching mathematics by discussing the sorts of questions teachers might ask students about different representations. Discussion about ways of teaching mathematics was threaded into almost every part of that observed meeting and included areas such as planning teaching, developing tasks and discussing classroom management.

All initiatives attended to aspects of teaching mathematics in various ways, apart from one, which was primarily concerned with the development of the teachers' ICT skills. In some cases a particular approach was promoted and in others the ways of teaching mathematics were implicit in activities such as creating resources and discussing the implementation of new policies or departmental issues.

The particular approaches promoted in the different initiatives were sometimes quite specific and in other cases more general. They included: using extended activities that encourage deep learning; developing more teacher-led lessons; encouraging students to write explanations; setting students into groupings according to their previous and predicted attainment in mathematics; encouraging more discussion about mathematics in the classroom; the use of 'rich' tasks[26]; and the use of more open questioning techniques and 'active'[27] learning.

We observed a wide range of approaches to addressing knowledge of ideas about teaching mathematics. In the two vignettes below, different approaches are described. The first takes place in a secondary school mathematics subject office, and describes an approach adopted by the department to teaching the subject.

Vignette 5: Index cards – writing mathematical explanations

> Adam, the subject leader, encourages the members of the department to give all pupils index cards on which to write down explanations. He says that he believes that, in writing down explanations, students learn to explain and articulate ideas. At the meeting I observed, Pete brought out some of the index cards his students had produced and the teachers discussed them.

In a second vignette, the focus is on the use of handheld computing devices.

Vignette 6: Using handhelds in mathematics – linking multiple representations

> This is a pilot evaluation of the device which includes CPD for the teachers. The CPD promotes the use of computing applications in KS3 and 4 classrooms, particularly focusing on the value of dynamically linked multiple representations. As the leader of the CPD explained, it encourages teachers to develop 'approaches which require the teacher (and/or learners) to explicitly link variables to solve mathematical problems'.

These two examples demonstrate some ways of teaching to which teachers were exposed. These, and many of the others we saw, are quite specific. However, the approaches suggested by other initiatives were often more general (such as the approaches described in Case Studies 1 and 2).

The discussion above has been concerned with strategies for teaching mathematics. Closely related to this are the resources used to support teaching (Remillard, 2005; Remillard & Kaye, 2002). Earlier sections have already mentioned specific resources, but to summarise, those promoted by the various initiatives included the ILM and Maths4Life resources files, the Mathematics Enhancement Programme resources, the software designed to support the teaching and learning of multiplication, the National Strategies published resources and 'Let's Think' materials.[28]

Some initiatives focused on raising teachers' awareness in the classroom; to be more aware of what they were doing and to be more aware of the students' responses to what they did. One approach we saw used video. In that lesson study initiative, five teachers in the same department met every Monday. They planned a lesson in detail over a period of

[26] In the guidance document 'Mathematics at Key Stage 4: developing a scheme of work', the Secondary National Strategy describes a rich task as:
* accessible and extendable,
* one which allows learners to make decisions,
* involving learners in testing, proving, explaining, reflecting and interpreting,
* promoting discussion and communications,
* encouraging originality and invention,
* encouraging 'what if' and 'what if not' questions,
* enjoyable and contains the opportunity for surprise.

[27] See footnotes 22 and 23

[28] This is a resource pack for primary schools developed by Kings College London researchers, published by NfER Nelson.

several weeks and then one taught the lesson and a local authority contact came in to school to video it. The researcher talked to one of the teachers, Sandy, about her experience of being videoed, and she said that she gets nervous every time, but she can see the value in it and is convinced that it is very worthwhile. She says that she learns something about herself and her teaching each time she watches a video of herself. She also remarked that she became aware of other approaches she could adopt by watching video of other teachers; the example she provided was that her colleague Mike often teaches 'from the back of the classroom' and that this had made her much more aware of her own tendency to stay at the front of the classroom.

A second example explains how one teacher's awareness had been raised through a focus on specific techniques in the CPD initiative. In interview, the teacher, Dave, said that there had been two key aspects of the course which had raised his awareness of mathematics classroom issues when planning and teaching and thinking about the effectiveness of lessons. He explained:

> *Firstly, the analysis of the use of ICT in the maths classroom and its role as a modelling tool to promote deeper understanding of ideas. For example, Tom [the course leader] is a great advocate of the software and makes use of it on the course and this helps when returning to school and thinking about delivery of lessons. Secondly, tutors have spent time developing 'higher order' questioning techniques with their group of teachers. This is an attempt to raise the level of questioning techniques to increase the way in which students can link ideas that promote a fuller understanding the ideas being taught.*

He explained that as a teacher, he is aware of the pedagogic approaches of his tutors on the CPD courses he is involved with. He learns a great deal from them about the way they choose to present the work and the way they run their classes and he also experienced what it is like to be a student. He described the slightly stressful situation of being required to produce an answer and said that this had made him more empathic with his students.

3.3.4 At the intersection: knowledge about mathematics, students' conceptions in mathematics and ways of teaching mathematics

In the three sections above we separated the three aspects of teacher knowledge so that we could focus on each one in turn. However, as Joubert and Sutherland (2008) pointed out, the relationship between the areas is crucially important. In this final section, three examples are used to demonstrate how these three different strands of teacher knowledge are integrated.

In the first, Sophie was the leader of this course for primary school teachers. The vignette is taken from the research field notes and describes the meeting.

Vignette 7: Primary teachers working with 2D and 3D[29] shapes

Sophie handed out some 2D and 3D shapes. She asked the teachers to work in small groups and sort them using a variety of criteria. The teachers sorted them; some by colour, others by materials, right angles, 2D/3D. After they had finished they discussed the task. Sophie discussed how the task might be used in the classroom, suggesting that teachers should accept all the children's answers and then use these as a basis for further discussion.

Sophie asked the teachers to stick their shapes onto the flipchart in either the 2D area or the 3D area. Discussion followed about which shape on the flipchart needed moving and why. A group discussion followed, addressing questions about how the children would approach this task and how to deal with their responses, including suggestions of questions to ask such as 'what is the rule', 'what do you think, why not', 'what does [a medium group] mean?'

Later on two teachers each taught this lesson to two groups of six Year 1 children. The other teachers observed. After the lesson, the teachers discussed how the children sorted, what their criteria were and what had surprised them.

[29] Two-dimensional (2D) and three-dimensional (3D) shapes

In this example, the teachers were exposed to mathematical ideas which were concerned more with the patterns and structures of mathematics than the specific properties of shapes. They thought carefully about the possible responses children might make when exposed to the activity, and then they observed the children and explicitly discussed what they had noticed about the children's responses.

In another initiative, one of the lesson study initiatives, teachers spent a significant amount of time discussing both the specific mathematics they had decided to study as well as how it fitted into the mathematical landscape. They paid explicit attention to the potential student responses to the activities they were planning. One of the teachers taught the lesson and it was videoed. In a later CPD session, they watched the video and discussed, among other matters, the expected and actual student responses.

The final example in this section is taken from the EYFS context. It involves a leader who is a researcher working with teachers in collecting data for her doctoral study. Her research focus is on children's mark making in mathematics[30]. In the observed session with the three teachers who work in a children's centre with children aged under five years, the three teachers all brought examples of marks that children had made and related the stories that surrounded them. Their observations were focused on children's spontaneous play and they discussed the mathematical aspects of their actions. They also brought some examples of children's work and discussed in detail the conversations that they had had with the children about the meanings of their marks and the distinctions between marks that were 'writing' and marks that were 'numbers' or mathematical symbols. In this context, the mathematics which was the focus was the early use of mathematical symbols and the work of the teachers focused on the mathematical activity of their pupils. The way of teaching being supported was based on the spontaneous mathematical activity of the children. Here the teacher could act as a facilitator by making sure that appropriate resources to encourage mathematical representation were available and also ask children questions that encouraged them to articulate their mathematical thinking and reasoning.

The three approaches described above are all different, but in all three the mathematics is non-trivial, there is an emphasis on understanding, observing and reflecting on the students' (or children's) thinking and new/different approaches to teaching evolve from them. Importantly, these CPD initiatives were arranged and organised in different ways, but the underlying principles were similar in that they all operated at the intersection of these three aspects of mathematical knowledge for teaching.

3.3.5 Integrating ICT into teaching and learning mathematics

One initiative had the development of ICT skills as its stated aim; the teachers learnt to program macros in Excel to create revision resources for use by Year 10 and Year 11 students.

In another, teachers learned how to use the TI-Nspire handheld computing devices. They then developed teaching activities incorporating the use of these devices, taught the lessons and evaluated them.

As already explained, the aim of the two networks was to develop and trial ICT resources. Vignette 3, (see page 30) 'Representations for multiplication' is taken from observation notes of one of these, and as described, participants discussed the mathematical meanings in the representations and the ways in which children might make sense of these. They also discussed the potential use of the software in the classroom. They used the software with their classes in school and in subsequent meetings discussed their experiences. The other initiative which developed and trialled ICT resources followed a similar pattern.

In both initiatives, the teachers reported that they used the ICT resources in their classrooms and observations suggested that their use was becoming embedded in their practice. They also reported that they enjoyed the experience of contributing to the development of the resources and felt that their contribution was valued.

Another initiative devoted a day to developing participants' skills in the use of the graphing software, Autograph. The use of *Autograph* was integrated into mathematics teaching and learning – a key component of this course. This course also used virtual classroom software for fortnightly on-line lessons on an aspect of A Level mathematics led by one of the course leaders and backed up by email and website support. In addition, the course provided access to 'hundreds of interactive resources including 'teach-yourself' random question generators, interactive Flash animations, spreadsheets and *PowerPoints*'. Interestingly, Dave's comment on page 34 is from one of the teachers in this initiative; as he said, 'Tom [the course leader] is a great advocate of the software and makes use of it on the course and this helps when returning to school and thinking about delivery of lessons.'

[30] See footnote 20

3.3.6 Research

A number of initiatives paid explicit attention to the research literature, reading research papers related to the teaching and learning of mathematics, to research methods and to other educational issues. Chapter 8 provides more details. Some reading and discussion of research literature took place during meetings, but much of the participants' engagement with this content took place between meetings.

3.3.7 Information

It was common to observe dissemination of information in CPD meetings, such as information about curriculum changes, as in the case of the National Strategies-based CPD initiatives. One of these focused on supporting teachers of children in Year 1 from one local authority in implementing the revised primary framework for mathematics in their classrooms. It worked on the basis of three day-long meetings held once a term. The teachers were given information about the revised framework and opportunities to engage with resources that supported the new emphases on speaking and listening, using and applying, assessment for learning and making use of real life contexts.

A second example is described in the vignette below. The CPD leader, Sarah, introduced the new secondary curriculum. This had not been an explicitly stated aim of the CPD, but she told the teachers that she had been on some training for it and wanted to let them know so that they could 'go back to their school knowing what's going on'.

Vignette 8: Introducing the new secondary curriculum

> Sarah handed out copies of the QCA document 'The new secondary curriculum. What has changed and why?'[31] and asked the teachers if they knew about the proposed changes. She told them that the new curriculum was to be introduced in the 2008/2009 school year for all students in Year 7. She went through some of the points made by the document and told the teachers that they could expect training in their own schools before the end of the year.

Others initiatives provided information about available resources for teaching, such as some of the FE-based projects which recommended the Improving Learning in Mathematics and Maths4Life resources[32].

[31] Reference: (Waters, 2008)

[32] The ILM and Maths4Life resources are discussed in footnotes 22 and 23

3.4. Encouraging change

The discussion above considered the areas of focus of the CPD meetings. However, RECME sees CPD as an ongoing process and we consider what teachers do between meetings to be an integral part of the characterisation of any initiative. In particular, it is important to consider the ways in which teachers use new knowledge. We argue that use of new knowledge is related to the effectiveness of CPD initiatives, but our interest here is to understand more about how CPD initiatives encourage the use of new knowledge and support the embedding of changes. The discussion above looked at the expectations of the various initiatives in terms of changes in teacher practice and it provided some examples. This section returns to this notion, looking in detail at the sorts of changes expected and ways in which the participants discussed what they had done.

Expectation of change

In many initiatives the teachers were offered suggestions about ways of working in their classrooms and then asked to try them out. In some initiatives, implementing something new in the classroom was strongly encouraged, such as with 'gap' tasks[33]. In one example, participants worked with handheld computing devices and were expected to try out working with them in the classroom. In two of the lesson study examples, teachers were expected to adopt more flexible ways of working with the students.

In other initiatives, teachers were introduced to new activities, resources and teaching approaches. There was much less of an **expectation** that these would be tried out in the classroom. For example, in one primary within-school initiative, the headteacher discussed new approaches to teaching mathematics with the whole staff, and the teachers could choose whether or not to adopt these approaches.

As discussed above, although for the Masters courses there was a necessity to make some changes to practice in order to carry out the research project, the choice of what changes to make was left with the teachers.

Teachers discussing change

Frequently there was an expectation that the teachers would talk to the CPD group about the changes they had tried out[34], as in one network described in the vignette below[35]. Laura was the leader of the CPD. Laura explained that in the last meeting some people set themselves some action points and she was going to ask them to present what they had done in the classroom.

[33] See Case Study 1, page 42 for example

[34] See Case Studies 1 and 5, for example

[35] This vignette refers to the initiative described more fully in Case Study 6.

Vignette 9: Different ways of teaching mathematics

Nathan works at a prison. He asked the participants to look at the paperwork he had placed on their tables, outlining the content of his presentation and including the worksheets he had given the students. He discussed the difficulties that some students at GCSE have with histograms and described the basic ideas. He concluded by asking for feedback and comments from the other participants, but none of them had comments.

Dan teaches at a 6th form college. The context of his presentation was AS level[36] – Laura emphasised that although not everyone does the same mathematics, the principles apply across the board. Dan and a group of other teachers had worked on circle revision (for end of C1) – they came up with the idea of making up some questions and some diagrams to go with them and asking the students to match the questions with the diagrams. He suggested that this method of working had 'opened up' questioning in his classroom. The effect on him, he said, was that he dusted off his interactive whiteboard then played 'silly games' with his students. He also asked students to draw a snowman using Autograph, and suggested that this is a good way to 'force students to use Autograph'.

Helen teaches basic literacy and numeracy. She told the group that she had looked at a common misconception – 4.39 is bigger than 4.7. She had previously asked closed questions about 'why' students thought this was the case, but said that she had had limited success. She said that she looked at the 'classic mistakes'[37] website but did not like that because it is explicit about when something is wrong (she explained that 'it puts a cross next to it'). She went to the NCETM portal[38] and got the idea of 'I heard a rumour that ….. ' (for example, I heard a rumour that 4.37 is bigger than 4.9). This wording, she suggested, meant that the students don't know if a statement is true, false, or sometimes true. She had made up about 12 problems on a sheet. She could go round and say 'tell me what you think' and 'why did you think that?' She remarked that you can use these questions and ask the students to work in a group to explain. She recommended a book 'Teaching maths to pupils with different learning styles' by Clausen-May (2005) which she had found very useful need very visual ways of learning.

In Vignette 9, the teachers reported on the new ideas they had tried out in the classroom, but there is no evidence that they questioned whether or how their changes in practice may have been beneficial to their students' learning. However, Helen also went on to tell the group that she had used visual aids because many of her students 'aren't very good with aural work or find it difficult to read' and in this comment was beginning to provide a reason why the approach she took may be of benefit to the students.

Teachers sometimes only reported in positive ways on changes recommended by the CPD initiatives without mentioning difficulties they encountered. For example, in Case Study 1 (see page 104) one of the teachers, Barbara, reported on a tessellation 'gap' task she had done with her students. She seemed to be very proud of their work and very pleased with what she had done. When she was interviewed at a later stage, she divulged that she had found that preparation for the task had been very time consuming but she did not mention this when she reported to the group.

Some initiatives explicitly encouraged reflective and critical thinking about the changes teachers had made, where reflective thinking includes critical evaluation of the changes and the effects these may have had on their teaching and their students' learning. In the lesson study initiatives, reflection is integral to the process and in the two initiatives that trialled resources, critical reflection was expected.

It was not always the case that comment about changes in practice was necessarily shared with the other participants but rather took the form of reflective logs (or journals[39]) or, in the case of Masters courses, reflections were incorporated in assignments and/or research reports. One initiative explicitly required the participants to evaluate the new ideas they had introduced in writing, providing them with lesson 'evaluation' sheets, which included questions such as 'What aspect(s) of the idea would you use again?' and 'What changes would you make?'.

Sustaining change/embedding practice

It is well recognised that sustaining change is important (see, for example, Joubert and Sutherland (2008)). However, it is often hard for teachers to sustain the changes they make to their practice, as some of the participating teachers explained. For example, pressure of examinations appears to have prevented teachers from trying out new things and hence getting the best out of their CPD. The curriculum was also cited as a barrier.

[36] Advanced subsidiary level, which includes two core units (C1 and C2) as well as a third module.

[37] www.classicmistake.co.uk

[38] Case Study 1, in Chapter 8, page 104 describes in detail how this teacher uses the portal.

[39] The organiser of one initiative described reflective journals in the following way 'A reflective journal is really the teacher's personal log of their activity and involvement within the project - and their thoughts about it... So it includes lesson evaluations, copies of emails, correspondence, 'notes' to themselves, action plans etc. It is probably the equivalent of a researcher's' field notes'. In some initiatives these were called 'learning diaries'.

In other cases, teachers explained that their school or department did not support them in making changes or resisted change. As one teacher remarked, 'traditional expectations from colleagues hamper my opportunities'. Another explained that she would like to experiment with topic-based learning but her department wanted her to follow a textbook. In a final example:

> *Approaches further up in my school mean I can't share this very successfully with colleagues in other age groups. Our school leadership is very conventional and would not call this real maths! The fact that I can't share this outside our year group means it is harder to keep the momentum up.*

Some teachers reported that the students resisted change and therefore they found it difficult to put their learning into practice.

> *Yes the children have mixed feelings about it and that can be a bit of a worry because I don't want them to dread it. One of them said it makes it much more interesting if you look at it this way. The worry is them being able to perform and getting through things and the exam pressure is the main worry.*

Another suggested that the students wanted conventional teaching:

> *The students expect chalk and talk. They want exam prep! They don't see the point of exploring the concepts and ideas!*

This suggests that teachers may need support in embedding change, and some initiatives can be seen as aiming to support sustained change. Instead of changing practice they aim more to embed previous learning[40]. For example, one FE network was set up to support teachers in embedding the use of the 'Maths4Life' materials (see footnote 23), to which participants had been introduced in a previous CPD initiative. The within-school initiative that used 'extended activities to promote deep learning' (see page 27) focused on supporting the teachers in embedding this approach.

There is an argument that courses cannot support teachers in embedding change in the longer term because of the fact that they come to an end. However, some courses do continue to provide support, such as one in the sample that provides online and telephone support for two years after the end of the course.

3.5. Conclusions

The thirty initiatives in the sample fell into three types which can be characterised as:

- **courses** – which were those initiatives having a number of meetings, with more or less defined intended participant learning
- **within-school initiatives** – where all the participants came from the same school
- **networks** – which were meetings for groups of teachers from different schools or colleges who gathered to provide mutual support for one another.

All the CPD initiatives in the sample involved teachers attending meetings organised in a variety of ways in terms of the number, their duration and when and where they took place. It was sometimes problematic for teachers to attend meetings, particularly when doing so meant taking time away from the classroom. Support from schools and colleges can make it easier for teachers to attend meetings.

The leaders of **courses and some networks** had responsibility for shaping the organisation and areas of focus of the CPD and therefore had the potential to exert a major influence on the way the CPD developed. Leaders in the **within-school initiatives** seem to be equally important; they initiated, planned and led the CPD and these initiatives were normally sustained by the commitment of this individual.

Some teachers took part in courses in order to gain qualifications. However, most teachers in the courses and networks seemed to participate not because they perceived a specific need but because they were invited, they wanted to take advantage of an opportunity or they were encouraged. The teachers came from more than one school or college and taking part provided them with opportunities to meet with colleagues from different institutions, talk to people with different professional experiences and be exposed to new ideas. In the **within-school initiatives**, all members of the staff or department took part in the CPD and they drew on outside expertise and/or the research literature for new ideas. These initiatives were primarily concerned with the development of the department or the school rather than the individual, and seemed often to foster departmental or school cohesion.

[40] This is exemplified by both teachers in Case Study 6 on page 66, particularly by Teacher 2.

Courses and some networks tended to introduce participants to new ideas and knowledge, frequently focusing on specific mathematical knowledge for teaching, but in some cases taking a more general approach to improving mathematics teaching and learning. The **within-school initiatives** also focused on generally improving mathematics teaching and learning.

All initiatives attended to aspects of mathematical knowledge for teaching combining, in various ways, mathematics, students' conceptions in mathematics and ways of teaching the subject. It appears to be difficult to address knowledge about students' conceptions in mathematics (and hence student learning), but the data do provide examples of approaches which achieve ways of attending to the students' learning: through the use of video of students' responses in mathematics lessons; through teaching 'real' children in CPD meetings; through stepping back and observing children and then collectively reflecting on this activity. In some initiatives, the participants engaged with ideas about integrating ICT into teaching and learning mathematics, in some participants read and discussed research and in others information was disseminated.

There was usually an expectation in the CPD initiatives that the teachers would try out new approaches in their classrooms and in some cases it seems that teachers saw the CPD as providing 'permission' to try new ideas. In many cases, trying out new ideas was followed with feeding back to the rest of the group at a subsequent CPD session or reflecting on the trial in a journal. Some initiatives, rather than introducing teachers to new knowledge and ways of teaching mathematics, focused on supporting teachers in embedding approaches to teaching and learning mathematics to which they were already committed.

4. Exploring the data: six case studies

This chapter consists of case studies of six of the initiatives. The case studies **characterise** the initiatives and begin to unpick the multiple factors contributing to the unique character of each. In doing so, they contribute to further addressing the first aim of the study (to characterise different types of CPD). Whereas Chapter 3 provided a characterisation of the sample across the 30 initiatives, this chapter provides more detailed characterisations of the six case study initiatives.

The case studies also demonstrate how different teachers take up and respond to different opportunities provided by CPD in different ways. Our purpose is not to provide exemplars of 'good' or 'effective' CPD or to evaluate CPD initiatives, but to present characterisations of CPD and emphasise that a single CPD initiative may influence teachers in different ways. However, while we do not evaluate the CPD initiatives, our analysis does provide evidence of change in individual teachers and we suggest characteristics of the CPD that may have contributed to the change. This begins to address the second aim of the project: to investigate the interrelated factors that contribute to 'effective' CPD for teachers of mathematics.

Chapter 3 distinguished three main types of CPD initiatives in the sample: courses; within-school initiatives; and networks. This section includes two case studies from each of these categories.

Courses:

- Case Study 1: a six-day course run by a local authority for secondary school teachers.
- Case Study 2: a 10-day course run by a local authority for primary school teachers.

Within-school initiatives:

- Case Study 3: an initiative run by an external provider for the whole staff of a primary school.
- Case Study 4: a lesson study initiative in a secondary school.

Networks:

- Case Study 5: a network providing support and thinking space for teachers of foundation stage children from a number of schools.
- Case Study 6: a network providing support and thinking space for teachers of mathematics and numeracy in the further education sector.

4.1. Developing a framework for characterising an initiative of CPD

The socio-cultural perspective we adopt suggests that the ways in which the organisational structures of CPD initiatives are combined will be influenced by the specific contexts in which the CPD takes place and hence we argue that each CPD initiative is unique. We argue that, in order to understand each unique CPD initiative, it is necessary to investigate not only the content, context and processes of the initiative, but also a range of other factors influencing the initiative.

In particular, CPD takes place within school and national contexts and is likely to be influenced by these contexts (Bishop & Denleg, 2006; P. Cobb & Smith, 2008). It is further likely to be shaped by the motives, beliefs, theoretical understanding and experience of the designers of the CPD (Rogers et al., 2007), the feedback they receive from the ongoing CPD, as well as the specific aims of the initiative, the intended teacher professional development (learning) and intended teacher change (Goodall, Day, Lindsay, Muijs, & Harris, 2005). This suggests that a characterisation of a CPD initiative needs to take account of these factors.

As outlined in the previous paragraph, CPD provides, at the most general level, opportunities for teachers to become involved in processes of learning and change. Different teachers, influenced by the contexts in which they work and their personal motives, beliefs, theories and experience, will perceive different opportunities, and these perceptions may shift over time. It might therefore be important to explore the responses of individual teachers to the CPD initiatives in which they are participating, in terms of their own learning, changes in their classroom practice and their perceptions of change in student learning. We expect these factors to contribute further to rich descriptions of individual CPD initiatives.

Taken together all these factors provide a framework for analysing initiatives of professional development. This framework characterises the initiatives of professional development from the perspectives of the observer, the organiser and the participants, particularly emphasising the experiences of individual teachers and.

To summarise, the categories used are:

- Context: describes the background to the CPD initiative
- Aims of the CPD: outlines the aims of the CPD as expressed by the organisers or leaders
- Intended professional development (teacher learning): also taken from what the organisers or leaders reported
- Intended changes in practice: also taken from what the organisers or leaders reported

- Content and processes of the CPD: describes the structure and organisation of the CPD taken from observations of CPD meetings and interviews with teachers and organisers or leaders of the CPD
- The teachers: provides some background to the teachers who were invited to take part in the in-depth part of the research, discusses their self-reported learning (actual professional development), changes in practice and changes in student learning
- Conclusion: discusses the CPT initiative and includes a comparison of the opportunities teachers took up and how they took them up and speculates on possible factors affecting these choices..

4.2. Case Study 1: Secondary course

4.2.1 Context

This initiative was run by a local authority mathematics adviser and a university-based teacher educator. The initiative is now in its third year; two cohorts have already completed the programme. The participants were all secondary school mathematics teachers from the local authority who attended five separate day-long meetings over the course of a year.

4.2.2 Aims of the CPD

Although the course leaders stated that 'this project focuses on helping teachers to understand the underlying principles of assessment for learning and applying these to embedding effective practice in the classroom' (www.ncetm.org.uk/recme), they told us that the actual content addressed in each of the days was, to some extent at least, informed and influenced by the work of the teachers both during the meetings and in the classroom, and by their concerns and questions. In order to be free to follow this flexible approach, the course leaders deliberately did not have any further documented specific aims.

However, they told us that their general aims were threefold and they saw them as related and interdependent: a) to provide time for the teachers to reflect, b) to encourage teachers to put their learning into practice in the classroom and c) to engage the teachers with relevant research.

They also said that the course aimed to create a community in which teachers could meet, talk, share and learn from one another. The leaders created a community web page where the teachers were able to share resources, thoughts and ideas, away from the face-to-face sessions.

4.2.3 Intended professional development

The course leaders told us that they hoped that by providing the opportunities described above, participating teachers would be inspired to think more critically about their own practice, to pay more attention to how pupils learn mathematics, and to develop the confidence to allow pupils to follow their own directions rather than scripting their lessons in detail.

4.2.4 Intended changes in practice

The intention was that teachers would change their practice in the short term by experimenting with 'gap tasks' (i.e. tasks to be tried out in the 'gap' between sessions[41]). In the longer term the course leaders said they hoped that teachers' practice would change in three main ways:

- They would use more challenging and open tasks in the classroom, with less reliance on textbooks and closed questions, leading to more exciting and unpredictable lessons for the students.
- They would reflect more on what happened in mathematics lessons, thinking more about what the learning had been rather than about how much material had been covered.
- They would become more relaxed in their interactions with the students and develop more collaborative classroom practices.

4.2.5 Content and processes of the CPD initiative

During the meetings the course leaders initiated discussion, frequently asking the participants to discuss issues (for example, how they felt about group work in the mathematics classroom) and then to report back to the group. Frequently one of the course leaders noted down the points made on a flip chart and, when each small group had reported back, drew out some of the key points. During the meetings they also introduced new resources to the teachers (for example, the 'Improving Learning in Mathematics' resource pack published by the Standards Unit)[42]; and discussed how they might be used. They also handed out research papers (for example 'Inside the Black Box: Raising Standards Through Classroom Assessment' (P Black & Wiliam, 1998)). They gave the teachers time to read them and then led a discussion about them.

[41] See footnote 11.

[42] These materials were discussed in Chapter 3.

In addition, they introduced various classroom mathematics activities and asked the teachers to work in small groups to complete them. For example, one of these activities used small cards with equations, graphs and co-ordinates of points printed on them, although some were left blank. The task was to decide how to group them and then to arrange the groups of cards on a large sheet of paper, paste them in place and add some explanations.

The teachers were asked to try out the activities in their classrooms between the meetings, using either this activity (suitably adapted for their particular circumstances) or some other activity designed by themselves. The activity they chose to use was called a 'gap' activity. They were asked to bring some of the students' work from these gap activities to the next day meeting to form the basis of discussion.

Teachers were also asked to keep a journal. At the last day meeting, they were asked to make a presentation to the group, outlining how their practice has developed through the project.

4.2.6 Teacher 1

This section discusses the CPD experiences of Barbara, one of the two teachers who were invited to take part in the in-depth part of the research. It reports on what she said when our researcher interviewed her and on the observation of her lesson, using the framework developed above to structure the discussion. Barbara had been teaching mathematics in secondary schools since 1976. She started in a school in East Sussex, and then moved to London where she taught in the same school for 24 years before moving to her current school, also in London. She had also worked outside schools, with government bodies, and as a consultant for her local authority's education centre. She became involved with initial teacher training at Local Authority Schools Collegiate[43]. She was originally lead mathematics mentor and then mentor for the school.

She said that she always wanted to go down the 'mathematics route' rather than 'school leadership route' as she felt that school leadership would take her out of the classroom too much. She loved the aspect of her job that involved teaching, but found that there were many pressures on her which distracted her from giving as much to teaching as she would have liked.

Barbara became involved in the current CPD because she had heard about the course and she had liked what she heard; the approaches promoted by the course were similar to the ones she believed in. She thought it would be valuable for someone in her department to attend and decided to go herself (rather than sending someone else from the department), because then she could 'cascade' (her word) the training down to the rest of the department. She saw this as an opportunity to develop herself in order to 'move the department forward'. She thought she would be able to do this by working on more effective student target setting, reducing teacher marking time and working on coherent practice across the department.

Actual professional development

Barbara said that she valued the time out of school to reflect, think and discuss, and she enjoyed having time to read. She had been introduced to new resources and had time to investigate them. During a visit to one of the meetings our researcher observed Barbara reporting back to the group and discussing what she had tried out in class. She had brought some student work in, and discussed how she felt about carrying out the gap task in detail. She discussed what the students did to complete the task, focusing on their activity but not discussing their conceptual development. Later, when interviewed, she said that she had enjoyed reporting back.

Barbara said that the gap tasks had challenged her inclination to take control of the direction students might go in and she had developed an awareness of her tendency to do this. She also remarked that she had developed an awareness that 'the obvious isn't obvious' but she did not explain further. She had never, at any stage, considered giving up the course and reported that it had kept her interest in mathematics teaching at a higher level than she thought would have been the case otherwise.

She said that the course had been the highlight of her year, and that she had enjoyed it thoroughly, because it had given her the opportunity to think about the teaching and learning of mathematics and had taken her back to what she really enjoyed doing. She emphasised the word 'back', saying that she felt that in recent years she had gradually moved away from her passionate interest in the teaching and learning of mathematics because of the pressures of school and management, but the course had reminded her about what she really liked doing. Barbara said the course made her very excited and gave her the opportunity to practise what she believed was good mathematics teaching.

[43] The Local Authority Schools' Collegiate offers a School Centred Initial Teacher Training Course for post-graduates who wish to teach in secondary schools see http://www.bscteach.co.uk/

Attending the course had made her think about the direction she wanted to move in, in terms of her role in the school, and had provided her with clear ideas about the way she intends to develop the department.

Changes in practice

Barbara also said that she had begun to use much more open-ended small tasks at the beginning of the lesson (sometimes called starter tasks in the UK), allowing the students more freedom to make suggestions before focusing on her teaching points. For example, she provided them with a diagram (Figure 2 below).

She asked the students to 'Write a statement about this diagram'. Barbara said that previously she would probably have asked a more direct question. She said she had allowed them to make any points they wanted before she focused on one or two suggestions. For other starter tasks, she said she chose carefully so that she could promote discussion, such as the question 'Find a number with exactly five factors', which led to a discussion of the fact that numbers with an odd number of factors are a special sort of number (square). She said that in the past she would probably have given the class a more closed starter such as 'What are the factors of 16?'

She said that she had also begun to ask the students to do more open and investigative tasks. For example, she gave the class coloured paper and scissors and provided the students with instructions on how to create the shapes she wanted them to work with. She asked them to investigate angles and lengths in the shapes, as well as tessellation properties. The class worked on this for a number of lessons and produced a large display (see Figure 3). (The yellow labels point out process skills (from the new curriculum) and the white labels point out interesting facts.)

Figure 2 Diagram for starter question

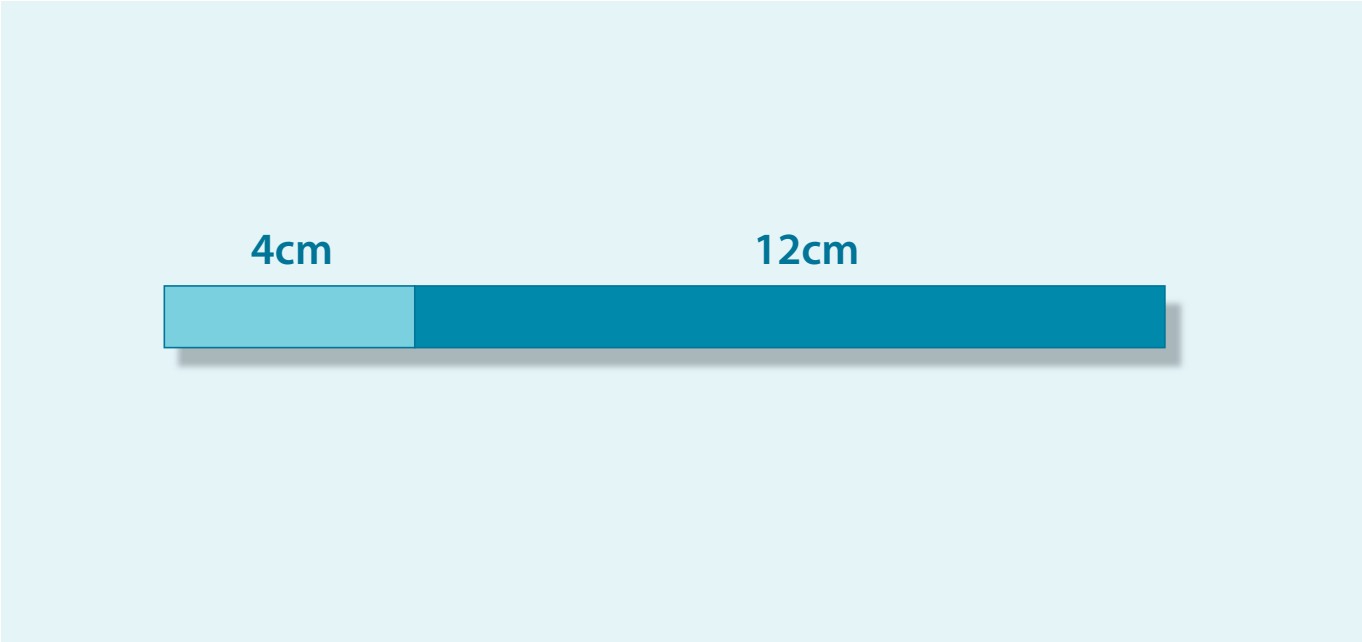


Figure 3 Tessellation display

As a final point, talking about student work and discussing how to share student work as part of the course made Barbara realise that she wanted to do the same thing in her classroom, so she got a visualiser[44] for her classroom. She then regularly shared student work in lessons, and said she hoped she was developing a classroom culture in which 'it is ok to be wrong, as long as you are thinking about your learning'. She felt that, because of her participation in the course, she had talked freely with her team about her own learning and she thought this was good for the team. When our researcher spoke briefly to the second in charge in the department, he reported that the whole department had benefited from Barbara's CPD because she shared new ideas with them and encouraged them to experiment in their own classrooms.

Student learning

Barbara reported that the students had initially been puzzled by the gap tasks such as the one described above (matching) because these tasks did not include explicit instructions. They asked for more help than she expected them to. However, one class in particular (Year 7[45]) were getting more used to open-ended tasks. Barbara said that the gap tasks had 'allowed my students to enjoy their work and made them think' and that she valued seeing them work in this way.

4.2.7 Teacher 2

This section discusses the CPD experiences of the other teacher from this initiative to be observed and interviewed. Once again, we use the framework developed above to structure our discussion. Peter was in his third year of teaching at a large comprehensive 11 – 18 school where he had overall responsibility for the first three year groups in the school (known as Key Stage 3 and culminating in a standardised national test at the time of the study). The school did not achieve as well as other schools in the borough in terms of student attainment in national standardised tests, and much of the work of the teachers focused on working with students to raise attainment levels.

Peter said that he decided to take part in the CPD because a member of the senior leadership team asked him if he would like to. The school wanted someone in the department to attend; he said that this CPD was seen as good value for money. A colleague had done the same course last year and had recommended it. He had seen some of the ideas she had come back with (such as the activities in the ILM Materials[46]) and he liked them, so he decided to participate in the course.

He also said that much of the CPD he had participated in previously has taken place in school and 'seems to be more about technical jargon than new stuff'. He was looking for something with more mathematics.

[44] A device which projects anything put under its lens onto a whiteboard

[45] The first year of secondary school in the UK, with students aged about 12 years old.

Actual professional development

Peter said that he saw the CPD as valuable because he was 'stocking up with ideas to try out in the classroom', and collaborating with other mathematics teachers. He said he liked the fact that there was enough time for discussion.

To Peter, the course leaders were very important; 'they prepare the stuff, they help us along'. He said that they provided a link between the theory and practice in both his own classroom and in sharing what other schools were doing. The local authority advisor had a good overview of what happened in the borough, and he said this was useful for the teachers.

Peter said that, as a result of the course, he had to 'push' himself to try something out and this was the most useful thing about it. He reported that the course 'replenishes my enthusiasm'. He also remarked on a change in awareness:

> *I am more aware of what I am doing and thinking much more about what I am doing and why.*

He said that the resources provided by the CPD were very useful.

Changes in practice

Peter says that since he had been doing this CPD his teaching had changed. He said that he tried hard not to stand over the students when talking to them but had started to crouch down to their level. He had tried to integrate some of the ideas from the CPD into his normal practice, rather than relying on the textbook too much. For example, he asked a Year 9 class to write a test and devise a mark scheme and he was very pleased with the work they produced. He was particularly pleased with the work of one of the girls. He said:

> *I will use this idea again as its fairly easy to setup, although grading is quite a challenge. It's effective because it allows students to show what they have learnt and it always easily differentiates between students' abilities. Answering a question on a test can be algorithmic, writing a challenging question (with a mark scheme) can show greater understanding.*

Peter had started to move away from writing the lesson objectives on the board, and at the time of the visit wrote primary and secondary objectives on the board (skills-based and content-based respectively). Sometimes he left an objective blank and asked the students at the end of the lesson what it was. This was an idea that came from someone at the CPD when he was chatting at lunchtime.

However, Peter also remarked that he was not able try out new things in the classroom as much as he wanted and this was partly because of an intervention programme that had been put in place to address the whole school emphasis on raising attainment. As he said:

> *This means intensive teaching with identified students, at the cost of losing lessons with regular classes at short notice, which means that I find it difficult to plan.*

Student learning

Peter did not report on changes in student behaviours or on improved learning, but he did say that the students did not all like some of the new ways he worked with them. In reference to the exercise where they were asked to write a test, he said:

> *Some students did not like this approach, they preferred a standard test – I supposed practising for conventional questioning requires less effort.*

4.2.8 Case Study 1: Conclusions

This initiative is organised as a course for secondary mathematics teachers within one local authority. Each meeting is loosely organised around a new 'gap task' and there was an expectation that the teachers would try out the gap task between meetings. Whereas the course was very loosely framed by the idea of 'assessment for learning' what actually took place within each session appears to be more emergent and influenced by the teachers' knowledge and experience.

Both teachers in this case study reported that they found the course valuable and worthwhile. They both reported enjoying the course and neither considered giving it up. Barbara reported that it kept her interest in mathematics teaching at a higher level than she thinks it would have been otherwise. Both teachers commented that they valued the mathematics subject focus of the CPD.

Both teachers reported that the course had made them more enthusiastic about teaching mathematics. They also said that they had become more aware of their own practice, and this, we suggest, provides some evidence that they were beginning to think more critically about their practice. Both teachers reported becoming more relaxed with their students, with Barbara explaining that the course was framed by the idea of 'assessment for learning'. There is evidence that both teachers changed their classroom practice to include more open questioning techniques, both in their 'starter' tasks and in the tasks they set for the students to complete.

[46] See footnote 22.

Although there was an expectation that teachers would try out the 'gap task' between sessions, the task was set up in such a way as to allow for a degree of personal choice in how this could be realised in the classroom. Both teachers tried out new activities in their classroom, which may be a starting point for more long-term changes in practice. Barbara tried using the gap tasks as they were presented. This may be explained partly by the fact that she liked the ideas underpinning the task and partly because, as she said, she 'had to' report back on the how she had found teaching these gap tasks. However, Peter appears to have been more influenced by ideas suggested by other members of the course than by the 'gap tasks' themselves, and this 'stocking up with ideas' seemed to be important to him. We suggest that the making of these changes was supported by the teachers' increased confidence and by the leader's strong expectation that they would make some changes and report back on them, together with the leader's 'permission to take risks' and the flexibility in the way the gap tasks were set up. We further suggest that the way the course was set up facilitated teachers sharing ideas and relates to the specified aim of creating a community in which teachers learn from each other.

The teachers reported on how the students responded to some of the changes they made in their practice, mentioning that they were 'puzzled' and that they did not always like the new ways of working. When Barbara reported to the CPD group on the tessellation task, she explained how she had set up the task and what the students had done in response. Her comments concerned their classroom behaviour and what they had managed to achieve but she did not discuss their learning. Peter's comment about the value of asking students to set a test perhaps demonstrates some attention to students' conceptions in mathematics.

The leadership of the course seems to have been a major influence on the teachers. Peter specifically mentioned that he thought the course leaders were very important; 'they prepare the stuff, they help us along'. He said that they provided a link between the theory and practice in both his own classroom and what other schools were doing. The local authority advisor had a good overview of what happened in the local authority and he said this was useful for the teachers.

4.3. Case Study 2: Primary Course

4.3.1 Context

This initiative was a response by a local authority to perceived problems with the quality of mathematics teaching in its schools and forms part of a drive to raise standards of mathematics teaching at all levels within the county. Its design was based on an earlier model of 20-day courses for teachers[47] which were common in England in the 1980s and proved successful to the extent that many of those in positions of leadership in primary schools at the time of this study had been participants. The whole programme involved over 100 primary school teachers in 10-day courses following the same format so that there were five parallel courses being run in the local authority. This was a large scale initiative with strong and clearly defined structures and content, with support in place for the participants. The course involved the teachers in eight days of face-to-face tuition. It also gave them two days within school during which they were free to act on some of the things that they had learnt on the course, while other teachers took responsibility for their class. In most cases, two teachers attended from each school.

Financial support enabled the teachers to attend the course during the normal school day and there were plans to follow up the participants in the next academic year. The support offered in the next academic year would be in the form of three half-day events where the participants would be able to share developments since the end of the course. They would also follow up work on subject knowledge areas of interest to them, as well as having some more input on using and developing rich mathematical tasks and using them for assessment.

4.3.2 Aims of the CPD

The initiative leaders said that the project aimed:

- To build capacity across the county by building confidence and expertise in teaching mathematics.
- To support primary school teachers in developing their mathematics subject knowledge, mathematics pedagogy and understanding of solving mathematical problems and thinking mathematically.
- To give the teachers opportunities to work with colleagues to develop their practice.

[47] During the late 1980s in response to the new demands of the National Curriculum, the Department for Education and Skills (DfES) initiated a programme of courses to support primary teachers in National Curriculum mathematics and science. For an evaluation of these courses see (Harland & Kinder, 1992)

4.3.3 Intended professional development

One premise on which the course was based, was that mathematics in primary schools is different from other subjects and requires a different kind of support. As the course leader, Robert, said: 'Maths is different from other subject areas in primary school; the teachers need to experience doing mathematics themselves in order to improve their subject knowledge.' Through the use of reflective journals to relate their own and their students' responses to mathematical tasks and through the reading of related literature, it was intended that the teachers should develop their understanding of mathematics, of ways of teaching it and students' responses to the subject..

4.3.4 Intended changes in practice

A central element of the course was engaging teachers with mathematical problems they could use with their students but which often challenged them at their own mathematical level. The organisers said that working with colleagues from their own or different schools would help the teachers to see what the difficulties and misconceptions might be in response to a particular problem, and to model in their own interactions the kind of practice that was being advocated within schools.

The course also offered the teachers a range of resources to use with new technologies, particularly interactive whiteboards, and the chance to experiment with software in the sessions and then use it in their own schools.

4.3.5 Content and processes

The content of the course combined mathematical subject knowledge and pedagogy with collaborative working with colleagues on changing practice, as well as solving mathematical problems and engaging in mathematical thinking.

The observed session began with a review of the teachers' and their children's responses to tasks and resources the teachers had tried out in the classroom since the last day of the course. It lasted about an hour and comprised small group discussion and feeding back to the whole group. The main part of the session focused on fractions. The teachers undertook a number of mathematical tasks in pairs and small groups and discussed implications for pedagogy and practice. One of the tasks involved ordering groups of fractions from smallest to largest, including examples that people might have difficulty with and which might reveal common misconceptions. The three groups were:

$$\frac{2}{5} \quad \frac{9}{5} \quad \frac{4}{5} \quad \frac{10}{5} \quad \frac{5}{5}$$

$$\frac{6}{3} \quad \frac{6}{8} \quad \frac{6}{4} \quad \frac{6}{12} \quad \frac{6}{7}$$

$$\frac{7}{8} \quad \frac{10}{11} \quad \frac{3}{4} \quad \frac{8}{9} \quad \frac{4}{5}$$

The task also involved drawing a diagram to illustrate each fraction and discussing and expressing in writing the reasons for their ordering. This involved the participants convincing one another of the validity of their mathematical reasoning. The task involved all the teachers and generated a lot of discussion and mathematical reasoning. In the observed session, the tasks raised and addressed some of the common misconceptions about fractions. The discussion covered the implications for individual teachers' practice in their schools, as well as more general issues related to curriculum content and organisation.

Many of the teachers were concerned about how the latest government guidance on teaching mathematics in primary school would and should impact on their practice and how it might relate to the work they were doing on the course. The course leader reassured them that the approaches and tasks suggested by the course were consistent with latest government guidance[48]. As Robert, the course leader, said:

> *Specific links were made with the revised framework relating tasks to units of work. Particular mention was made of the importance of aspects of AT1, using and applying being integrated into the tasks.*

The course gave the participants opportunities to try tasks they might use or adapt to use with their students.

In addition to the face-to-face course days, the teachers were expected to keep a reflective journal about their own mathematical learning and their feelings about their participation. They were also expected to undertake some additional reading – which covered both mathematics subject knowledge and research into teaching and learning mathematics – and to try some activities with their students and reflect on those trials. Successful completion of the course, including a piece of written work, would lead to accreditation by a university.

[48] See http://www.standards.dfes.gov.uk/primaryframework/introduction for details

4.3.6 Teacher 1

The teacher, Hannah, was in her third year of teaching. For her first two years she had a class of 11-year-old children but now taught a class of seven - to eight-year-olds. She has always enjoyed mathematics as a subject and volunteered to go on the course when her headteacher asked who might be interested. She is keen to pursue her interest in teaching mathematics, possibly by co-ordinating the subject within her school or even going on to lead professional development for other teachers.

Actual professional development

Hannah described herself as feeling quite confident about teaching mathematics at the start of the course and said it helped her develop her enthusiasm for teaching the subject.

She also described the value of being put in the position of a learner of mathematics:

> *There have been times when I felt that horrible feeling like being back in the secondary classroom and it made me aware of my stronger areas of maths and my weaker ones. One of the weaker ones was probability. I felt really frustrated on that day because I never really got it and everyone else was doing it quicker than me and I felt a bit stupid. I wrote down in my jot book that I really wondered why I couldn't do it and lots of other people seemed to find it easy. So I maybe wanted to give up that task because I felt a bit frustrated, but not the course. I haven't wanted to give up the course.*

She valued her involvement on the course very highly and felt that she would miss it when it was over:

> *I really enjoy the way the course has been put together. I like the fact that we get to do some mathsy things because it has put me back in the seat of the learner. And I really like looking at the theory behind why we do certain things and the misconceptions people have. Apart from all those things, there is a really lovely atmosphere at the course. I think Robert is a brilliant leader and he is really good at presenting things and making links. He has really opened my mind to the breadth of questions that I was using and what I was trying to cover, and to see the value of the task for different outcomes.*

This suggests that the expertise and enthusiasm of Robert, the course leader, was central to Hannah's learning.

Changes in practice

Hannah was very clear that she had altered her practice as a result of involvement in the course and was very impressed by the suggestions and advice of the course leader. For example, she commented on what she had done in the lesson that was being observed saying:

> *Robert said that children often find it very difficult to count back, so since then I have become more aware of that and given them more practice with it. So I did more counting backwards around the clock and using different start points and jumping in and out because that gave me a chance to see how fluent they are with that.*

Hannah also commented more generally:

> *Emphasising that there is a different way we could say this and getting the idea of the making links thing has been important with the course. I always put things into word problems now and always show that context of it, and then I look at the mechanics of how they are doing it. But I always use a context first now.*

Hannah expressed the value of working with a colleague from her school as a co-participant saying:

> *We have had the opportunity to talk about things and we are going to collaborate and look at the thinking of children in different year groups and ability levels and also she's in a different year group and I've done things in a different way or we've done different activities and it's been good for seeing progression and to see how you can adapt things.*

She went on to describe the relationship between her feelings about being put in the position of a learner of mathematics and changes in her own practice as follows:

> *When I reflect, I guess I am a bit more realistic, thinking more about actually 'why haven't they got it?' Alan was getting mixed up with his (clock) hands and maybe he hasn't had as much exposure to time and I have become more aware. So I'm not so frustrated with him and it's also helped that I have felt stumped in the course and I wouldn't like the teacher to turn round and say to me 'why aren't you listening?' – so that has helped me to understand what it is like for the children.*

Another key feature of the course has been the use of practical resources to support the teaching and learning of mathematics. This has been strongly taken up by Hannah, as was evident in her use of clock faces for every child in the class in the lesson that was observed. As she commented: 'It doesn't matter what age or to some extent what ability they are, I think that actual physical resources are really important.' In all the comments Hannah made about her practice, she was attributing changes in her practice to her involvement in the CPD course. She emphasised the central importance of using mathematical language:

> *I get the children to say it aloud and I'll pretend I've forgotten and so they say it again – so I am reinforcing things with the right vocabulary.*

Hannah expressed passion about teaching mathematics in the following way:

> *…I am passionate about teaching maths and I see the difference in my attitude towards teaching maths and teaching other subjects. I really look forward to going on the course and I think incredibly carefully about my planning in maths. I think carefully about who I am going to work with and how I am going to do it.*

Student learning

Hannah was also aware of the importance of engaging the children in meaningful and challenging mathematical problem solving:

> I'll give them a challenge and they'll see why I've given it to them and they get really excited about it and I love it when that happens. You know, when I was doing the counting down and I said a half, a quarter and Melissa was jumping up and down and they got to 1/128 – and I just love it when that happens! I drop a little thought in there and they run with it and if they are really stumped they just want a clue and it's a bit of a game really. I do get a lot of enjoyment out of working with the higher ability children who really love learning. We just have this really good chemistry in a way and we have really good discussions and they can help the other children. I really enjoy it.

The example that she describes occurred in the observed lesson. It appeared to be an important moment that evidenced the engagement of the children in mathematical thinking. Hannah seems convinced that this level of engagement and enthusiasm together with the spontaneous extension of the mathematical idea of extending the sequence:

$$\frac{1}{2} \quad \frac{1}{4} \quad \frac{1}{8} \quad \frac{1}{16} \quad \text{to} \quad \frac{1}{28}$$

was a change in student learning that followed from her changes in practice.

4.3.7 Teacher 2

The second teacher, Jessica, was in her second year of teaching, having followed an in-school training programme to qualified teacher status through working as a numeracy assistant[49] in the school. The school setting was an infants' school and Jessica was teaching a Year 1 class (children aged 5 to 6 years). The school was a one-form entry school so there were no parallel classes. Her work as a numeracy assistant meant that she felt she had a good understanding of teaching and learning mathematics throughout the school. Jessica planned to take a career break to travel at the end of the academic year in which she was involved in the CPD.

Actual professional development

Jessica described how the course had served to give her permission to focus on one area of learning for longer, rather than simply covering the prescribed content as quickly as possible:

> *We have learnt quite a lot about how children need to have rich activities and how they need to have first-hand experience and that it's OK to give them the same question to focus on for most of the lesson (rather than like 'we're doing this in the teaching and this in the activities'). I wouldn't have always done before. Before, I was sort of focusing on quantity and thinking that it would be good for them to have a mixture of experience, but we've sort of learnt that it's about the quality and it's better for them to do one thing and begin to get the hang of that than to whizz through lots of different things.*

Many of the children in the class were speakers of English as an additional language, whose lives had been disrupted by frequent moves. Jessica felt this had restricted their experiences and that they needed more practical experiences and practice than might otherwise have been the case.

[49] Numeracy assistants work as assistants to the teachers in numeracy lessons throughout the school. Teaching assistants are common in many local authorities and are variously known as Learning Support Assistants, Teaching Assistants and Educational Support Workers.

Jessica had reservations about studying mathematics at her own level and was keen that the course should focus on what would be of direct relevance to teaching mathematics to children of the age with whom she was working. As she said:

> *It's nice to have if you're a bit stuck on something and you need to see it in a different way but I'm not really interested in developing the maths content of my knowledge. The first part of the course I found that a bit frustrating. We spent a lot of time developing our knowledge and I hadn't really expected that. I thought it was going to be more like help for the children… Maths is not my favourite subject – whereas I quite like teaching it to the children, I don't like learning it myself. So I suppose at the start of the course I was just thinking 'Oh I hope it's not all going to be like this'. Some of the Y1 and R people found that they couldn't easily take it back to the classroom.*

Changes in practice

Jessica was convinced that participating in the course had made her a better teacher of mathematics and suggested that after her career break she would like to go on to do a Masters in education.

> *I think it's definitely made me a better maths teacher, but there are lots I would like to do to try to consolidate and make more effective for the children… I'm sort of thinking about doing a Masters… I am sort of interested in creative thinking and thinking skills and stuff like that.*

In the observed lesson, the children were involved in practical experiences of measuring volumes of water, which they seemed to enjoy. Jessica expressed concern that they had missed the significance of the experience and felt that this was partly to do with their lack of experience of water play in some cases:

> *They do need a lot of practical activity and I think a lot of them don't get it at home. Because they move around quite a lot they may have missed the kinds of Year-R practical experiences and they hadn't had enough experience of just playing with the water. I think that is partly why some of them didn't get the hang of it as much as I thought they would.*

Another change that Jessica commented on, was around allowing the children more time to respond to her questions:

> *I try and give children time to work things through in their heads so I say, right I am giving you some thinking time because I understand more now about how children learn and how they need time to think things through*

She also talked about changing the groupings of the children more frequently and being less inclined to keep them working in 'ability' groups:

> *I try now to group them differently so that they aren't always in their ability groups, so I try and assess them in the first couple of days and put them into groups for that week and that works quite well.*

Another change in her practice was in using games and problem solving tasks more often:

> *Games used to be a treat and now I realise they can be very useful and so we try and build them in a lot more, and problem solving as well.*

Student learning

Jessica did not comment much about changes in student learning but she did say that she felt that she would like to plan more loosely than the system allowed, so that she could adapt her weekly plans to fit in with the children's responses to the learning situations she offered them:

> *My planning has probably changed the most because now it is more thorough and more able to be taught. I would like to do looser planning, not planning from Monday to Friday but kind of adapting it as I went on depending on how the children understood it.*

The observed lesson showed the children exploring practical resources and tackling problems about volume that they initiated themselves. In the plenary session, they commented on the importance of measuring volumes using the same container, as this excerpt shows:

> *P: I found out that the little jug went into the big box 99 times.*
>
> *T: Why do you think it is important to use the same container when you are filling it up?*
>
> *P: Because it isn't fair and you can't count.*

This was influenced by her involvement in the CPD and illustrates her pupils' developing understanding of the importance of using standard units for measuring.

4.3.8 Case Study 2: Conclusions

This 20-day course for primary teachers involved teachers of children in primary schools. Teachers were given research to read and consider and were asked to write reflective journals.

Both teachers were able to articulate clearly their approaches to teaching mathematics and their comments suggested that they had given their practices, and the changes they had made in them, considerable thought.

We would suggest that these changes could have been triggered by inter-related aspects of the CPD initiative: their engagement with new resources as learners of mathematics; the expectation that they would try out new resources in their classrooms; and writing reflective diaries. Further, we suggest that the level of reflective thinking the teachers displayed may be attributable to their engagement with writing about teaching and learning mathematics.

We would also suggest that the strong and competent leadership of the tutor on the course was a significant factor in its effectiveness: Robert engaged the teachers in working in a variety of ways to develop their teaching. He had a clear agenda for the course content but was receptive and responsive to the teachers' questions and problems and was knowledgeable about the subject he was teaching.

Some teachers were resistant to developing their subject knowledge beyond the level at which they would be expected to teach mathematics and this may be accounted for by a lack of value congruence with the objectives of the CPD.

More generally the course leader commented on the effects of working with teachers from both Key Stage 1 and Key Stage 2 saying that:

> Teachers in both KS1 and KS2 benefited from discussions across the phases – KS1 teachers considered how what they did in class influenced mathematics learning in later phases and saw 'where the maths went'. Those in KS2 classes gained insights into the importance of the foundations laid at KS1 and how KS1 approaches might support some learners especially at the start of Year 3.

4.4. Case Study 3: Primary within-school

4.4.1 Context

This whole primary school initiative was set up by the headteacher and involved an external commercial provider. The headteacher wanted to improve attainment in mathematics as part of the school improvement plan. She called in an outside organisation, BEAM[50], to act as leader of the initiative. The setting up involved collaboration between the consultant and the school to establish the needs of the staff and the aims of the CPD. The headteacher, mathematics subject leader and consultant decided to focus on developing the mathematical subject knowledge of the teachers and teaching assistants, while improving both the children's engagement with mathematics and their mathematical creativity. The planned programme of CPD involved a programme that ran throughout the academic year. It comprised a number of sessions of CPD run as twilight sessions, as well as whole and part days. The initiative involved the external consultant and mathematics subject leader in mentoring, course delivery and classroom support as well as collaboration on developing documentation such as a calculation policy. It offered the teachers resources to use in the classroom, as well as suggestions for ways of working with children on their mathematics.

4.4.2 Aims of the CPD

The organisers said that the aims were:

- To raise attainment in mathematics with a focus on creativity and children's engagement.
- To develop teacher and teaching assistant subject knowledge and expertise in pedagogical approaches that support children's mathematical learning.

4.4.3 Intended professional development

According to the organisers of the initiative, the intention was to change teacher beliefs about the nature of mathematics and mathematics teaching and learning.

4.4.4 Intended changes in practice

It was hoped that changes in beliefs would have an impact on teachers' classroom practices which would in turn have an impact on children's attitudes and learning. It was hoped that the focus by the whole school on these changes, including developing speaking and listening activities, opportunities for creativity and using assessment for learning in mathematics lessons, would enable teachers and teaching assistants to talk about issues related to the changes.

[50] See footnote 17

4.4.5 Content and processes

The external consultant, Jane, spent seven days in the school, spread over one academic year, working with teachers and teaching assistants both in their classrooms and in workshop sessions. Each day had a different focus. These included assessment for learning, using mathematical games to promote speaking and listening about mathematics, working on developing an approach to calculation that was consistent across the school, and using children's mistakes and misconceptions to promote learning.

On the day on which the researcher observed the CPD, Jane led a session for teaching assistants about models and images for division. She worked from the expertise and experiences of the assistants and supported them in developing their understanding of division, as well as sharing with them a number of resources they might use to support their students' learning. After coffee, Jane had a meeting with the subject leader, Kerry, considering teachers responses to a previous day of input on the creative use of children's mistakes and the development of a calculation policy. This continued after lunch with Jane and Kerry working on developing the calculation policy. After school, Jane led a twilight session for the teachers on division. This was similar to that run for the teaching assistants in the morning but made more connections with other aspects of mathematics and emphasised children's understandings of division in terms of the related concepts of sharing, grouping and repeated subtraction. Resources for use in the classroom were shared and considered and the teachers articulated the progression that they would expect their students to make from year to year.

In addition to these kinds of sessions, the initiative also involved Jane working with teachers and teaching assistants in the school in a number of different ways. Firstly, she worked with the mathematics subject leader, Kerry, to develop various documents for structuring the progression of mathematics teaching throughout the school. These included writing a calculation policy indicating at what stage and in what form different approaches to calculation should be introduced to the pupils. Secondly, she and Jane spent time in other teachers' classrooms observing their mathematics teaching and offering them support in developing it. Jane and Kerry also taught lessons to other teachers' classes so that the other members of staff could observe the approaches they were advocating.

4.4.6 Teacher 1

Kerry is a young teacher in her third year of teaching and is the subject leader for mathematics in the school. She trained as a primary school teacher with a post graduate qualification after a first degree. She became mathematics coordinator and Key Stage 1 phase leader at the beginning of the year in which the CPD took place. She is a talented and enthusiastic teacher of mathematics, as is evidenced by her being a leading mathematics teacher for the local authority in which the school is based. She is highly motivated and keen to share her enthusiasm and knowledge with other practitioners. She did not enjoy mathematics as a school subject herself and wondered whether that might have made her a better teacher of mathematics. As she said:

> *Funnily enough, maths at school was one of my worst subjects but I love teaching it. I don't know whether that is because I did struggle.*

Actual professional development

Kerry sees her role as leading the development of mathematics teaching throughout the school. She is aware that if she is setting herself up as in some way an expert, then she needs to be following her own advice in her own practice: 'Because if I am making judgements of people I have to be able to do what I am suggesting well.' She feels strongly that her own involvement in the project and her support of the development of her own colleagues has led to her own professional development too. She suggested that not only had she become more confident to try out new approaches in her own classroom, but she had also become more confident in leading the CPD for her colleagues:

> *I am more confident with helping colleagues and able to support them and make judgements about their teaching and be more helpful for them. I am able to advise so that when we look at results and see there is a group of children here who need more input I can make suggestions like ' you could try…'. Having the BEAM input has helped me to develop.*
>
> *I am very much a convert and into encouraging teachers not to rely on exercise books but to walk around and think about what the children are doing and what we can do in mental maths.*

Kerry appeared to be convinced of the value the new approaches the CPD encouraged:

> *There isn't anything that makes me want to give that up. You get those eureka moments when they suddenly get it and you see that they can be independent learners…*

She also commented that she felt the revised framework (see footnote 46) offered teachers of mathematics in primary schools some new opportunities to change their practice:

> *Some people don't like the new framework but some do. I like the fact that it is freer and that you can lengthen it or shorten it and we have been able to merge units together. We have already met a lot of our objectives for Year 2 so I can do speaking and listening activities in maths. This year my love of maths has really blossomed and having all the tools and more confidence to do it, and planning for it and leading it, is great.*

Changes in practice

Kerry commented that her involvement with leading CPD had changed her practice so that she had become less reliant on textbooks. She said that she had begun to use open-ended tasks, which sometimes meant that there was no record of the activity in their exercise books. She said that she sometimes used post-it notes to record what the children had done:

> *I jot down the children who have or haven't got it and I offer them much more practical work.*

An example of the practical nature of the tasks Kerry used in the classroom was seen in the lesson observed by our researcher. Kerry allowed the children to engage with a variety of problem solving tasks related to shape and space. She suggested that the children could record their findings by using a variety of approaches such as lists, Venn diagrams, Carroll diagrams and so on. She gave the children some statements about shape and asked them to decide whether they were true or false by exploring them using some plastic 2D shapes she supplied and any other examples of shapes that they could find in the classroom. The statements included for example 'all four-sided shapes are squares' and 'all squares are blue'.

Student learning

In the observed lesson, a number of children drew on the environment around them for examples that addressed the questions they were considering and Kerry felt that this was an important development that had been actively encouraged by her involvement in the CPD. She said:

> *I was really pleased with the children's creativity and their ability to think for themselves and to work in pairs and look at ways of presenting the data for themselves. Some have chosen pictures and pie charts. It is lovely to see their independence. They weren't easy statements but they were still able to have a go and I am sure it's mainly because it was so open ended.*

> *One child had it in mind that he had to have a list and he was getting too stuck because he couldn't make it work and he was really challenged. He is very able with maths but not creative so it was good that he was really challenged.*

Kerry also felt that the children's views of learning mathematics had changed and that they were now more enthusiastic about challenges and keen to gain certificates, which were applauded in assemblies[51] and had ensured that the profile of mathematics achievements had been raised in the school.

4.4.7 Teacher 2

Angela is an experienced teacher who has been working at the school for over 15 years. For her, the ways of working that were being suggested in the CPD were very different from the ways in which she had previously taught mathematics and involved much more practical work and games.

Actual professional development

Angela talked about enjoying teaching mathematics and the support that the CPD initiative had given her in developing her practice:

> *There has been a lot of support for the change and they have become more involved and they enjoy it so much more. For me that is a very positive way of showing that it is the right way of going about it. It is the reaction of the children that has made me realise that this way of teaching is better.*

Another key support for Angela was the fact that this was a whole school initiative and everyone on the staff was seeking to develop their mathematics teaching in similar ways. This whole school approach was supported by guidance on progression and calculation strategies across year groups, so that teachers were supported in understanding how concepts would develop through the school.

Changes in practice

Angela's initial approach could be seen as 'trying out' new ideas in the classroom rather than 'embedding' an approach to which she was already committed. As she said, 'I have also decided to try it and if it didn't work, it didn't work.' However, as discussed above, it seems that she became convinced of the value of the approach, and she described some of her changes in practice. Some of the main differences that

[51] In English primary schools, whole school assemblies are an important part of the school day and they are often used to highlight the achievements of individuals and groups of pupils. It is unusual for the focus of these assemblies to be mathematics, so raising the profile of the subject within assemblies would be likely to have a positive effect on the children's attitudes to mathematical achievement and on participating in mathematics.

Angela reported with her teaching were on the use of practical working and the reduced emphasis on writing things down:

> *I use more activities, far more resources and practical activities. Now if people were working practically and they didn't have written evidence of their learning, that wouldn't worry me. I don't feel that a child has to write something down to know it.*

Another strategy that Angela had adopted was of writing observations of children's mathematics on post-it notes as part of her strategy for assessing children's achievements in mathematics. She made these during the course of the lesson and encouraged teaching assistants to do the same.

Angela described how her understanding of teaching mathematics had developed from a textbook-based approach, to one that involved far more practical work and allowed the children more space to think for themselves:

> *I think children learn better through practical activities and you have to have them there for them to see what best fits the children. It is not a case of just opening up a page of maths and doing pages and pages and they understand. It's about doing some examples and practical tasks and giving support where and when it is needed, then, if there are misconceptions, you are there to clear them up.*

In the observed lesson, Angela had been intending to use an interactive whiteboard protractor to help the children to learn how to use a protractor. However, the interactive whiteboard was not working, so she got the children to talk in pairs about their protractors and how they might use them to measure angles once they had established what angles were. She allowed them a lot of time to observe the way in which the numbers increased and decreased and the two parallel scales for measuring. She also spent a lot of time with them recalling their understandings of acute and obtuse angles and what was significant about their size in degrees. Angela said that she would not have previously allowed as much time for the children to explore the situation or allowed them to discuss what they saw with one another:

> *And if there is a group, then with the subgroups, we know they instantly know they can't do it and they have the chance to support one another. I can see where I need to target extra help of explanations.*

These comments show the teacher using 'assessment for learning' approaches to observing the children's work in groups, which was part of the intention of the CPD initiative.

Student learning

Angela was convinced that her changes in practice had led to changes on the part of the students and she described them as more enthusiastic and more engaged with mathematics:

> *They enjoy maths more and they are working as a group so there is always someone there to help. I think the enjoyment is the main thing. The children are more involved in everything they do.*
>
> *With the lack of exercise books and doing it practically, they get just as much done.*

In the observed lesson, the children were engaged with learning how to use a protractor and focused on measuring angles that they had been given and checking with each other whether they were correct. Thus they were able to correct each others' measuring errors and misconceptions about how to use the protractor and the direction in which to count the measure.

4.4.8 Case Study 3: Conclusions

This whole (primary) school initiative was set up by the headteacher and involved an external commercial provider. It involved collaboration between the consultant and the school to establish the needs of the staff and the aims of the CPD. It also involved the external consultant in mentoring, course delivery and classroom support, as well as collaboration on developing documentation such as a calculation policy. It offered the teachers resources to use in the classroom as well as suggestions for ways of working with children on their mathematics.

Kerry's lesson demonstrated that she was encouraging the children to ground their mathematics in the resources around them and to spend time discussing mathematical ideas without necessarily recording them in their books. Angela's lesson showed a similar emphasis on discussion between the children about mathematics that was not necessarily mediated by the teacher. This evidence suggests that the teachers involved in this initiative were changing their practice so that they relied less on text books and that they had moved away from concerns about collecting evidence of the mathematics children had done in their exercise books. It also demonstrates that the teachers were encouraging their pupils to discuss mathematical ideas – a stated aim of the CPD. As Angela explained, she now felt confident that her children's learning of mathematics did not depend on what they wrote in their books but on what they were able to work out. She felt able to observe this learning by helping them to engage with one another on discussing their mathematical ideas.

Both observed teachers also reported using more practical mathematical activities and this was observed in both their lessons. Developing the use of formative assessment was another aim of the CPD and the teachers reported making notes on post-it notes as a strategy for assessing pupils, so that they were observing the children's mathematical behaviour rather than necessarily expecting the children to record answers in their books.

Both teachers reported that they had become convinced of the value of the approach because of the children's response to it. We suggest that this is important, particularly for Angela.

Angela reported that she had moved away from using textbooks as the basis for her mathematics teaching. This was a significant change in her practice after many years of experience of teaching mathematics using books and worksheets. She was willing to give the suggestions of the course leader a try to see how the children responded, and we would suggest that this was probably at least partly due to the support of a wide network of colleagues within the school. The whole school approach to change, towards a more open and problem-solving approach to learning mathematics, seems to offer a coherent methodology that is accepted by teachers who have previously relied heavily on text-books as their main resource for teaching mathematics. The acceptance by the staff of these new ways of working was helped by the fact that every one of them was involved and they had opportunities to discuss the changes with each other as well as receiving formal support from Jane and Kerry.

The extended programme of workshops for teachers and teaching assistants over a long period of time may also have helped with the changes, as their importance was repeatedly stressed throughout the academic year at each meeting. During this academic year most of the school's time available for CPD was devoted to this initiative which probably also served to raise the importance of the initiative for all those involved.

4.5. Case Study 4: Secondary within-school

4.5.1 Context

This initiative involved all members of one mathematics department in a secondary school. They worked collaboratively along the lines of the lesson study model[52]. It was led by the second in department, Matthew, in response to a perceived need to develop mathematics teaching and learning within the school. The idea for the initiative came from involvement in an NCETM conference in which the lesson study model for CPD was presented and at which Matthew was present.

The department was based in a selective girls' school and Matthew was involved in staff development throughout the school. The department as a whole has been involved in a number of development initiatives over the last few years, led by Matthew, which have involved developing teaching and learning to an enquiry-based approach for pupils in Year 7. The lesson study initiative and the enquiry-based teaching initiative both received financial support from NCETM.

Previous ways of working within the department had been traditional and textbook based. The impetus for change had been provoked in part because of a perception that the highest attaining pupils were not being sufficiently stretched or interested by the mathematics curriculum as it was being offered.

4.5.2 Aims of the CPD

The lesson study approach aimed to give the department an opportunity to consider in detail one aspect of the curriculum and how it was taught. It also offered them an opportunity to work collaboratively and to reflect upon and discuss their teaching approaches.

4.5.3 Intended professional development

The lesson study focus was on one subject area (factorising quadratics) so this meant that the focus of the CPD was on one particular mathematical topic. However, the intention of the leader, Matthew, and the head of department, Nigel, was that there would be a wider impact both in related curriculum areas and also in terms of changing the teachers' beliefs, confidence and practice.

[52] See footnote 18

4.5.4 Intended changes in practice

To finesse an approach to teaching students about the factorising of quadratic expressions using the expertise and input of everyone in the department, so that all members of the department would have ownership of the resources of the lesson plan and materials devised for it.

4.5.5 Content and processes of the CPD initiative

Initially, a lesson plan was made for an introductory lesson on the topic of factorising quadratics for a Year 9 class (this is earlier than the topic is normally introduced but it was felt appropriate for the students involved). This lesson was taught by Matthew and videoed by Nigel. The video was viewed by the whole department before the observed CPD session. The CPD session itself involved working on a revised plan for the lesson, based on the teachers' understandings and interpretations of the way in which students had responded to the first lesson.

In the observed session, all the teachers in the department worked on revising the lesson on factorising quadratic expressions, which had used a PowerPoint presentation. Based on their analysis of the students' responses they looked at the set of examples and questions that they had used and revised them – changing the contents and talking about the dynamics of the PowerPoint presentation and how it could be used to support the students' learning. They also developed questions that would be used for a matching and sorting exercise based on the type used in the ILM resources[53]. There was also discussion about the mathematical responses that the students had made in the videoed lesson and suggestions were made about how the difficulties and misconceptions that had arisen might be addressed. The work they were doing also built on previous work done as a department to develop enquiry-based learning resources and lessons for use with Year 7 students, so there was a shared history within the department that valued collaborative lesson planning and resource creation. During the observed session, some time was devoted to predicting the students' likely responses to the new suggestions.

4.5.6 Teacher 1

Matthew was second in the mathematics department in the school and had held that post for 10 years. He has a mathematics degree and did his PGCE in Manchester. He taught in another secondary school which was poorly resourced and with more challenging pupils than in his current school. Matthew talked about the opportunities for creativity and collegiality that had been available in his previous post and the way that contrasted with the traditional approaches he found on arriving at his current school. However, he was appointed to this post with a view to changing the mathematics department's ways of working and at the point of interview felt that he was able to make a difference to the quality of mathematics teaching within the department as a whole. As he said:

> *I had to adapt and fit in with the style that was prevalent in the department. But now people are headed towards where I was 10 years ago.*

Matthew was an enthusiastic and committed teacher of mathematics with an enquiring mind, who gave the impression of being deeply committed to improving the teaching and learning of mathematics for the girls at the school, not only in his own classroom but in those of his colleagues.

Actual professional development

Matthew has been an avid reader of theory about educational practice and had strong connections with a local HEI, where he had contributed to some teaching of mathematics on a course leading to BSc and QTS. One of the past lecturers there, Henry, had made some suggestions for reading to him and had also taught at the school. Matthew had followed Henry's recommendations for reading, which included books by leading mathematics educators and researchers. Matthew said that he found it difficult to separate elements in his practice and to ascertain what they owe to which aspect of his professional development.

Matthew found the experience of leading CPD empowering and was developing an outreach project based on the same Japanese lesson study model with other secondary schools within the Leading Edge[54] group.

[53] See footnote 22

[54] The leading Edge Partnership Programme involves high performing specialist schools in working with other schools in their area to raise the school performance and to close the achievement gap by addressing issues of under-performance by certain groups of pupils. See http://www.standards.dfes.gov.uk/leadingedge/

Changes in practice

Matthew felt that his involvement in CPD had radically altered the ways in which he taught but that it was difficult to separate out different influences such as the lesson study approach and developing an enquiry based classroom:

> *I am involved in so many things here. I started to find stuff on the Internet about approaches to teaching. The DH set up a Teaching and Learning group and Henry came and worked with us and I was involved in a wider reading around pedagogical ideas around maths. Since then I have been involved in a whole series of professional development activities and working together with the whole department and collectively they have completely transformed my teaching. I have probably moved on hugely. Everything about the way I teach has changed.*

Matthew was particularly interested in working with other teachers to develop their practice as well as his own and had become involved in supporting other secondary schools, who are part of a Leading Edge group, to set up their own departmental lesson study groups. As he said: 'When I was working with the Leading Edge group, there were ideas of Henry's that they just hadn't seen before. It was great to talk to them.'

Changes in student learning

Evidence for change in student learning was expressed clearly in Matthew's response to our request for information about this:

> *The evidence for change is my own personal observation. For example: At the end of a lesson a girl who has struggled with a new idea saying 'Oh! I get it now' – a 'wow' moment. Perseverance leading to learning.*
>
> *Asking students at the beginning of the lesson: 'Do you know how to solve problems of this sort?' (and maybe a couple say yes) by the end they are all solving those problems.*
>
> *Giving an open starting point pupils independently pursuing 2 or 3 different lines of enquiry and then explaining their investigations to each other.*

Indeed, the lesson that was observed included an incident in which one of the pupils explained to the others how to work out the solution to

$$\frac{x}{3} - \frac{x}{4}$$

She wrote clearly on the board and she explained how we needed to change the fractions into equivalent fractions with the same denominator and that once we had done that we would have

$$\frac{4x}{12} - \frac{3x}{12}$$

From there she explained that the subtraction was simple and the answer would be

$$\frac{x}{12}$$

The classroom culture that had been established by Matthew involved co-operation and collaboration between the girls. There was strong evidence of pupils actively engaged with learning mathematics and interested in and committed to the process. Pupils spontaneously wandered round the room to help one another if stuck and there was a collective sense of engagement with the mathematics under consideration. The talk between pupils was overwhelmingly about mathematics. The room was set up so that two columns of pupils faced one another across the tables. These tables ran from the front to the back of the classroom in two columns so every pupil had others to talk to across the tables and on either side of them.

We imagine that this culture contributed significantly to the changes in learning that Matthew reported.

4.5.7 Teacher 2

Nigel was the head of department and a participator in the CPD led by Matthew. He started teaching after starting a PhD in astrophysics and not completing it. At the time he started teaching, it was not necessary to have a PGCE to teach. Nigel spent six years working in a large inner city comprehensive before getting a job in a girls' grammar school in southern England as second in department. He became head of department at this school 12 years ago.

Actual professional development

Nigel feels that his involvement in the CPD has encouraged him to consider his teaching more deeply and that this has an impact on lessons beyond the one that was the focus of the lesson study:

> *I think what the lesson study work has made me realise is that it is quite deep and impacting on a very subtle basis. Obviously it is interesting filming a lesson that you know you can be taking. I think with the emphasis of the lesson study being on the girls and filming the girls - it felt very different from being the teacher going round and it made me aware just how interactive maths can become.*

Nigel also felt that the engagement with the lesson study approach had 'taught us an awful lot of maths' and expressed a wish that he had more time to devote to preparation with colleagues and less time in front of classes.

He felt that changes in his practice had made his lessons less predictable and more interesting and that he was more able to be himself in his classroom:

> *I feel more confident in the sense, not of my knowledge base, but more confident in front of the class, putting across more excitement and enthusiasm than would be possible with just a text book.*

Changes in practice

Nigel felt that the CPD in which the department has been engaged had led to substantial changes in his practice and that he had been increasingly willing to let the girls take the lead in lessons: 'I think it has chivvied me even further along the road of getting the girls involved more, of taking a slightly more background role.'

Student learning

Nigel commented that asking more open questions and promoting more discussion between pupils gave him much more insight into the girls' knowledge than a traditional approach would have done: 'You wouldn't know that your pupils had this level of understanding without working like this.' In data that was collected at the summer residential, he said:

> *In my CPD, I find it difficult to find words to describe how the students have changed. Students are stronger/more able because of the interaction amongst themselves in my classroom. I find that in Year 7 the way students talk about the subject amongst themselves is leading to more openness, more focus and appreciation that this subject is not just confined to textbooks. I believe the reality and understanding and skills evoked in an open approach changes their ability and enhances their skills in other subjects as well.*

We find the enthusiasm and excitement that is captured in this quotation striking. This comes from an experienced teacher working with groups of students who had always performed adequately, but who were now engaging in mathematics with more interest and a greater sense of its meaning and importance. Clearly this teacher feels that his involvement in this CPD has had an impact on his students' learning as well as their attitude to mathematics.

4.5.8 Case Study 4: Conclusions

This whole (secondary) mathematics department initiative was led by the second in department in response to a perceived need to develop mathematics teaching and learning within the school. It has received funding from NCETM and is based on the Japanese Lesson Study model.

Matthew described how his teaching had been affected by his engagement with books on mathematics pedagogy and educational research and the ideas that he had picked up from these. He had set up the lesson study project in his school because he felt the processes that were being suggested could be useful for the professional development of the whole department and he said that the involvement of the whole group had radically altered his teaching. Nigel said that his involvement had made him realise how complex the business of teaching and learning was and that he had shifted his focus away from his teaching onto his students' learning. He also felt that his mathematical knowledge had improved. At the same time, he felt that he was more relaxed and confident in his teaching and more willing to let his students take the lead in lessons. These kinds of deep reflections and observations about teaching and learning fit with the aims of the CPD. We suggest that the shift in attitude and practice described by Nigel, the head of department, is particularly significant. Here was an experienced teacher with a sound record, who was rejuvenated in his teaching and found himself enjoying his teaching and interactions with his students more than he had previously.

More generally, the department as a whole seemed engaged with the process of lesson study during the observed meeting. There was a sense of joint responsibility for the creation of the resources and genuine concern to develop the best lesson that they could collectively. The methodology (i.e. Japanese Lesson Study) seems to provide a structure within which teachers are supported to reflect upon their teaching and the learning of their students and to change their practice. Whereas the mathematical focus of study within the Japanese approach was 'factoring of quadratics' it is likely that this was only a starting point in more substantial changes to teachers' practice, as Nigel's change illustrates.

The use of video recording as a means of observing and critically reflecting on a particular lesson also seems to be a key aspect of this particular initiative, allowing the teachers to scrutinise the responses of the students closely after the lesson. Nigel and Matthew both commented on the shift in their focus, from their own teaching onto a scrutiny of the students' learning.

The role of the leader within this whole-school initiative appears to be important. This leader is clearly very open to and receptive of research and development ideas within mathematics education. His role as a leader of change appeared to be recognised both within the department and in the school more generally, evidenced by the way the head of department used his skills and the head of the school called on him to lead other CPD initiatives within the school. The previous work Matthew had done with the department, on developing enquiry based approaches to teaching for Year 7 pupils, meant that the department had a shared history that valued collaborative lesson planning and resource creation. We would suggest that Matthew's role as an enthusiastic leader of change was highly significant in this initiative. We suggest that the changes in classroom practice may be explained by this strong leadership offered by Matthew, in terms of modelling his own professional change as well as prompting the rest of the department to scrutinise their teaching and the learning opportunities they offer their pupils. This strong leadership has led to a culture within the department that is supportive of professional change and focuses strongly on students' learning.

Similarly the involvement of the whole department as a group is significant in supporting individuals in scrutinising and changing their practice. Another aspect of this initiative that struck us as significant was that this was a school with an established record of high attainment from its pupils in mathematics, and their focus was not merely on maintaining those high standards but on improving students' attitudes to the subject and encouraging more of them to continue studying it for longer and at higher levels than previously. It seemed as though the department's previous work on developing enquiry-based learning approaches at Key Stage 3 had encouraged them to think this would be possible, and the current lesson study approach sought to achieve similar objectives with older students.

4.6. Case Study 5: EYFS network

The case study presented in this section concerns one strand of the EYFS network discussed in Chapter 3. 'Context', below, begins by providing some background to the Case Study and then describes the Case Study initiative.

4.6.1 Context

This initiative is set in the context of EYFS[55] education in which a group of teachers and practitioners established a network group in a city in the south west of England. The network was initiated by two researchers, who seem to be passionate about children's early mathematics, as evidenced by the fact that they run courses and conferences in the area around a major city. The researchers, Melanie and Lizzy, said that their passion was evidenced by:

> *… our strong desire to help make mathematics more meaningful, challenging, accessible and interesting for young children.*
>
> *… our deep and enduring interest in young children's learning.*
>
> *… our belief in the significance of research.*
>
> *… the considerable number of research projects on children's mathematical graphics (and the related pedagogy and CPD) that we have conducted during the past 18 years.*
>
> *… the numerous articles, papers, chapters and book we've published (with many more due to be published in 2009).*
>
> *One reason that our work has been successful is also that we have been teachers (and Lizzy is still directly involved with children) and developed children's mathematical graphics when we were teaching in the nursery and in schools in the 2-8 year age range: this means we both really understand what is possible for mathematics in Foundation and Key stage 1.*

This description shows that for these researchers, involvement in CPD was driven by a passionate commitment to children's mathematics and to ways of working with other professionals to develop it. This had originated in their own teaching experiences as a result of careful research into teaching and learning mathematics and reflecting on their practice over a number of years. The theme of passion and its relationship with CPD is picked up in Section 6.4.

[55] See footnote 4

Sarah, a teacher who went on a course run by one of the two researchers, said:

> *This was an inspirational course and came at exactly the right time for me and my setting where I am maths coordinator. I initiated the Group in March 07 under the umbrella of the two researchers' organisation and Melanie has been very supportive throughout.*

At the course, Melanie and Lizzy suggested that forming groups at a grass-roots level would help to encourage and support teachers and other professionals in working with children's own mathematics. In the context of Early Years education, this means focusing on mathematical graphics that children initiate themselves to explore and communicate their mathematical thinking, and using their attempts to express mathematical meaning as the basis for their teaching and learning.

Sarah acted on this suggestion to form this group. As she said:

> *I was enthused by Melanie and, having identified a gap in the curriculum in the transition between Foundation Stage (pre-school and reception) and Key Stage 1 (first years of formal schooling), which my own setting was seeking to fill, I was able to pursue the ideas.*

Within the school over the previous year or so there had been a significant change in the approach to teaching in the reception year, especially in mathematics, which had been driven by new Early Years Foundation Stage Curriculum[56] guidance.

The leader, Sarah, describes the work of the group as follows:

> *I have introduced practice and understanding from the CPD I received from Penny and fed back to both my own setting and the group. It has made me research an area of the curriculum about which I am strangely passionate, reflect on my own understanding and practice, collect and collate evidence and share this with fellow maths enthusiasts within my school and the group.*

So the group was set up partly in response to Sarah's perception of a gap in the curriculum and in provision for transition between Early Years Foundation Stage and Key Stage 1 in the school in which both teachers work, as well as in response to the suggestions made by Melanie and Lizzy at the course Sarah attended.

4.6.2 Aims of the CPD

- To develop teachers' and other practitioners'[57] professional understanding of young children's understandings of mathematics and to support them in developing strategies to develop and support children's early mathematical development, through considering examples of children's work and reading relevant research literature.
- To encourage teachers to observe children's spontaneous mathematics in terms of mark making, problem solving and communication.

4.6.3 Intended professional development

The intention of the group was that the professional development would involve:

- Supporting teachers and other professionals in developing effective strategies to support children's mathematical development.
- Developing an understanding of the importance of children's mark making and the ways in which children make sense of early 'written' mathematics..

4.6.4 Intended changes in practice

Melanie and Sarah hoped that the participants' practice would:

- Move away from imposing mathematics on children and work towards supporting children in developing their own mathematical understandings and representations in meaningful contexts.
- Support children in adopting conventional symbols, such as the numerals, by working with the children's own representations and understandings.

[56] See footnote 4

[57] As well as teachers, a number of other groups of early years practitioners, who have professional training in child care and child development, work in EYFS settings including nursery nurses. A number of early years practitioners were participants in this group as well as some teachers.

4.6.5 Content and processes of the CPD initiative

The group was informal and met about once every six weeks. It involved teachers and nursery nurses from a number of different primary and nursery schools in the local area. In most cases more than one teacher participated from each school. Meetings were held after school and the venue changed from school to school. They lasted an hour and a half, with refreshments provided by the host school. The leader of the group, Sarah, intended to delegate more responsibility for convening the meetings and managing the discussion to others in the group and welcomed participation at all levels from everyone. The group was observed to be supportive, open and egalitarian in its structures. For example, at the observed meeting Sarah did take the lead, but all the participants brought their own contributions and all commented freely on each others observations without Sarah dominating the meeting. Towards the close of the meeting another member of the group offered to host the next meeting and the agenda for the following meeting was collaboratively decided upon as an outcome of the observed meeting. One of the participants said that colleagues from another school had seemed interested and the group decided that they should be included in the next meeting.

The group receives no funding from the schools or any other source, except in the supply of venue and refreshments by the host school. The agenda and content of each session is decided co-operatively by the whole group, which means each participant is supported in their participation by the relevance of the content of each session and the collegial support from their peers. During the meeting that I observed, the participants all contributed examples of children's spontaneous mathematical problem solving which they had observed in their own settings. These examples were shared with the group and the scenarios from which they had arisen were discussed. The topic had been chosen at the previous meeting in response to the focus of the Revised Numeracy Strategy and in the Early Years Curriculum Guidance on problem solving. Sarah described this as follows:

> *At the group meetings we share examples of our children's mathematical learning supported by photographs, quotes, samples of work etc. We are currently working towards a shared file of examples of children's problem solving as a resource for all members of the group. Sharing our experiences, children's work, information from Melanie, other CPD training and ideas, adds to our collective knowledge of teaching mathematics.*

This sharing of children's work formed the substance of the observed meeting and included a tremendous variety of examples which had been carefully analysed by the professional presenting it. In many cases, these examples involved accounts of what the children had done, examples of their productions in terms of marks made on artefacts created and photographs of the children in action. The group discussed in detail the mathematical aspects of each example and talked about how they could support the mathematical thinking that it represented.

4.6.6 Teacher 1

Sarah was the leader and administrative organiser of the group. She was an experienced teacher with a post graduate teaching qualification and had studied mathematics to GCSE level. She specialised in Early Years and Key Stage 1 and took a leading role within her school for provision within the reception year, and so managed the transition from EYFS to Key Stage 1.

Actual professional development

For Sarah the main gain from the group was in:

> *… enabling me to continue to keep abreast of current thinking, be reflective and share my ideas and experiences with fellow early years practitioners, teachers and nursery nurses in the private and maintained schools, in a safe, supportive, non-threatening environment.*

Her involvement in the group and attendance at various conferences in the area run by Melanie and Lizzy had developed her understanding and enthusiasm and she was in the process of becoming a researcher in her own classroom. This is evidenced by the following comment:

> *I have done additional research to promote children's mathematical graphics and problem solving, which are the main things that the group has focused on so far.*

Sarah had read a lot of research articles about children's mathematical graphics and problem solving and felt that this was important:

> *I liked knowing that I am aware of current thinking, research and best practice.*

Sarah's participation in the group had made a significant contribution to her professional development. She had become more confident, as she said in her questionnaire response:

> *I feel more confident in my teaching of mathematics and proud of my school's early years team's development in this area. The group is a lot of extra work for me but I find it personally rewarding, professionally exciting and socially enjoyable. It has been great to visit other settings as we take it in turns to host the meetings – and the next meeting will be chaired by the person hosting the meeting, so I might feel less responsible!*

For Sarah, one of the key outcomes of involvement was the opportunity to discuss ideas related to EYFS teaching with colleagues from within her school and other schools, and to share examples of good practice as well as current guidance and issues arising from practice.

Changes in practice

Sarah was now committed to practice focused on children's mathematics as a result of her extended study of children's mark making and problem solving. This involved a way of teaching that was completely different from a worksheet-and textbook-based approach that used to exist in her school.

Evidence of this change was observable in Sarah's classroom. Examples of the children's spontaneous mathematical work were displayed in annotated form on the walls and in their books. The environment offered a huge range and variety of resources for mathematical investigation which were all freely available to the children. Sarah voiced her enthusiasm and passion for the CPD and her work in leading it but also expressed the sense of pressure that taking on a commitment to leadership of the group had engendered. She said she would like to:

> *Feel less overwhelmed by my overall work load and how many balls I am trying to keep in the air while making directed changes and keeping abreast of new initiatives and government requirements. I would like to feel less pressured all the time so I could really get down and focus on the children, their understanding and interests and then work with them to develop their mathematics within a balanced and meaningful curriculum.*

This quotation illustrates that for Sarah children's mathematical learning was centred on the children's interests, understanding and the meaning that they could attach to it. Developing her own professional understanding of this process was time consuming but very worthwhile. Sarah voiced her frustration at finding it difficult to find time for this work that she regarded as important.

Student learning

Evidence of changes in children's learning of mathematics was displayed on notice boards around the classroom as well as in the children's books and they were able to articulate their mathematical understandings clearly. As Sarah said:

> *The children in our classes have a positive attitude to sharing and representing their mathematical thinking. They are developing confidence in their mathematical graphics which are valued, they are developing fluency and a willingness to talk about their thinking. By focusing on problem solving they are identifying meaningful problems, rising to the challenge and developing a sense of achievement and satisfaction in finding a solution. They are sharing ideas and drawing on prior experiences to inform their strategies. Hopefully this positive attitude to mathematics and problem solving will stay with them. The children are able to demonstrate their individual ability and explore concepts beyond the normal curriculum.*

The displayed work, both within children's books and on the walls, demonstrated the detailed observations and analysis that Sarah made of evidence of the children's mathematical thinking and understanding on a day-to-day basis. It also illustrated the importance of mathematics for these children in this class.

4.6.7 Teacher 2

The second teacher involved was Anne, who was working with a reception class of children aged four to five years in the same school as Sarah. She was an experienced teacher who had worked in primary education for over 20 years in a number of schools. Much of her teaching prior to her involvement with the group had been traditional and based on working with young children using schemes of work and worksheets drawn from published resources. Her participation in the CPD arose through the leadership and encouragement of Sarah, who felt that they would both benefit from the added support that the group might offer them. Anne was convinced by Sarah's argument and willing to try the approach out in her classroom (and also to support Sarah within school against some opposition from teachers of older children to the changes in approach).

Actual professional development

Anne suggested that before taking part in the CPD, she had found teaching mathematics less interesting than literacy and some other subject areas. However, having adopted the new approaches suggested by the CPD, she said she had become passionate about teaching mathematics.

Anne was initially resistant to the idea of changing her mathematics teaching to focus on the children's mathematics. She said that she was uncertain about how much mathematics the children would engage with if they were not involved in filling in worksheets. As she said at interview:

> *I didn't feel that comfortable to start with and it wasn't until I realised they (the children) were learning so much more that I was convinced. Pursuing their own maths gives them unlimited potential to develop their mathematical ideas. The imaginative games they have come up with that are far beyond the maths in the scheme. I could never go back to that now. The meetings gave me confidence to speak to parents and feel sure that I could justify our decision.*

Changes in practice

Anne described her teaching of mathematics before her involvement with the group as traditional and based on worksheets and teacher-led activities. She described how she had moved from directing the children's mathematics to stepping back and offering the children prompts and suggestions so that they could pursue their own mathematical ideas. As she said:

> *I am more confident now but there is still more to learn. It's a learning journey and it's lovely to have a small class and be able to observe the children carefully… For me seeing 'is that really maths?' was a revelation and now I am so excited about what they produce and waxing lyrical about the marks they make and we all (teachers and nursery nurses in the group) enthuse and gain from each other.*

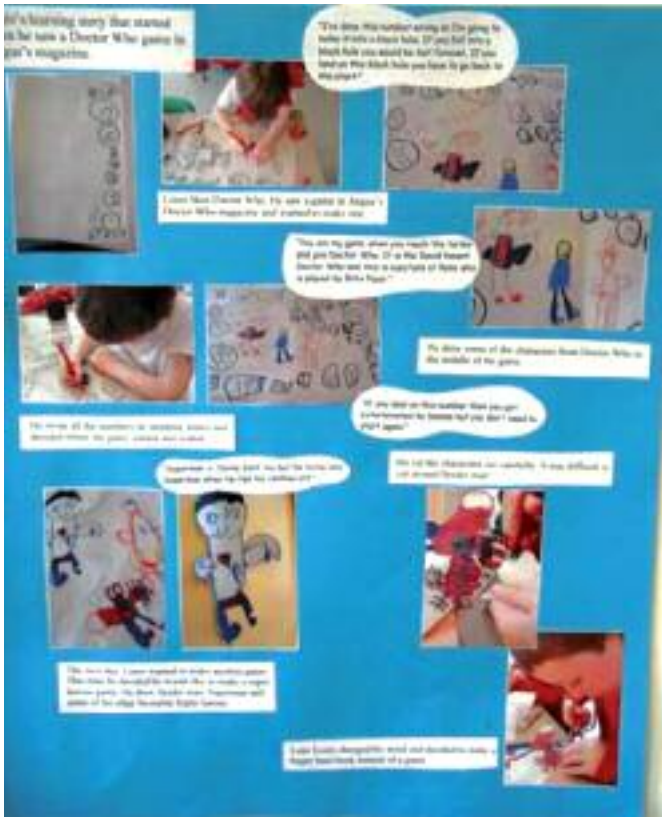
In the lesson observed, the children were working on a variety of different mathematical tasks of their own invention that were triggered by some initial counting activities as a whole group. After this, the teacher prompted the children by sharing with them her mathematical problem for the day. She told the children that she needed to work out how much money to take with her to the staff barbeque that evening and then suggested that they might work something out themselves. No constraints or questions were offered and the children were entirely free to choose their own activity, mathematical or not. They all chose to do something that had some mathematical element to it, probably prompted by the counting activity that had been the starting point for the session. One child chose to count and record the number of syllables in the first line of various songs so she wrote down that Baa baa black sheep was four. Another child was involved in making a chart like a register for an imaginary class of children. Several children acted in the role of teacher to one another, including one girl explaining very patiently to a boy how he should write a '5' so that it was the right way around. The boy concerned was writing numbers to record a quantity as part of his own activity and asked his peer whether he had written the number correctly, which prompted her support. Three children wrote numbers with marker pens on a whiteboard and carried on writing correctly all the numbers to 31, correcting each other's errors in the orientation of the digits. The order of the digits was not problematic for them.

Student learning

Anne offered many examples of the richness and high mathematical content of the children's mathematical productions. She described a boy, aged four years, who had got interested in big numbers and counting in her class the previous year and who had been fascinated by a pedometer that she wore, to the extent that he would tell her how many more steps she needed to take that day to reach her target of 5 000. He also suggested to her that she should keep walking around while she was talking to him so that she would increase her count. Several children in the class had their work displayed on the walls and they were able to tell the stories that lay behind their productions very clearly and coherently. The standard of the mathematical understanding, thinking and reasoning that the displays revealed was far higher than the specified curriculum objectives for children of this age. For example, one girl showed photographs of a paper chain that she had made and described how she had estimated the number of links she would need to make to ensure that it was the same length as the table. She had also made a tape with numbers written on it in order to create her own measuring tape, so she was beginning to conceive ideas about measurement and estimation not usually introduced into published schemes until children reach the age of six. There were many other similar examples of children's mathematical thinking.

The following example, Figure 4, shows the detail of the accounts that Anne's descriptions offered, both in work from their books and on display on the classroom walls.

Figure 4 Display in the EYFS classroom



4.6.8 Case Study 5: Conclusions

This network of EYFS teachers is very much a bottom-up initiative and the starting point was input from two local 'experts'. The ownership of the network was devolved and the organiser sought to empower all the participants to take it in turns to lead sessions. The venue of the meetings changed on a regular basis, as did the person who led the meetings. These were decided upon co-operatively. Membership of the network was open and growing but involved a strong commitment to participation. All members of the group were expected to contribute to meetings and to share their experiences. The focus of the meetings was children's mathematics and the teachers brought examples of children's work and photographs to share. The central focus of the teachers' work was on supporting children as they developed their mathematics and in allowing them to pursue the mathematics in which they were interested.

Sarah described how the CPD had helped her to reconcile new curriculum guidance with approaches to teaching mathematics to young children that needed to change. Her reading of research literature about children's mathematical graphics and her involvement in courses led by Melanie and Lizzy had led her to set up the group. Anne became involved in the group as she was a colleague of Sarah's and they were both concerned about implementing the new curriculum guidance that involved changes in practice from their previous ways of working. In Anne's case especially, this involved shifting quite considerably from previous practice and overcoming an initial reluctance to change and scepticism about whether the change would be beneficial to the children's learning.

The changes that the teachers made in their practice were fully in line with the aims of the CPD. We would suggest that the success of Anne in overcoming her reluctance to change may have been due to the support that she got from the group and especially from Sarah. This suggests that ways of working with teachers that facilitate their mutual support and offer them ownership of the content, purpose and direction of their CPD may be particularly effective in supporting radical changes in professional practice.

Participant ownership of this initiative helps to sustain involvement and that the members support one another in sustaining this passion and enthusiasm. Overall, the initiative supported the participants in their professional change by giving them a space for the detailed and joint consideration of children's mathematical thinking. It supported them in following up research sources that would support their analysis of the children's mathematical graphics and enabled them to encourage children to take charge of their own mathematical activity. It also offered them a supportive and encouraging arena in which their professional concerns and difficulties could be discussed.

another significant feature of this initiative is its focus on careful consideration and analysis of children's mathematics, and the ways in which professionals can support and encourage the children's mathematical thinking and reasoning. We were struck by the emphasis on observing and analysing children's spontaneous mathematical activity. This emphasis seems to shift the teachers' focus from teaching to learning and to give them the opportunity to consider the children's mathematical understanding and thinking. The teachers are then able to use this to support the children in their mathematical development and to plan appropriate adult-led activities that help the children build their mathematical thinking and reasoning, such as the counting.

4.7. Case Study 6: FE Network

4.7.1 Context

This initiative was run by an NCETM FE Regional Coordinator, with input from an NCETM consultant and Subject Learning Coaches[58]. This network, like other NCETM FE networks, was part of a wider programme which had three elements: the resources, the coaching programme and the network meetings. The coaching programme was generic, so the subject part of the programme was covered in the networks, although the network used coaching techniques when appropriate.

Most of the participants were practising teachers in post-16 education. The mathematics they taught varied from A Level (mathematics and further mathematics) to basic numeracy and key skills. Their students ranged from full time, 14-19 year old students to part time, adult learners. Two participants worked in prisons, four taught in work-based learning contexts, others taught adult learners, most taught in FE or 6th form colleges and some were from schools with 6th forms.

4.7.2 Aims of the CPD

The initiative brought together mathematics teachers to explore approaches to teaching and learning, in particular the pedagogy exemplified in ILM[59] and TTM such as active approaches to teaching and learning, more open questioning techniques, a variety of methods of assessment. It aimed to encourage discussion, collaborative planning and sharing experiences of trying out new ideas. Also, teachers were encouraged to share their experience with colleagues in their organisations and to 'spread the word' about the approaches either informally, by running CPD sessions themselves, or by coaching colleagues.

4.7.3 Intended professional development

The organiser told us that for some teachers, reinforcement of subject knowledge was important, and suggested this was helped by them trying out learner activities. She said that for many teachers, the intended learning was about changing their beliefs about the way mathematics should be taught (a move from the more traditional 'passive' learning to 'active' learning).

The organiser hoped to raise teachers' awareness of how their own learners might feel and challenge them to think about their own approaches (by using activities which put the teachers in the position of learners).

4.7.4 Intended changes in practice

The organiser of the network reported:

Some intended changes (to varying degrees) were:

- to become more reflective practitioners
- to use active learning approaches
- to work collaboratively with colleagues
- to focus on learning rather than teaching.

4.7.5 Content and processes of the CPD initiative

Meetings took place termly, and ran for a day. There was usually a whole group session (the one observed by the RECME researcher was about using more open questioning techniques). Very often, participants made a presentation. The leader of the CPD told us that she approached these people to present, either because they had told her about what they had done in the classroom or because they had included plans to do so in their evaluation at the end of the previous sessions. She also said that by encouraging participants to make presentations, she hoped to build a culture in which the teachers took ownership of the CPD and made it their own. She felt that participants who had been attending these meetings for a while found the environment safe and friendly and were therefore happy to share their views and experiences.

In the observed meeting, there were four presentations, including one by teacher 1 below. Three of these are described in Section 3.4. There was also a presentation by one teacher (teacher 2 below) about the process of obtaining funding from the NCETM for an action research project.

Usually the meeting also included a number of parallel workshops, to cater for people with different interests and needs. In the observed meeting, the teachers discussed some of the harder-to-teach topics in their areas (basic skills, GCSE and A Level), and made some plans about how to tackle these. These workshops were led by participants in the CPD. The decision to ask the teachers to lead the workshops was a deliberate one on the part of the organiser, and she explained later that through doing this, she was trying to encourage the teachers to make the meeting their own.

[58] http://www.subjectlearningcoach.net/

[59] see footnote 22 and 23

4.7.6 Teacher 1

This section discusses the CPD experiences of Helen, one of the two teachers who were invited to take part in the in-depth part of the research. As with all the teachers interviewed, the lesson observation and interview notes were sent to Helen for her comment. Helen added extensively to the notes to include further explanations. As a result, this section has a strong teacher voice.

Helen reported that she had always worked part time, as she had three children and wanted to stay at home to bring them up. Most of her career she had taught IT part time, for adults, with a small amount of GCSE mathematics (her degree is mathematics). About 12 years ago she started teaching numeracy to adults and acquired some basic skills training over time. Recently she had also taught literacy to adults.

She became involved in the network (this CPD) about two years ago. She explained that she was 'the sort of person who gets involved'. She felt very isolated as a numeracy teacher and she said she 'keeps wondering if she is doing it right'. She said that she went to the network meetings to meet other teachers and talk about what she and they were doing.

Actual professional development

Helen said that going to the network provided the opportunity for her to meet people, even from the same college with whom she found it difficult to keep in contact. She liked to keep in touch and getting together with others was good for her confidence. She said that as a result of the CPD she had become more confident. It had also made her more aware of herself and her feelings; she said she did well enough in education, but had other difficulties in common with many of her learners and knows what it feels like to lack confidence.

She said that through the network she had been exposed to new and innovative teaching resources and she said that the yellow 'Thinking through Maths' pack distributed by the FE network had been a big influence on her teaching.

Helen also reported that she enjoyed being exposed to 'interesting' mathematics but that sometimes she found it difficult to understand the mathematics. She said that she enjoyed this challenge, as it made her develop her own A Level mathematics skills at home. She said that she had tried hard to get really into the 'nitty gritty' of the difficult parts of teaching and learning mathematics and she had thought more about how people learn.

During the network meetings, together with other teachers, Helen sometimes made resources and games to take back to her learners.

She said that the experience of attending meetings rejuvenated her.

Changes in practice

Helen reported that 'being in the network has made me try new things'. She said that she frequently adapted the activities to which they were introduced in the meetings for her own learners. For example, she had adopted more open questioning approaches as described below from our observation notes.

Helen started the session; three participants were there. Helen began by talking about factors, and asked if anyone could think of a number that has loads of factors. Henry suggested 100 and Helen wrote it on the board and underneath wrote a bracket:

(1, … , 100)

By now more participants came in (not all together). Helen asked for some other pairs, and Sue suggested 2 and 50, and Helen wrote on the board:

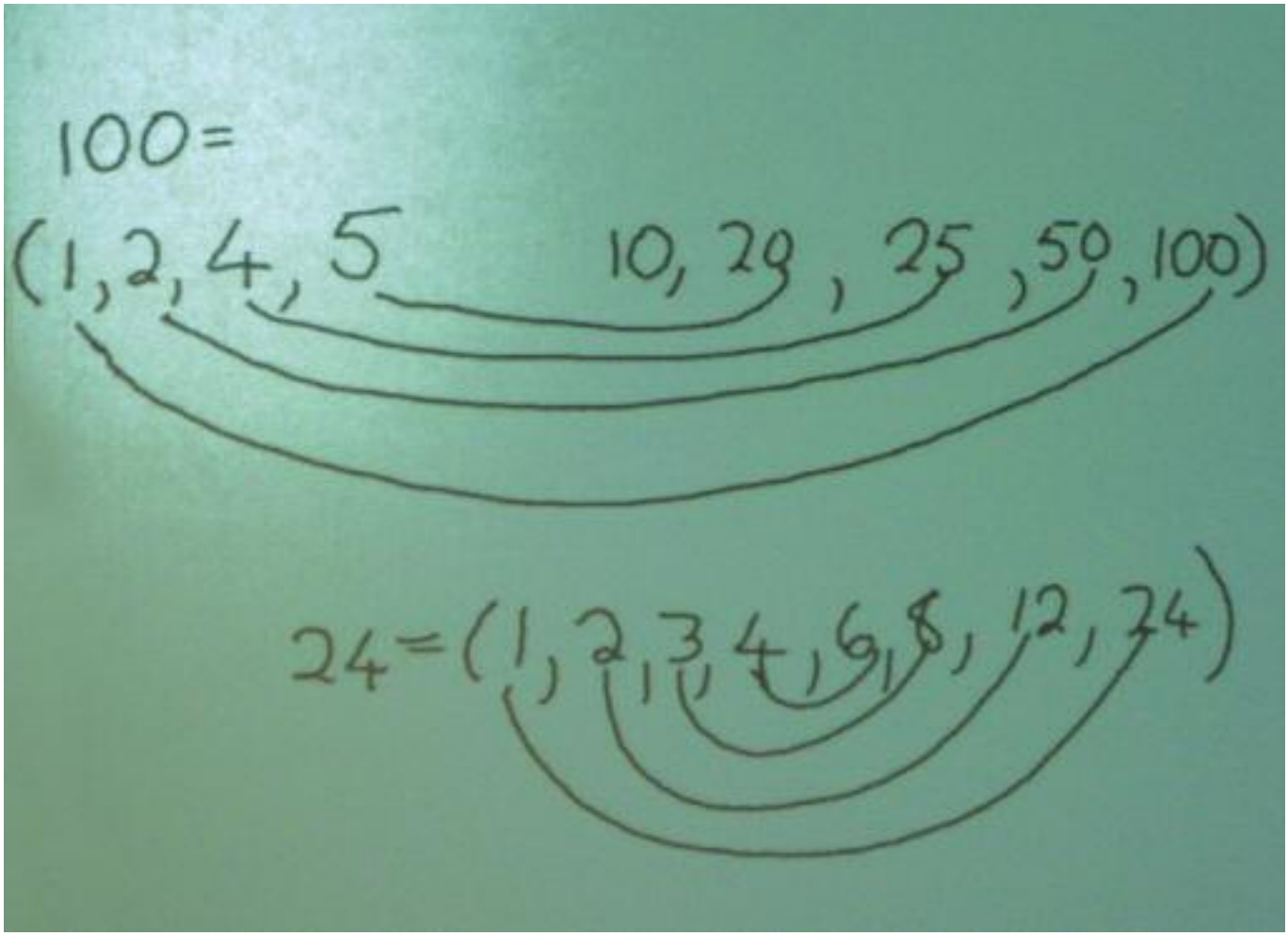
(1, 2, … 50, 100)

Gill said '10' and Helen remarked that 100 is special, and said that they would discuss 10 later.

Sue suggested 5 and 25, and Helen said, let's think about 5 – and did a division calculation on the board, and got 20. So she pointed out that 5 and 20 made a pair (see Figure 5) on page 68.

They did all the factors (1, 2, 4, 5, 10, 20, 25, 50, 100) and Helen said again that there's something special about 100. They repeated the exercise with 24 and paired them off. Helen said she wanted them to think about why she had paired them off. She asked them to work out what was special about 100. Eventually Henry said, 'We're not going to get it – what is it that you want us to notice?' Helen showed them that in 24 all the numbers are paired off, but in 100 the 10 in the middle is not paired off.

Figure 5 Board work on factors



Helen said, 'There's a certain kind of number where there's a factor in the middle that doesn't pair off'. She asked them what the special kind of number is called and Gill suggested prime, and then corrected herself and said square. Helen explained the name 'square' by drawing a square (showing that the sides are the same).

Helen suggested that this approach was directly influenced by her CPD, and went on to explain how her teaching had changed:

> *I would have given them a number to factorise before, rather than let someone choose. I didn't have enough confidence, before the FE network sessions, and would have wanted to use examples that I'd worked out for myself beforehand. I was criticised in the past in GCSE Maths observations for being too careful and in control, and I think that was because I worked everything out too meticulously and stuck to it, rather than adapting to what the learners wanted.*

Helen also said that she had changed in that she now does a lot more small group/pair work and encourages more collaboration. In the lesson we observed, these ways of working were evident. For example, she suggested that that Jenny and Natalie work together on fractions. She said she had worked on their assessments and saw that they both had glitches on fractions. She encouraged them to talk to each other to make sure that each understood as they went along.

In considering the changes she had made, Helen said that she felt her teaching had definitely improved.

Student learning

This was Helen's first year of teaching in this role, so she said it was difficult for her to comment in detail on whether there was an improvement in student learning. However, she thought that student learning had generally improved. She said that her students had achieved better test results than students in previous years.

She now has a new group of 12 students and she reported that 12 of the 13 liked the approach ('active learning') that she used. The thirteenth student, she said, preferred a 'text book and worksheet' approach. One of the indicators she used to assess her success with students was retention, and she reported that retention was much improved among her students.

Helen also told us that:

> *Out of the learners you saw, Jenny, has really blossomed. She is working on activities from the Nrich site www.nrich.maths.org on prime numbers, etc. and is doing the everyday practice work very well too. She will definitely take maths further than these National Tests, we prepare them for, now and loves a really challenging problem to get her teeth into.*

In response to a question about whether Jenny's success could be attributed to her, Helen said not necessarily, but that she thought the active methods she used had certainly helped Jenny.

4.7.7 Teacher 2

Like Helen, this teacher provided full and detailed feedback on the research notes sent to him, so once again this account has a strong teacher voice.

David began teaching 21 years ago. To get his teaching qualifications he did an honours degree in mathematics and computing combined with a Certificate of Education. He taught in an inner city secondary school in the UK for three years and then went to Turkey to teach there. He returned to the UK after two years and followed a variety of career paths, as well as being primary carer for his children. He set up and ran English language summer schools for Turkish students and recruited teachers for private schools there. He joined his current institution, an inner city FE college, towards the end of 2000.

At college he coordinated and taught Key Skills Application of Number and taught Key Skills ICT and Vocational Units that involved mathematical content to students who were studying on BTEC vocational courses. This involved embedding practical mathematics into vocational contexts relevant to the particular vocational course of each class he taught.

David recently completed the subject learning coaching (SLC) CPD by attending a nine-day course. At the subject learning coaching training program CPD he was very much influenced by the work of Malcolm Swan and the '8 principles of effective learning'[60] and through this he developed skills in using activities such as card matching, making posters and discussion in the mathematics classroom, and that had changed his practice.

Since beginning his career, this recent CPD experience (SLC) and the current involvement in the network was the only mathematics-specific CPD he had been involved in; he reported that most of his CPD had been college based, generic and college focused – he described it as 'death by *PowerPoint*'. He said that he valued the mathematics focus of the SLC CPD and the network.

He was encouraged to join the network and wanted to do so because he valued meeting other teachers.

He was carrying out action research (funded by the NCETM) about functional mathematics at his college and with two regional mathematics networks, which he was enjoying very much. He saw action research as an 'ideal vehicle for CPD' where a group of practitioners worked together, decided on a common goal and research options, as well as how to achieve that goal. The group also committed to achieving that goal.

He was particularly interested in the teaching and learning side of functional mathematics and he said that he hoped its assessment would not detract from the problem solving/ transferable process skills philosophy, as advocated in the standards.

Actual professional development

David told us that the SLC programme in which he had previously been involved was very comprehensive in all areas of mathematics. He said that the network meetings (the current CPD) revisit most of these topics so, in terms of the general principles of active and connective learning, the meetings serve to reinforce the SLC learning and exposed him to how different practitioners approach active learning, and to different areas of mathematics.

David's main reason for continued participation at the meetings was because he liked the contact with people he met there and because he was sometimes called upon to present or tutor at the network meetings.

[60] These eight principles are explained in the ILM and TTM resources, see footnotes 22 and 23

According to David, in some ways the CPD addressed his needs in that he liked meeting up with others in the field. However, he did not feel that he had direct needs concerning his immediate work and he was not looking to the CPD to fill any particular needs at the moment. On the other hand, applying Standards Unit principles[61] to Key Skills does have a useful role in validating his ongoing classroom practices in a college environment where 'training' learners was sometimes seen as more important than educating them. He said that the network was also an excellent place to get support if needed.

Changes in practice

David said that his practice had not been influenced by the Network CPD, as he was already adopting the approaches suggested by the SLC programme CPD which formed the basis of this.

When we observed his lesson, a level 3 vocational ICT unit, we saw an example of 'active learning' applied to that particular unit.

He handed out a card matching worksheet. He asked the learners to cut out the cards and match numbers in base 10, base 2, base 8 and base 16 together.

He suggested that they work in pairs or threes.
The students took the worksheets, cut out the shapes and worked in their pairs discussing their solutions (see Figure 6). They all seemed to be on task and working steadily. There were very few requests for help.

Figure 6 Working on different bases

After the lesson, David told us that:

> *The active learning worked well within this context, the learners achieved their learning goals and all learners presented correct learning checks.*

Student learning

David's response to the question as to whether he had noticed an improvement in student learning since he started the CPD, was a detailed account and is included here in full to provide the reader with an understanding of the context in which he works:

> *After 11 years at school we get learners who can barely add two numbers together and are thoroughly disillusioned with mathematics education. Even learners who achieve GCSE grade C's or above in mathematics have 'had enough' and never thought they would have to do any form of Maths again.*
>
> *In colleges we are told to overcome these barriers by teaching a 35-hour key skills course that aims to raise learners' qualification by a level and support them on their main vocational programme - at the same time we must meet a 65% achievement rate or get our courses 'axed'. We must also improve the student 'learning' experience while meeting our own colleges' generic lesson observation criteria – which does not match what we are told at Network meetings that OFSTED is looking for in a maths lesson (i.e. Swan's eight principles). We are not helped either by literal interpretations of specifications that are not always fit for purpose, cumbersome and time consuming assessment methods that are insisted on by managers, dated syllabuses, league tables and most importantly the emphasis on funding. Any improvements seen in teaching and learning must be seen within these contexts.*
>
> *CPD has helped me develop my own practice but reflection centres on questioning things which are not in my control – when we encourage learners to reflect they often ask questions that are 'dangerous' for the profession and the solutions are beyond our control or there are no solutions - after seemingly 11 years of mathematical conditioning where maths has always had an answer this is a shock to their systems.*
>
> *Under the present regime compliance is emphasised (and easier) rather than understanding – it is also easier to evidence 'activity' using a worksheet than learning by matching cards that are only around for one session – for some learners (and some management) a fat folder is the only proof of learning.*
>
> *The emphasis on developing process skills is hard to assess and often misunderstood by learners and other colleagues – they have never been given time to reflect and it goes against the 'keep them busy' culture.*

[61] This is the term he used, but it refers to eight principles outlined in the ILM materials, see footnote 22.

Learners enjoy active learning to a point – many would rather be told what to do rather than think (vocational 'training' culture) – thinking and understanding challenges and exposes their weaknesses and many especially at the lower ability levels who have little motivation have not developed the social skills necessary to cope – the 'I hate maths' barrier can be put up very quickly. On the other hand, some do shine and enjoy helping less able students. There is also more tension in the classroom as learners find it harder to 'hide' – not a bad thing in terms of learning but difficult to justify if a learner leaves because of it putting a dent in our retention figures and costing up to £5000 in retention related funding!

4.7.8 Case Study 6: Conclusions

This FE network is run by an NCETM FE Regional Coordinator and appears to be playing an important role within a sector that has historically not provided many subject-specific CPD opportunities for its mathematics teachers. Both teachers remarked that they valued the subject-specific focus, and also seemed to value the opportunities provided by the network to meet with other teachers in the sector. One teacher also remarked that the CPD rejuvenated her.

Both teachers reported that they had developed confidence through taking part in the CPD, with one teacher saying the participating in the CPD reassured her about the 'active learning' approaches she was taking, and with the other suggesting that the CPD reinforced the principles of active learning. Both the teachers seemed to be committed to the ideas about active learning and starting from the prior learning of the students, but the reassurance they gain from the CPD meetings seems to be important to them.

The active learning approach is strongly espoused in the resource materials and these materials were a strong component of the CPD.

We observed that both teachers adopted active learning approaches in their classrooms. We suggest that for David, this may not have represented a significant change in practice, but for Helen, it seems it was a bigger change. As she said, she was now less controlling in the classroom. There was also evidence that she was using approaches that put the student at the centre; as the observation notes demonstrated, she devised different tasks for the students depending on what she perceived their needs to be.

It seems that both teachers take on a leadership role in their colleges and within the network. With Helen, it seems that the college in which she works is recognising her skills and putting her into an informal leadership role:

I have now got two new numeracy teacher/LSA (Learning Support Assistant) trainees attached to the evening group so I doubt if my superiors would do that unless they thought that I would be a good influence on them.

David's action research project puts him in a role of leadership.

The network is organised in such a way that participants are encouraged to present within sessions and in this respect a distributed leadership approach is being encouraged. Both these teachers regularly present at meetings and take responsibility for aspects of running and leading sessions within network meetings. Interestingly, David suggested that he was interested in perhaps becoming involved in providing CPD for teachers of mathematics.

4.8. Conclusions

This chapter presented detailed case studies of six CPD initiatives. It discussed how the initiatives were organised and the sorts of activity taking place during the meeting (or in some cases two meetings) observed and this contributes to a detailed characterisation of the initiatives. The particular emphasis was on the responses of the teachers to the initiative, reporting on their professional development in terms of learning, changes in awareness and changes in attitude. It also discussed their reported changes in classroom practice and changes in student learning and began to suggest how the organisation of the CPD may have influenced the teachers to make these changes. We conclude the chapter by addressing these three aspects of the case studies.

Characterising CPD

All the case studies addressed mathematics, such as, for example, functions, graphs, quadratics and fractions. All addressed ways of teaching mathematics, such as using a wider range of questioning techniques, using new resources, relying less on the textbook and encouraging collaborative working among students. In two case studies (4 and 5), there was also an element of planning teaching, predicting student responses, observing these responses and discussing them together. We suggest that these two initiatives were explicitly paying attention to students' conceptions.

In some of the cases, teachers were also encouraged to engage with literature related to specific approaches or resources suggested by the CPD. For example, in Case Study 1 (see page 30) teachers/lecturers worked on mathematical tasks and used resources that were related to 'assessment for learning' and they also read and discussed related research. In Case Study 2 (see page 36) the teachers worked on mathematics and used mathematical resources, and read more general research literature about teaching mathematics and about how children learn mathematics.

Different methods were used in the case studies to mediate discussion about teaching and learning mathematics. In Case Study 4 (Lesson Study, see page 56) video was used as a way of engaging the whole group on both teaching and the students' actual responses. Within the other Case Study initiatives, other artefacts were used. These included examples of children's work, such as in Case Studies 1 and 5.

Approaches to change fell into different groupings: trying out new things and embedding change. In Case Studies 1, 2 and 3 the CPD leader/facilitator encouraged teachers to try out new ideas in the classroom. The teachers were encouraged to engage in a cycle of trying things out and reflecting on their experiences. Case Studies 4, 5 and 6 can be seen more as providing support for embedding approaches the teachers were already adopting, and in these three case studies teachers discussed what they had done in their classrooms within their CPD meetings.

Evidence of teacher change

This section discusses teacher change in terms of:

- teacher learning (including awareness and beliefs)
- teacher attitudes
- classroom practice.

Teacher learning

The teachers all reported some form of professional learning. In some cases, this was in terms of their learning of new knowledge and skills in the areas of mathematics and keeping abreast of current developments. The teachers seemed to generally like the mathematics focus of the CPD initiatives and reported learning both mathematics and approaches to teaching and learning mathematics. There was a reported increased enthusiasm of the teachers which was related to the learning associated with their CPD.

Other comments from teachers related to increased awareness of their teaching, and sometimes awareness of student learning. Increased awareness influenced the practice of the teachers by encouraging them to think about their own teaching approaches and the learning of their students. However, it seems that teachers found it difficult to talk about their students' learning and tended to talk about the behaviours of their students or their reactions to the tasks they were asked to complete. To support teachers in discussing learning, deliberate and careful efforts need to be made, such as in Case Studies 4 and 5.

There was also evidence that some teachers were becoming more reflective (Case Studies 1 and 2) and were articulate about the teaching approaches they adopted. In these cases, the teachers were engaging with the mathematics education research and professional literature related to teaching and learning mathematics, and it seems that these opportunities to read and think about teaching and learning mathematics were important in supporting reflection.

There were teachers who suggested that they believed in the values of the CPD before they took part in the initiative but other teachers seemed to have changed their beliefs about teaching and learning mathematics over the course of their engagement with their CPD initiative. However, two of the teachers told us that they had initially been reluctant to change the way they did things in the classroom, but they had engaged in a process of change and had become convinced about the ideas they were experimenting with by the responses of their students. This seems to suggest that it may be important for CPD initiatives to pay attention to teachers' beliefs, and also to support more sceptical teachers in implementing changes in their classrooms so that they can see how the students respond (such as in Case Study 3).

Teacher attitudes

Evidence from the case studies showed that engaging in CPD could increase teachers' enthusiasm for, as well as their enjoyment of, teaching mathematics. For example, in Case Study 5, a teacher described herself as having developed a 'passion' for teaching mathematics because she had developed her understandings of children's ways of making informal representations on paper (mark making) and the relationship between these marks and mathematics.

Another theme was increased teacher confidence. Teachers reported increased confidence to try things out, and it was apparent that the support of the school or department, or even a colleague, was important in building this confidence. Increased confidence seemed to be important for teachers in introducing changes in the classroom, such as using more open and unpredictable tasks, letting go of control and letting students take the lead. Changes in practice related to this included using more open questioning techniques, moving away from relying on textbooks and becoming more relaxed with students.

Some teachers seemed to become more confident to take on roles of leadership within their schools or colleges. Where teachers described this, it seems that they were encouraged to do so by the CPD, but they were willing and keen to do so because they were convinced of the value of the approaches suggested by the CPD. Sometimes there was also a suggestion that taking part in CPD provided teachers with some status within their schools or colleges, and this too may have developed these teachers' confidence.

Classroom practice

In Case Studies 1, 2 and 3 teachers reported changes in their classroom practice. These included the use of different questioning techniques and trying out new ideas in the classroom (Case Study 1), using more practical activities (Case Study 2) and using more practical activities and new assessment techniques (Case Study 3). In all these initiatives, there was a clear expectation on the part of the course leader that teachers would try out new ideas in the classroom, and we suggest that this expectation provoked teachers to make the changes. In addition, in Case Study 1 there seemed to be some pressure to report back to the group and in Case Study 2 to write reflective diaries, which may have provoked teachers to make changes. In Case Study 3, considerable in-school support was provided for teachers to help them try out new ideas.

In Case Studies 4, 5 and 6 teachers reported that they had further embedded some of the approaches recommended by the initiatives. In these cases, the role of the CPD is more to reassure teachers (such as in Case Study 6) and for teachers to continue to develop new ideas together than to support or to provoke teachers to make changes.

5. Investigating factors contributing to effective CPD

This chapter addresses Aim 2 of the project: To investigate the factors that contribute to 'effective' continuing professional development for teachers of mathematics. The approach in this chapter was to ground our understanding of 'effective' in the teacher voice. We drew on the data from the questionnaire, where the majority of the respondents (82 out of 92) said that they thought their CPD was effective[62]. These respondents were asked to explain why they thought the CPD was effective. Further data were taken from the interviews with teachers – particularly their responses to the questions 'what has kept you involved?' and 'does this CPD address your needs?' In their responses, teachers frequently revealed what they considered to be effective CPD.

Teachers' responses to questions about what they thought was effective about the CPD initiatives in which they were engaged fall roughly into two areas: what made their CPD effective and what evidence they had of effectiveness. This chapter reports on the former, and the responses concern the way the CPD was set up.

5.1. Leadership

As discussed in Chapter 4, the professional role of the organisers, leaders or facilitators in the 30 initiatives ranged from participant teachers to university lecturers. In some cases there was clear leadership, such as in all but one of the courses, which were led by a teacher educator from an HEI or local authority.

Some teachers participating in CPD courses suggested that their CPD was effective because of the course leaders (the teacher educators). They suggested it was important that the leader had wide knowledge of the field of mathematics education as well as current experience of classroom practice. Other teachers reported that their CPD was effective because, for example, it had a 'good' or 'brilliant' leader, and others pointed out the importance of a leader like Peter in Case Study 1 (see page 42). One teacher, when interviewed, explained that she benefited greatly from the course because the two main leaders complemented each other so well. She explained that one of them supported her well because she understood 'what it is like trying to fit in study with a full time job' and the other in 'providing a safe environment where we can say what difficulties we have with maths. It's important because we are adults and teachers and we are supposed to know the maths. He doesn't make me feel silly when I ask questions'.

In some of the networks, such as in Case Study 5 (see page 52), there was no clear leadership. The teachers involved thought this was effective because it kept the content closely related to their needs. As one said:

> *We run it ourselves and it follows the needs of the group. The impetus is talking to other people and valuing the presentation (of the children's own mathematical work) and keeping the evidence. Once I saw that others were valuing this I became much more comfortable with it… now I couldn't go back to the textbooks.*

[62] One teacher said their CPD was NOT effective and, as a reason, supplied the explanation 'What is CPD??' Nine teachers said that their CPD was PARTLY effective. Their comments are reported, as appropriate, in the body of this section.

5.2. A practical approach

Teachers also reported in the questionnaire that they valued practical experiences which were relevant to classroom practice. They suggested that the CPD was effective because it was 'practical and involved hands on explanations', 'very practical and topic based', 'very practical and informative'. One teacher stated that:

> *I am greedy for knowledge if it helps in the classroom and this CPD was classroom based.*

In observations of CPD meetings, there were examples of activities that teachers described as practical, illustrated in the two vignettes below. The first reports an activity in an FE network meeting which was described to us as practical and hands-on. Sally was the leader in this example.

Vignette 10: Activities in FE network meeting – exploring questioning techniques

Sally put up a PowerPoint slide with a question (about telephone usage charges). She talked about the question on the screen and suggested that it was not an open question. She suggested that, although we all know about 'lovely open questions', she continued to say that 'we don't generally have the time to plan them and make them up'. She wanted the participants to think about what can be done with standard questions to make them more interesting and challenging and told them that they were going to look at a few ideas.

Sally suggested that the words 'mobile phone' will engage the interest of learners. She asked the teachers to think about other questions you could ask based on the scenario presented. The discussion ranged over the following ideas: construct 'what if?' scenarios, make the scenario more realistic such as including considerations such as the time of day at which calls are made, or asking the students to create their own problems. Someone suggested they might like to think about whether the contract is good value. The point, Sally suggested, is to try to get them to think about the question and to avoid the 'tell me what to do syndrome'.

Together the group went through three or four further examples, discussing similar questions. The mathematics was at pre-GCSE level. They then discussed some examples with 'harder' mathematics (AS level) and the discussion ended with a slide with prompts to open up questions.

Sally asked the teachers to work in groups at their tables on some standard questions. She handed out two questions per table and said they could do one or both, and in varying detail. (Maybe one in detail and one more superficially). The questions were printed on A4 sheets of paper and teachers were given large sheets of flip chart paper to work on. They used glue (provided) to stick the question onto the large sheet of paper and then wrote around it. They worked for about 15 minutes and then Sally put up the questions on the screen and asked if anyone did the question, and if so, what ideas they had.

This example is interesting because it started on a very practical note, with Sally pointing out at the start that 'we don't generally have the time' to develop 'lovely open questions'. She constructed the activity so that the teachers could work on examples they might come across in their own institutions, encouraging them to think in new ways about old questions, and asking them to practise doing so then and there.

A second example is taken from the initiative that was based around the Revised Strategy advice, delivered by a team of advisors in a local authority to a group of Year 1 teachers. It offered them a range of resources to use in their classrooms and focused on the pedagogic strategies on which they were based. One group of activities related to games based on a collection of resources with a seaside theme such as sand, shells and model fish, as well as the usual mathematics equipment such as counters, multilink cubes and so on. The leader recounted work she had been doing with children in school where she had shared with them some simple games such as a seaside version of pelmanism, matching and sorting the fish according to different criteria and so on. She explained that the children went on to develop over 21 different games based on the seaside theme. It seems that the work described here fed directly into the teachers' own practices and was appreciated by them. As one said:

> *Everything they do is practical and the recording they do has a practical purpose. So the most important thing has been making things meaningful and have a purpose and a context.*

We suggest that in these examples, teachers saw the CPD as practical because they would be able to put their learning into practice in the classroom. However, in some cases, teachers reported that they could not put their learning into practice because of practical aspects of their lives and schools. For example, three explained that they were not currently teaching in an appropriate situation. Two were not currently teaching mathematics, and the third explained 'sometimes I am not able to put my learning into practice as I am an online teacher of maths.' Some teachers cited financial constraints as a barrier to their getting the best out their CPD, with some comments concerning with the expense of hardware and software meant they could not use the computing knowledge they were developing.

5.3. Stimulation, Challenge and Enjoyment

A third set of comments about why teachers thought their CPD effective relates to stimulation and enjoyment, ranging from 'fun' and 'exciting' to 'stimulating' and 'challenging'. One teacher explained why she thought the CPD was 'fun':

> *Fun … enjoyable, entertaining, thought provoking. I like the mechanics behind a lesson, I love seeing some bits that go together. It makes me think, seeing what underpins other bits in a lesson plan. I like the working with the other people aspect of this CPD, and I do not feel threatened by this way of working together, of sharing practice…*

Others, from other initiatives, explained that their CPD was interesting, with one commenting that 'it has been very interesting to work with a different group of mathematics teachers'. Another suggested that 'the actual preparing of the lesson for the project is also interesting, seeing how it evolves and develops. It changes for me depending upon if it is my familiar class, or if I'm a contributor but with unknown learners from another class. I like both but have different thinking patterns for each scenario.'

Teachers also reported that they found CPD effective because they were intellectually challenged by it. One teacher said that, 'Other recent CPD has not really challenged my thinking, this one does'. Other teachers said they thought the CPD was effective because it was stimulating. One teacher said that sometimes she did not understand the mathematics covered in the CPD but she enjoyed this challenge, as it made her develop her own A Level mathematics skills at home: 'I am interested in maths at all levels; even though I don't teach at that level; I am still keen to learn. I get the journal of 'The Association of Women in Mathematics', AWM, and a fair bit of it is above my head, but I'm going to keep trying to understand'.

At the same time, many commented on the support they received in order to tackle the challenges. As one teacher stated, they were given 'challenging tasks with a lot of support'. Another reported that she sometimes found all the algebra involved in the course a bit overwhelming, but she explained that she 'gets carried through and it is worth it because what they work towards is really interesting (like deriving the approximation of π by using an infinite geometric series)'.

Vignette 11 below captures a sense of the enjoyment and challenge a group of teachers appeared to experience when they tried to do some mathematics they found difficult. It describes also how Tom, the course leader, provided support for the teachers.

Vignette 11: Teachers working on trigonometric functions

Tom set a mathematical problem asking teachers to prove that the graphs of y=tanx and y=cosx cross at right angles. The teachers worked in small groups (twos and threes) on the problem and became very animated and engaged. After about five or 10 minutes, and before any of them had arrived at the solution, he stopped them. He worked through the problem on the board (the problem, he pointed out, with the approach the teachers were taking was that they were trying to find the points of intersection of the two graphs, but actually – as he demonstrated – this was not necessary.)

At a later stage, he asked one of the teachers to talk the whole group through the mathematical steps that had been taken to solve the problem. One of the teachers remarked later that Tom often used this technique and that she found it useful.

5.4. Time

Many teachers reported that the CPD was effective because it provided them with time. The concept of time in this context is slippery; what exactly did the teachers mean? In most initiatives, meetings took place during the day and in all but one of these, the teachers were released from the classroom to attend CPD. This, in itself, provided time the teachers would not otherwise have had, so by participating in CPD automatically they got 'time'. Those initiatives that took place as 'twilight' sessions also provide 'time' to engage with CPD issues. In the context of this research then, we suggest that what teachers mean by 'time' is 'time specifically set aside for …. ( )'.

In many cases, the teachers explained how they used the time. Barbara, as discussed in Case Study 1 (see page 31), for example, reported that she valued having time to investigate resources, to reflect, think, discuss and read. Others commented about having time to work with new resources and activities, such as 'time to look through resources and develop them, iron out any problems with activities before they go into the classroom'. Some remarked that the CPD was effective because it gave them time to plan and to work together as a department.

One teacher made the point that the CPD gave her 'a chance to talk about teaching mathematics professionally'. She went on to say that she valued having enough time to 'actually look at things in depth and discuss them'. We find this comment interesting, because of the phrase 'in depth'. The point is that, as the teachers reported, they have very little time in their daily working lives to stop and reflect, as suggested by this comment from one teacher:

> *I think day to day you have so little time to really reflect and most of my reflective time has come through my CPD.*

In the questionnaire, teachers were asked to select factors that 'got in the way of them getting the best out of their CPD'. Almost half the teachers reported that they did not have enough time and there were many comments to explain further. Some of these reported that they needed time to implement new ideas, or that they found it difficult to find time. For example, one teacher remarked 'It is difficult to make the time to try out the new lessons when I am back at school'. Others provided some details about why they did not have time, such as family pressures or the demands of other aspects of their jobs (e.g. as head of subject duties) such as in the comment below (which includes both these reasons):

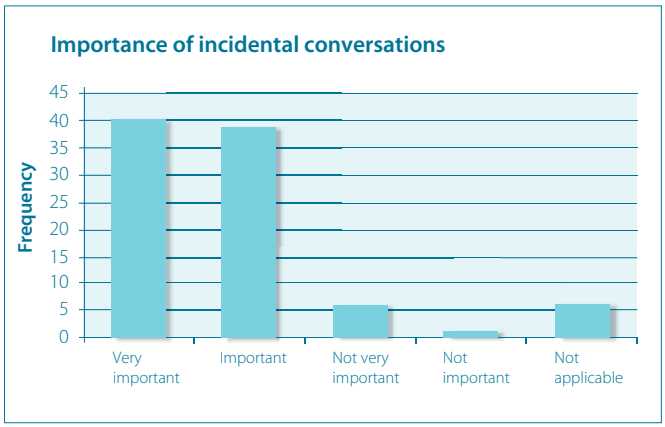
> *I already manage a faculty, teach a 76% timetable do a lot of extra-curricular work, am a husband, and father of three, need a life.*

As already discussed in Chapter 4, some initiatives involved some research and reading outside meetings. Teachers explained that they did not have enough time to do this work. For example, one remarked 'I am unable to give the amount of time to research which I had hoped to do'.

5.5. Networking

Many teachers reported that they thought the CPD was effective because it provided them with opportunities to meet with and talk to other teachers. They also suggested that the informal learning opportunities provided by incidental conversations were important, as Figure 7 below demonstrates.

Figure 7 The importance of incidental conversations at CPD meetings (n = 92)



It is perhaps important to understand what it is about these incidental conversations that is valuable to teachers. Our data suggests that, for many teachers, there is value in sharing the day-to-day concerns of their professional lives. One teacher, for example, remarked that 'it is effective because we are all practising teachers who are coming together to talk about real dilemmas we are faced with and to come up with ways of solving these together'. Another teacher, from a primary school, reported that she benefits from 'brainstorming with other teachers, teaching the same year'. This may be important; in many primary schools there is only one teacher per year group and it seems that this teacher valued the opportunity to discuss issues related to this year group with another teacher in the same situation. There were similar comments from teachers in FE who mentioned the importance of meeting up with other numeracy teachers to 'discuss the issues raised in delivering numeracy'.

Teachers from within-school initiatives also seemed to value the experience of meeting with and talking to other teachers in their department or school. In these cases, some teachers commented on the value of developing the working team's common agenda.

On the other hand, some teachers explicitly valued meeting people with different experiences, including, in one example, an advisor from the LA. One teacher explained that 'it encourages me to reflect on my own practice, in collaboration with other colleagues with different experiences and approaches'. In another example, teachers mentioned the value of meeting teachers working with learners in different phases. As she said:

> *[It is] highly stimulating to be working in a primary/secondary group - a) new perspectives, b) there's a need to articulate things really clearly rather than just presuming that everyone knows what you're talking about (because they're usually doing the same job).*

For some teachers, networking and incidental conversations seem to be of value for sharing ideas. One teacher talked about teachers combining their 'best ideas to improve learning and improve teaching as a result' and another said her CPD gave her the opportunity to meet with practitioners from other areas to discuss effective methods of learning and teaching and to share ideas and resources:

> *It enabled me to work with other teachers and to exchange ideas as well as concerns about the new strategy.*

As a further example, Peter, from Case Study 1 (see page 42), reported using an idea that had been suggested to him during an incidental conversation with a colleague from a different school.

Some teachers suggested that networking takes place whenever a group of teachers meets, saying that the meeting itself provided these opportunities. They suggested that networking was in itself valuable whether it was linked to a CPD initiative or not. As one head of department said, 'I sometimes think my most valuable CPD is when I meet other department heads at local authority events'.

It could be argued that by attending a CPD event, teachers are highly likely to do some networking. However, some of the initiatives in the sample explicitly aimed to provide opportunities to network and there was an element of 'free' time built in to the programme explicitly to provide opportunities for networking. As one organiser said, 'I build in 'time for time''. Another organiser reported that she allows an hour and a half for lunch, to provide opportunities for networking.

5.6. Conclusions

When teachers were asked to explain why they thought their CPD was effective, their responses concerning the organisation and structure of the CPD fell into five main areas, discussed below.

Leadership

Leadership of the CPD was identified as of key importance by teachers and the teachers especially valued leaders with wide knowledge and understanding of current practice. This emphasis is of particular significance in that the characteristics of this group of professionals is often overlooked. It is important to teachers that the leaders of their CPD are knowledgeable about mathematics education and have recent and relevant experience of classroom practice.

A practical approach

Teachers valued practical advice that was directly applicable to the classroom. They appreciated access to resources and banks of resources that they could use with minimal adaptation and in many cases valued having attention drawn to practical artefacts which support mathematical thinking and reasoning. They appreciated CPD grounded in classroom practice.

Stimulation, challenge and enjoyment

Teachers valued CPD that was stimulating, enjoyable and challenging. Challenging CPD may not be a comfortable experience for some teachers and can revive feelings and attitudes to the subject that are deeply held and can lead to resistance. The level of challenge that teachers experience will vary from individual to individual. Initiatives need to be aware of the levels of support that participants need to meet the intellectual, emotional and professional challenges. To provide stimulation and challenge, the content of the CPD should be of interest to teachers and should aim to provide enjoyment through appropriately supported intellectual challenge.

Time

Time was mentioned as a big issue for most participants. They valued the time that their involvement in the CPD gave them to focus on their professional practice. This often involved release from the classroom, standing back from and reflecting on their day-to-day practice. Reflection is a crucial aspect of professional development and teachers need time to engage in it.

Networking

The opportunities that involvement in CPD gave teachers for networking with colleagues from the same or different chool were highly valued, especially as for those working in their own classrooms for the majority of their working day, often with few opportunities to interact with other teachers. Teachers also appreciated opportunities to work with teachers from other phases or settings. They also emphasised the value of the incidental conversations that took place within CPD sessions. Ideally initiatives of professional development should take account of the value teachers place on networking and consider how to maximise its benefits.

6. Investigating evidence of effective CPD

Chapter 5 was concerned with the factors contributing to effective CPD and built an understanding of these factors, based on the responses of teachers to the question of why they thought their CPD was effective. This chapter draws on teacher responses to the same question but, whereas the previous chapter used a subset of responses concerned with the organisation of the CPD, this one uses a subset concerned with teacher and school change, and addresses Aim 3 of the project: to investigate evidence of effective CPD for teachers of mathematics.

The first set of responses is about change in the teacher. In some cases, the teacher claimed to be a better teacher than they had been previously, but in most cases this claim is implicit in the changes the teachers reported. The changes described include learning from the CPD and changes in attitudes. The second set of responses is about changed classroom practices. There were no responses explicitly stating that teachers thought their teaching had improved, but once again this claim may be considered to be implicit in the comments about change in practice.

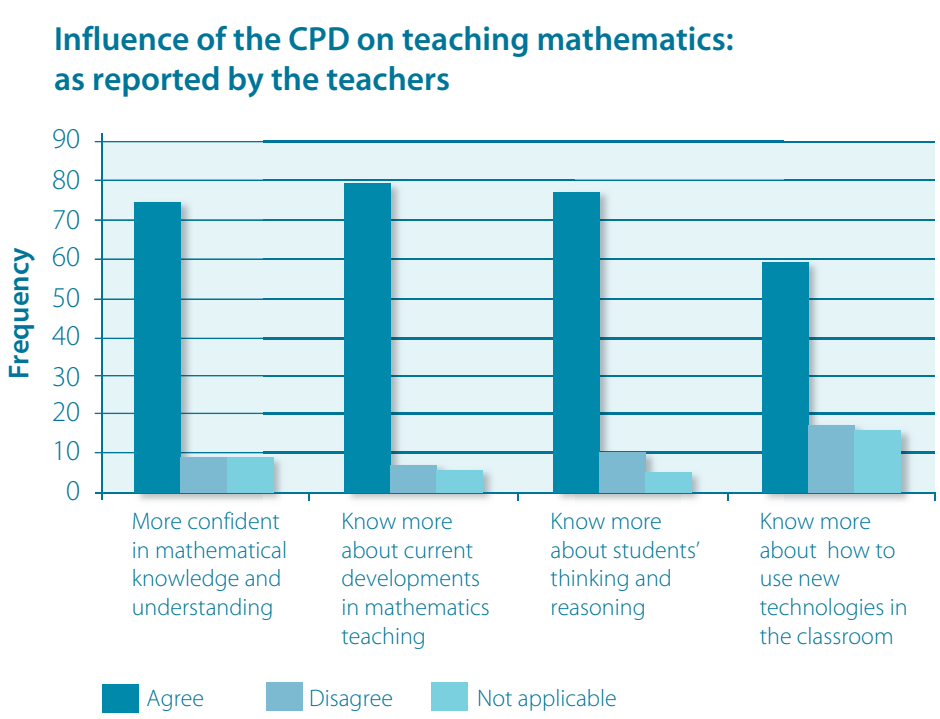
The chapter also draws on other data from the questionnaire, on interview and observation data and on data from the summer residential.

6.1. Participants' learning from CPD

Some teachers related the effectiveness of their CPD to their own learning. In the questionnaire, we asked teachers to report on their own learning. The graph (Figure 8) below presents an overview of their responses.

As the graph indicates, the majority of teachers reported becoming more confident about their own mathematical knowledge and understanding (and by implication learnt mathematics). Most of the teachers also reported knowing more about current developments in mathematics teaching and about children's or students' thinking. Slightly fewer reported knowing more about using new technologies. We now consider the more specific responses in a discussion framed by the various foci suggested in Chapter 3.

Figure 8 Teacher learning as reported by the teachers (n = 92)



6.2. Knowledge and skills

Many teachers related the effectiveness of their CPD to the knowledge and skills that they believed they had learned. Sometimes they commented in general terms referring to 'extending' or 'topping up' knowledge and 'learning a lot'. However, many were much more specific and included comments about learning about mathematics, learning about teaching mathematics and learning about students' and children's understanding of the subject.

Knowledge about mathematics

Some teachers suggested that their CPD was effective because they had learned mathematics, saying, for example the CPD had 'developed my own mathematics skills and knowledge'. One teacher said 'it's taught us an awful lot of mathematics'.

However, some teachers were reluctant to engage with mathematical ideas which were not directly relevant to the teaching they were doing. As one teacher remarked:

> *I am a teacher of less able children and I'm doing proof theory but practically it is of no use to me at all.*

In some cases, teachers were reluctant to engage with mathematics at levels which they felt were beyond the mathematics they would be teaching their pupils. As one teacher remarked:

> *I cannot put the academic work we are given into practice as it is too far above the level I teach and too high a level for me to understand with so little knowledge of mathematics.*

As a further example, one of the primary teachers from Case Study 2 (see page 47) commented that mathematics was not her strongest subject and not one that particularly interested her either. As she said:

> *To be honest I found the first couple of days a bit difficult – I can't remember which topic it was but it was all like fractions and decimals. I didn't really do very well in my GCSEs – I obviously got the minimum that I needed to get and so I found that really difficult I kind of feel it's a bit pointless I mean I teach Year 1 and I've got my GCSE and really don't want to teach above Year 3 or 4.*

Knowledge about students' conceptions in mathematics

Teachers reported that they thought the CPD was effective because of their increased understanding of children's and students' ways of making sense of mathematics. For example, one suggested she understood more about children becoming 'active thinkers and thus better at tackling problem solving'. Another said that she had learnt 'a lot about how to question children and enable them to work things out for themselves' and a third mentioned that she had learnt about the importance of allowing children to struggle with their own learning.

Knowledge about ways of teaching mathematics

Some teachers related the effectiveness of their CPD to knowledge about teaching mathematics. Once again some comments were general:

> *Introduces teachers to a new way of teaching mathematics.*

Other comments were linked to the focus of a specific initiative:

> *I learnt about whole class interactive teaching from the tutor].*

Most of the comments, however, referred to ways of structuring mathematical activities and tasks. One teacher said that the CPD 'taught me how to think through mathematics activities so they enable children to develop their understanding of concepts correctly', and another suggested that the CPD had 'opened my mind to the breadth of questions that I was using and what I was trying to cover and to see the value of the task for different outcomes'.

Many of the participants cited exploring resources as the reason their CPD was effective. For example, one teacher said 'great resources' and another said that 'the course has fantastic materials and guidance for teachers'. The vignette below gives more detail from one teacher.

Vignette 12: Teachers exploring resources as part of CPD

Through the network, Helen has been exposed to new and innovative teaching resources. She said: 'One thing I forgot is, what an influence the yellow 'Thinking through Maths' pack distributed by the FE network has been. The 'Which Operation' chapter at the end, has been the learners/my most successful use of it so far.'

Practical apparatus is related to resources. One teacher commented:

> *This CPD has made me much more aware that children need to be given lots of practical opportunities in maths. It has addressed a range of practical and more formal ways of teaching maths.*

New awareness

Teachers reported the effectiveness of their CPD in terms of their altered awareness of the processes of teaching and learning mathematics. Once again, some of their comments were general:

> *Inspires you to think about the way you teach mathematics.*

> *It makes me question what I am doing.*

Other comments were much more specific and suggest ways that the CPD activities they were involved in had raised their awareness of their own practice:

> *Lesson study is fascinating - a very rich source of material for reflection - immediately and longer-term, from the minutiae of teaching to the big picture of whole-school teaching and learning - and everything in-between.*

> *It's like a zoom lens that is based around everyday practice and involves observations and recording that I would do in any case. It has stimulated my own thoughts about practice.*

> *Looking at one particular aspect of algebra in detail has also made us reconsider the way in which we tackle related techniques.*

One of the teachers in Case Study 2 (see page 47) commented that being a learner of mathematics had made her reflect on the position of the child in the mathematics classroom, and seems to have raised her awareness:

> *My course has made me think completely differently ab my role as a teacher of mathematics by putting me in a position of having to go back to being a learner struggling with mathematics, thus giving me a greater appreciation of what it feels like to be a child.*

Similarly one of the Early Years teachers explained how she had become more aware of the mathematics of the children and of how she could help children:

> *I think I am probably more aware of what the children are trying to achieve and what I should be trying to teach them and more aware of the skills they need to get out of the maths lesson; more aware of this now I recognise the maths in the children's play that I used not to see.*

Information

Some teachers said their CPD was effective because they had been given information that they had not previously been aware of. For example, one teacher remarked that she had found out about a relevant qualification for herself:

> *Through attending this I have found out about and hope to do my Level 5 Numeracy Diploma later this year.*

Other teachers said they had found out more about current developments, particularly in terms of the in curriculum and National Strategies Framework. As one teacher said:

> *The course has greatly developed my understanding of the new mathematics framework.*

6.3. Teacher change: attitudes

Teachers reported that their CPD was effective because it had given them confidence. Some comments related to confidence to try out new things. For example, one teacher said that 'it has built my confidence in using handheld technology within the classroom' and another that she felt confident to try out new things. This last comment resonates with Barbara's story, in Case Study 1 (see page 30), where, as we reported, she developed the confidence to try out new things. We suggest that confidence and trying new ideas are closely linked.

Other teachers said that they had become more confident with mathematics (see Figure 8 at the beginning of this section) and others talked more generally about confidence, as illustrated in the vignette below.

Vignette 13: Becoming more confident as a teacher

Helen said that as a result of the CPD she has become more confident. It has also made her more aware of herself and her feelings. She says she did well enough in education, but had other difficulties in common with many of her students and that she knows what it feels like to lack confidence; but 'being in the network has made me try new things'. She is also getting more confidence to voice her passion about mathematics – being part of the network has 'made me fight harder.'

It seems that, for some teachers, the fact that they are taking part in a CPD initiative builds confidence in itself. Sometimes this was linked to the ways in which other members of staff regarded them. Peter, from Case Study 1, for example, said that other members of the department seemed to think he was 'a bit of an expert' and this had raised his confidence.

Some teachers related the effectiveness of their CPD to motivation, feeling inspired, challenged and refreshed, with comments such as:

Remotivates you…

I enjoy teaching mathematics anyway so I have found this course refreshing.

Vignette 14, below, discusses one teacher's growing confidence and motivation. This teacher was involved in the initiative discussed in Case Study 4 (page 56).

Vignette 14: Developing confidence – becoming motivated

Nigel had been head of department in a successful secondary school for over 10 years. He said that the department used to adopt a traditional text book-based approach and the examination and test results for the department were always very good. However, the department was concerned that the students were not as enthusiastic about continuing their study of mathematics as they might have been.

They approached an external consultant who suggested adopting an enquiry-based approach to teaching at Key Stage 3, and the whole department has engaged in a lesson study approach based on these principles. Nigel feels that this has transformed his teaching and said:

'It has changed us all for the better and it has excited us. I feel more confident in the sense not of my knowledge base, but more confident in front of the class, putting across more excitement and enthusiasm than would be possible with just a text book. What are they going to come up with next? It has been a beautiful breath of fresh air.'

Finally, teachers reported that they thought their CPD was effective because they had started to enjoy teaching mathematics more. This enjoyment seemed to be linked to confidence in some cases.

Both enjoy it more and feel more confident – if the kids are enjoying it, I'm enjoying it more.

Others linked increased enjoyment to what they perceived as improvement of their teaching. For example, one teacher said:

Now I enjoy it again. I think I'm pretty good at what I am doing and I'm getting better. It's something you have to work at and I am still working on it. We're still in the early days of the process.

6.4. Teacher change: becoming energised by CPD

During the project launch event, the notion that 'passion is an energiser' originated from a group of teachers and organisers of CPD initiatives. This group suggested that professional development could evoke a passion experience, resulting in a surge of energy that keeps teachers going, helping them to overcome obstacles and sustaining them when in developing professionally. We suggest that becoming energised by CPD can be seen as teacher change, and this section draws on the teacher voice to explore these ideas further. In particular, it investigates what passion is in CPD: how it is experienced, what triggers this experience, and in what ways it is a factor in effective CPD.

The data are taken from teacher interview responses to the question: 'Some people talked about a link between CPD and passion. Have you experienced something like that? Could you please explain what passion for you would be?' The coded responses were shared with participants at the summer residential, who were asked to critique, amend and add examples from their own experiences.

This section presents the main findings from the interview data and the summer residential data.

Making sense of past and new experiences

This happens when one observes that a new experience resonates with a previous experience but develops in different ways. We suggest that this occurred when the teachers were able to bring the past into the present and make connections between their past experiences and new learning. The following quotes illustrate this:

> *It is having the opportunity to look at what you did with the children.*
>
> *You start to look at what is happening in your classroom because you are linking it to what you are learning.*
>
> *Because it is over a sustained period it brings some of that learning to the front of my brain, I am making links, I am thinking about it a lot. I do not file the learning. It is about little and often, bubbling, thinking all the time, always linking to things I have seen in lesson study, that illustrate points.*
>
> *Passion comes from understanding better in my classroom what is happening.*

This resonance with past experience was often linked with finding answers and solutions to longstanding professional problems or questions. It occurred when the CPD allowed the teachers to find responses, and at times solutions, to issues in their classroom practice that they might have identified as problematic but did not necessarily know how to address. As was said:

> *Passion is about excitement and wanting to do it. Triggered by feeling that you have found a solution to the problems of teaching maths.*

Making sense of past and new experiences was often linked with situations in which the CPD offered the participants cognitive challenges which led them to question their own thinking and practice. Some reported this as an uncomfortable feeling, others referred to dealing with such high cognitive challenges as 'fun', as the following quotations illustrate:

> *This project is high level. I am thinking, talking at a much higher level and things are thrown in that challenge this high level thinking.*
>
> *This is what I call 'fun': the thinking of how you can make it work, the fitting things together.*

To make sense of past experiences and link these to new ones, teachers are exposed to views and interpretations which can be different, new or involve a re-thinking existing views. It is not necessarily a smooth, clean process as it involves making new connections, being receptive to differing views and accepting that old views might not fit.

Fitting with the teacher-self

This is when one notices that the CPD initiative's ways of working or intentions resonate with one's sense of self. It confirms the teachers' perceptions of how they think about and evaluate themselves as teachers.

This happened when they were experiencing a sense that their own image of themselves as teachers fitted the image being projected in the CPD. In these cases, the teachers felt strengthened in their view of their teacher-self or the teacher they wanted to be. They feel valued for who they are, for their ideas, beliefs or their professional outlook:

> *I love helping pupils make sense of it and make it stay with them and make them value it; it gives a real notion of worth as a person.*
>
> *It has reminded me of why I love teaching maths; resonates with my higher self.*
>
> *It reconnects me with the original passion which precipitated my going into teaching which is supplemented by a more mature passion for teaching now.*

This also linked with a sense of belonging engendered when teachers felt positively about their involvement in the CPD and that they were in the right place, because their ideas, thoughts and contributions were valued. It involved sharing ideas, working together, learning from each other and supporting each other:

We all enthuse and gain from each other.

Everyone takes part, learning from each other, sharing experiences and working as a team.

It also connected with the pleasure and enjoyment that the teachers got from their involvement and the sense of engaging either with others who shared their enthusiasms or with activities that provoked their enthusiasm:

I love talking about what we are doing.

I'm alive again as a teacher. I'm enjoying working with young people (I always have), but now I'm enjoying freshness, change, the intellectual challenge of engaging with newness and uncertainty.

At the same time, in many cases the teachers said that the CPD satisfied their own interests and they were able to act upon and follow their own existing interests within the CPD, or as a result of the CPD:

I could pick up things that interested me.

Experiencing a sense of 'fit' involved being able to imagine oneself doing what the CPD initiative advocated and affirmed the teachers' personal values and choices. This would help to develop self-trust and a belief in the participants' worth as teachers.

Experiencing a sense of the possibility of being capable; empowerment

This took place when the teachers felt that they could act in the ways that the CPD was advocating. This happened when the teachers tried activities and approaches out in the classroom and they perceived positive responses from their students:

The best CPD is when I can see it in my classroom.

Every time I have come back I have had lots of practical things to do with my whole class and the kids have appreciated that. And they like it, it's all practical and they are learning, they are learning things and we are reinforcing that learning.

I become very excited when I share my lessons and resources with colleagues and get feedback about how fantastically their lesson went.

When the teachers felt capable of applying ideas in their practice, they often found that the choices they made were valid, worked for them and their students, affirmed their personal values and again increased their levels of self-trust. It involved experimenting with making choices about what connections to make and reflecting on the consequences. Teachers become aware of the real possibility of potential success, of being capable of doing what they wanted to do and this offered them a sense of the possibilities open to them.

Desire

We identified desire as involving both wanting to do something and carrying it out. It occurred when the teachers experienced 'passion energy' in many or all of the ways described above simultaneously. Desire came from wanting to do something, knowing what that something was, knowing it would be possible to do and hence led on to a strong commitment to doing it. It came with a strong focus of attention and a surge of energy, and could energise the teacher to keep going with professional development. The following examples illustrate this level of commitment and follow through:

I sometimes feel really enthusiastic about it after the event. Like when I plan to implement something I have learnt or when I actually do it in class.

It gave me a pump of energy, a nudge to go out there and try again.

It does make you more enthusiastic as you see the children making progress, the more you are setting up your aims of 'I have got to keep up with them'.

It [passion] is the fact that I get excited teaching those lessons; you want to get out of the room and get to try it with the children.

The continuous aspect is key: I'm on a journey that I don't want to stop.

I'm a [name of CPD] groupie looking forward to the training days – to be able to talk, think, discuss, and teach with others, to talk about our own teaching of the maths. Once the training days are over, I'm filled with inspiration to go out and teach the lessons. I believe in the philosophy of the physiology behind it.

The data above offered rich descriptions of how teachers experienced a release of energy as a manifestation of experiencing passion. We analysed the data in terms of what triggers this energy and what this energy is used for in the context of professional development. We found that this passion-energy release happened as a result of any, or a combination of making sense of old and new experiences, when experiencing a 'fitting of the self', when experiencing the possibility of being capable of doing what you want to do and when feeling desire. The teachers reported these occurrences in the context of involvement in CPD which had given them the opportunity to experience situations that led to the passion-energy release.

6.5. Changes in classroom practice

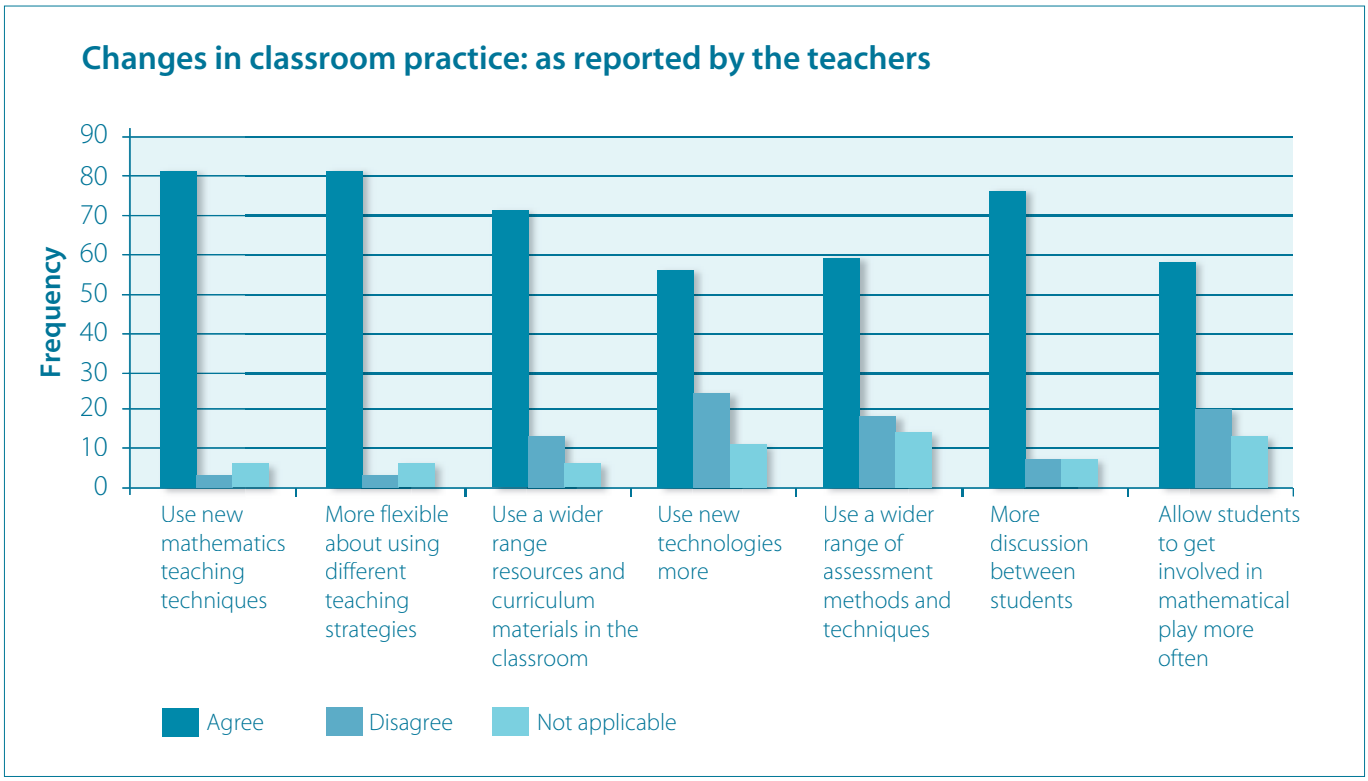
Many of the teachers commented that their CPD was effective because, in some way, it improved their teaching and encouraged them to make changes in their classroom practice. The data provided some examples of the sorts of changes that had taken place in classrooms, but in the main the respondents reported changing their practice but did not say how. Many of the comments from teachers made a direct link between what they saw as changes in their understanding to changes in their classroom practice. In one or two cases, some link was made between the changes in practice and the learning of the students.

The questionnaire asked teachers to report on changes in their classroom practice as a result of the CPD experiences in which they were engaged, providing seven potential areas of change:

- using new mathematics teaching techniques
- being more flexible about using different teaching strategies
- using a wider range of resources and curriculum materials in the classroom
- using new technologies more in the classroom
- using a wider range of assessment methods and techniques
- offering students more opportunities for discussion
- allowing students to get involved in mathematical play more often.

The data from this question are summarised in the graph below (Figure 9).

Figure 9 Reported changes in classroom practice (n = 92)



As the graph shows, most teachers reported changes in all the suggested ways, although fewer reported using new technologies, a wider range of assessment methods and encouraging more play.

The data concern reported changes in classroom practice. It suggests that teachers perceived that their practice had changed in the ways suggested, but these changes do not necessarily relate to the effectiveness of the CPD. However, many teachers did report changes in classroom practice as evidence that their CPD was effective. Most of the comments related to changes in practice concerned:

- changes in teaching strategies and techniques that had already taken place, and
- more short-term changes in practice that involved trying things out (with no indication as to whether the trying out leads to longer term changes in practice).

6.5.1 Changes in teaching

One set of comments suggested that the CPD was effective because the respondents' teaching had improved. The teachers described changes in classroom practice on a general level. For example, one teacher said that 'I have been able to use the knowledge to improve my teaching'. A large number of teachers referred to changes in teaching techniques mentioning that their teaching styles had changed:

> *It changed my teaching styles dramatically and helped me to develop new skills.*

Some were more specific, describing more flexible approaches, such as putting the learner at the centre. For example, Caroline teaches numeracy to adults and she reported how she now puts the learners' needs first (rather than so much whole group teaching) by tailoring the tasks she sets for her learners to meet their needs and interests. In the observed classroom session, she suggested that Jackie and Nasreen work together on fractions. She said she had worked on their assessments and saw that they both had 'glitches' on fractions She encouraged them to talk to each other to make sure that each understood as they went along. The others were working on the problems she had handed out. Louise asked Anne for some work on formulas, because she was due to take her Level 2 test next week and wanted

some practice in algebra. Another teacher reported that she had learnt to let go of control and to let all the students have a voice. As an example, she lets the students come up to the board and make contributions.

Another teacher described her changes in practice, which could be seen as becoming more reflective:

> *Now I am much more of a researcher-teacher of maths. I spend more time sitting back, refraining from teaching and taking time to figure out what the students are learning and to understand more fully what they are thinking.*

One teacher explained how she thought the changes in her practice were positive in terms of her pupils:

> *I have a less traditional approach and I am more willing to try new ideas; I feel as though I am being fairer to the children and I'm making it more enjoyable because I am making it real for them.*

6.5.2 Trying out ideas in the classroom

A number of respondents reported that the CPD was effective because they had tried out new ideas in the classroom. This notion was discussed in detail in Chapter 4. The comments below provide examples of the sorts of things they had tried:

> *I always go back to work with a new idea to try with my learners that I have got from either the facilitators of the meetings or other colleagues.*
>
> *With some courses it is easy to put the papers on the shelf and then not get around to trying things out but with this one there were so many practical ideas that you could try out.*
>
> *Helping me to use IWB in a useful way within a new teaching style.*
>
> *Trialling resources in the classroom.*

6.6. Student change

So far, this chapter has reported on responses teachers provided as evidence of the effect of their CPD. Few, however, suggested improved student learning or different ways of interacting in the classroom in answer to this question. However, the reported changes in practice were likely to influence students' learning and classroom interactions. This section provides the evidence that teachers reported in terms of changes in students' learning and behaviours, drawing on data from the case studies, from interviews with teachers, from the summer residential and from the questionnaire. In some cases, observation data also provides evidence of the types of student behaviours teachers reported. While these do not provide evidence of *change*, they do strengthen the claims of the teachers.

6.6.1 Student learning

This section focuses on teachers' reports of student learning. Some teachers discussed learning in terms of their observations of the students as they worked on the mathematics in the classroom (process) and some related learning to attainment and achievement (product). All these are discussed here.

The research on the case studies deliberately and explicitly asked the teachers about improved student learning. Generally the teachers provided **generic responses** that could have applied to any subject area. One mentioned that the students were getting more used to the type of tasks she was setting and that the tasks made them think, and others suggested that if the students struggled they 'just want a clue' and reported they have 'good discussions'. There were further comments of this type in the other data, such as:

> *Children are now more able and willing to explain their thinking.*

In another example, a teacher described the changes she had made in her approach to teaching mathematics (more practical mathematics and investigation work):

> *We make sure we do investigations more now and getting the children to be more analytic and explain what they have done rather than just to say, I just knew it… I've always thought it is very important to be very practical doing maths and that's why it excites me: it's given me licence to do it… A lot of the thing is that children need skills in order to investigate and there is a balance between getting the skills and making it meaningful. And the question is, can you teach some skills through investigation?*

Although this teacher did not actually discuss improved student learning, it is implicit in her comment. The overall impression from observing a lesson taught by this teacher was of a group of students working on a common task and providing insights from their activity that were relevant to the whole group.

This sort of comment provides information about the students' generic skills (and attitudes) rather than any learning specific to mathematics.

On the other hand, some of the case study teachers reported learning more related to **mathematics** classroom contexts. Matthew in Case Study 4 (see page 66) discussed mathematical contexts and Helen in Case Study 6 (see page 58) described in detail some of the mathematical learning of the students.

The vignette below provides an example of a focus on mathematical learning. In this vignette, taken from the summer residential data in response to the question 'What counts as evidence of student learning', a teacher described part of a lesson about sorting and classifying.

Vignette 15: Describing students' mathematical learning: a sorting task

> Students were asked first to clarify/agree on names and features of the animal cards. Then I told them that half the group were going to sort them together and half would watch and whisper to each other how they might do it. The children sorting them first worked very well together by discussing how to put cards in animal groups, in lines, then in alphabetical order and by colour. Then they told me it looked like a bar chart. This example showed me just what could be possible if a group of seven-year-olds talk, agree, motivate each other and challenge themselves to find this ambitious solution.

In this example there is an implication of improved student learning. The teacher was trying something new in the classroom and the phrase 'just what could be possible' may mean that the student learning was better than she expected.

Another example is taken from a lesson that was observed with a Year 6 class working on data collection and data handling. The teacher involved said she was pleased with the way this had developed the mathematical achievements of children at both ends of the spectrum:

> *The majority of the children really looked critically at the information and had some really good comments about the graphs … we have fewer children who just sit looking at a blank page when they are faced with problem solving and now they know they can have a go and it doesn't matter if they make a mistake because you can learn through making mistakes…*

Once again, there is an implication of improved student learning in the phrase 'we have fewer children'.

A teacher in one of the FE initiatives which encourages using the 'active' approaches advocated in the Improving Learning in Mathematics and Maths4Life resources (see footnotes 22 and 23) and gives them a collection of resources to support this approach, reported that 'Students have a deeper, more underlying knowledge that they can apply to more situations'. Again, this comment implies improved learning.

At our residential event for our focus teachers, we asked them to give us some detailed accounts of what they meant by changes in their students and one wrote:

> *I am more aware of the children's thinking about their mathematics. They see themselves as being successful in maths and all having something of value to contribute. Often the best maths comes from children making mistakes, unpicking misconceptions, clarifying understanding/learning and listening to their peers/ learning from their peers. It is not just the teacher who holds the answer.*

Helen, in Case Study 6 (see page 66), was reluctant to comment on improved student learning, but she commented on raised attainment among her students in comparison to the previous year. Comments taken from the other data also include some related to raised attainment:

> *There is a clear impact on raising standards for Year 11 students in all the schools that participate owing to the tangible outcome of the CD ROM (Key Stage 4).*

> *Better results - better attitudes to key skills classes (Adult learners).*

There were also responses in the case studies which reported what mathematics the students could do, such as in Case Study 2 (see page 37) where the teacher described students' work with fractions, and in Case Study 3 (see page 52) where the teacher reported that she was pleased with the ways the children had responded to a task about presenting data. The summer residential data included comments from a teacher from one of the FE initiatives. She said the students told her that they could do mathematics and said that they had come into class and made comments such as the following:

(Such and such) asked me a question and I could answer it.

I was listening to the radio and heard a GCSE question and I could answer it!

I could give the bus-driver the right money.

I still don't like maths but at least I can do it now.

One of the focus teachers described an adult in FE numeracy who succeeded in checking change after using practical resources to practice shopping in the classroom.

Vignette 16: Learning about money: practical resources in FE numeracy

I had a student (Adult) working at Entry Level 1 or Entry Level 2 level in the Adult Numeracy Standards[63]. She complained that she was not being given the correct change when she went shopping and her mum was getting cross with her. I found she knew what the coins were but not notes. I got out the play money and we began marking up amounts in different ways and then played shopping. A few weeks later she came to class really proud of herself – she had checked her change found it was wrong and confronted the cashier and had it corrected. She had put her mathematics into practice. I have been able to see that my behaviour and teaching has changed as well as my confidence improving and this has impacted on the learners which unless you reflect in this way you do not always do or have time to do. You know your learners are improving but it tends to be a more vague feeling.

[63] See http://www.qca.org.uk/qca_6932.aspx

6.6.2 Student attitudes

Responses to questions on improved student learning also included responses about improved student attitudes. For example, Angela in Case Study 3 told us that students enjoy mathematics more, and are more involved. Many of the teachers at the summer residential and manyof those who responded to the questionnaire, talked about their pupils enjoying mathematics lessons more. The comments about enjoyment came from teachers of students in all phases:

My class love numeracy! They enjoy and develop their numeracy skills within a playful, practical and challenging environment. (Key Stage 1)

Students on the whole enjoy their maths lessons more which means they are better behaved and more attentive. (Key Stage 4)

Students find the lessons more enjoyable. (Key Stage 5)
[The students] see maths class as fun, results have not changed markedly, but I am placing less emphasis on them myself (Adult).

One teacher explained that students were more willing:

… a willingness to contribute to group discussions, to share methods with other learners and to tackle problems in small groups/pairs rather than just saying that they can't do it.

From this comment it seems that her students were more motivated and confident as evidenced by their willingness to work together and tackle problems. Motivation of students was mentioned frequently and teachers seemed to feel that their students were more focused on their learning of mathematics and keener to make progress:

Students are keen to progress to the next level and want to know how to do it!

The children I work with have a better attitude to learning than they used to. They are more motivated.

At the summer residential, some teachers explained how they knew their students were more motivated. One teacher of adult learners commented that in the past her students had disliked mathematics and were unhappy about being in the classroom, but she described how they had become engaged in bringing resources to the lesson (such as different kinds of packaging) when working on volume. She also described how adults with English as an additional language were initially reluctant to write down their mathematics but eventually, after being offered the pen a number of times, would take up the challenge and have a go themselves. Another aspect of the changes in her students had been that they were now more willing to help one another even when she was not there.

Increased student confidence was also reported by the teachers:

> *Setting children has allowed teachers to match teaching to the needs of the group. I've seen children develop in confidence within the groups I've taught as a result of this.*
>
> *Improved self esteem from lower ability pupils because of enthusiasm for their project.*
>
> *My impression of how students view themselves now is of being capable of 'getting' any maths concept at a pace that is comfortable. They are confident in thinking the maths through individually or with each other's help and consider themselves as 'good' or 'OK' at maths rather than 'rubbish' or not good at all. There is a palpable buzz which is steadily increasing and they are talking about achieving the next level for the having only just achieved entry level 3 or level 1.*
>
> *Learners are more confident as I become more confident.*

Of particular interest here, is the link between the teacher's confidence and the students' confidence, which is mentioned in the last quotation. This teacher was part of a network of FE tutors who were working together to improve their teaching of mathematics using the Maths4Life resources. This initiative supports teachers by providing them with support to embed the active approaches encouraged by these resources. The teacher concerned went on to say:

> *My views about teaching maths haven't changed but it has just made me more confident with how I already do it. My learners' views about maths have changed because they have told me. They say I do things very differently to how they remember things in school. My learners always arrive on their first week and tell me 'sorry I am no good at maths and hate it'. Within three or four weeks most start telling me they enjoy coming to class and look forward to the challenge.*

6.6.3 Student interactions

When teachers were asked to report on improved student learning, some responded by reporting different student behaviour in the classroom. The case studies suggested that in some cases the students were beginning to work more independently (Case Studies 3 and 4).

The teachers in Case Studies 2 and 4 suggested there was more discussion in the classroom and there was evidence of more discussion in other initiatives:

> *I have always facilitated discussion but perhaps at times I have achieved greater fluidity within the group regarding the free flow of ideas e.g. I enabled and documented a discussion regarding 'Is 0 a number?' where most of the group participated.*

In interview, one of the teachers involved in an initiative where the members of the department created resources to support three to four week units of work focused on engaging students actively in their mathematics lessons, said:

> *Pupils expect to discuss methods and have to explain answers. [It is] normal now for pupils to help each other and explain to each other and have less reliance on teachers for answers.*

Other data, from the questionnaire, suggested that, following the teachers' changes in practice, pupils shared their mathematical knowledge and worked collaboratively more often. Once again this was common in the FE projects, as exemplified by the response from one teacher, who wrote, '[it is] early days but more collaborative learning [is] taking place – discussion and helping each other.'

In an observed lesson in a primary school setting that focused on data handling, the children in a Year 1 class worked together collaboratively to collect information from teachers in the school about their favourite settings for stories. This built on some collaborative work on data collecting that they had done in a previous lesson and which collected data from the class about their favourite characters in stories.

In one within-school initiative based in a secondary school which puts inclusivity high on the agenda and where students are taught in mixed ability grouping within two broad bands from then onwards, observations of the lessons taught by the two focus teachers showed the students actively engaged in stimulating mathematical tasks that were accessible to them all despite the lack of setting.

6.7. Conclusions

In considering evidence for effective CPD we have focused on changes that the teachers reported to us in their learning, in their attitudes and in their own classroom practice, as well as changes that they observed in their students' learning and attitudes. These data have been triangulated in many cases, by observations of the classrooms of our focus teachers during or after their involvement in the CPD.

Teacher learning

Teachers reported learning in three main areas: mathematical knowledge for teaching, increased awareness both of their own classroom practice and of their students' responses, and learning new information. 'Awareness' as a concept has been widely discussed and is often discussed together with noticing (see, for example, (Mason, 1998, 2002). Gattegno (1987) argues that only awareness is educable; if this is true, there are implications for CPD initiatives in the planning and content of their CPD.

Not many teachers discussed their own mathematical learning and learning about students' mathematical conceptions and when they did, they tended to provide non-specific examples. Some teachers discussed learning about ways of teaching mathematics, mostly referring to structuring tasks and activities.

Change in teacher attitudes

This was also reported as evidence of effective CPD. Teachers reported that their CPD was effective because it had given them confidence. Some comments related to confidence to try out new things. For example, one teacher said that 'it has built my confidence in using handheld technology within the classroom' and another that she felt confident to try out new things. Some teachers related the effectiveness of their CPD to motivation, feeling inspired, challenged and refreshed, and to renewed enjoyment of teaching mathematics.

Increased passion and energy

This seemed to be an important factor in effective CPD. There were data to suggest that effective CPD increased teachers' passion and energy to **keep** going, to keep working on professional development, to keep trying out ideas in their teaching practice, even with other pressures of work or life. We found that this energy release took place as a result of making sense of old and new experiences; experiencing something that fits with the teacher's sense of themselves as teachers or realising that it would be possible to do what you want to do or indeed any combination of these things.

Hence, passion can be evoked by taking part in CPD. Passion energises and leads to commitment ('I really want to do this') which can help the teacher to keep going and to overcome obstacles that hinder participation and embedding of professional development. Evoking passion in CPD could therefore be very valuable, especially when aiming for *continuous* professional development. Csikszentmihalyi captures this elegantly: 'Without the passion, we soon lose interest in a difficult task.' (Csikszentmihalyi, 1996:p72).
Changes in practice

Teachers suggested that changes in classroom practice provided evidence for the effectiveness of their CPD. Many expressed the view that their teaching had improved and some elaborated on this by suggesting, for example, that they now put the learners' needs first, that they allowed their students more control over, and input into, lessons. For example, one teacher reported that she had learnt to let go of control and to let all the students have a voice. As an example, she lets the students come up to the board and make contributions.

Other teachers reported that the CPD was effective because they had tried out new ideas in the classroom, but in some cases there is insufficient data to allow us to suggest whether this represented a sustained change in practice.

Student learning

We suggest that improved student learning provides crucial evidence of effective CPD, but teachers tended not to report improved student learning or changes in ways of working as evidence of the effectiveness of their CPD. However, when questioned, teachers reported such improvements by referring to students' work, what students said and improved attainment. These improvements seemed to be important in convincing teachers that they should sustain the changes they had made to their practice, as described by Anne in Case Study 5 (page 60).

Changes in student attitudes

Teachers often reported that students' attitudes had improved since the teachers had participated in the CPD, with students being more willing to share knowledge and collaborate, to engage in discussion and communication about mathematics and to persevere in tackling difficult tasks. It was often reported that these changes improved the atmosphere in the classroom and led to increased confidence and motivation on the part of the students.

Student interactions

Students in the observed classrooms seemed to be engaging in mathematical thinking and reasoning in collaboration with others and discussing the mathematics they are working on with their peers and their teachers. Teachers also described ways in which their students had changed the ways they worked together, such as discussing mathematics more, working collaboratively and sharing knowledge.

- I felt challenged with regards to controlling all learning. Wanted to pick up everything
- Tasks connected with exam preparation.
- Cost (Resources)
- Some group discussion not always fruitful. Independence?
- Don't question each othe
- Assessment ???

7. Roles of research in CPD

This chapter addresses Aim 4: to establish the different roles of research in professional development for teachers of mathematics. It draws on data from a set of questions sent electronically to the organisers of the 30 initiatives, responses to the questionnaire and observations of meetings. The data suggest that about three-quarters of the initiatives (23) in the sample entailed some form of research in their set-up and running. We call this 'research–involved CPD'.

The chapter begins by considering ways in which the CPD initiatives are research-involved. It includes the ways the organisation of CPD was informed by research and the ways research was used by the participants. A further section analyses the effect of research-involved CPD on teachers.

We suggest that the involvement of HEIs may have an impact on the research aspects of CPD, so a final section explores the involvement of HEIs on the 23 initiatives that were identified as having some form of research in their set-up and running.

7.1. Research-involved CPD

The data related to the role of research in CPD were categorised as: reading research literature; using resources that have been developed based on research; research-informed CPD; research-inspired CPD; being part of a research project; and doing research as CPD. These are discussed in more detail below.

Research informed CPD

Several of the initiatives mentioned research in connection with their aims and objectives. For example, one said that they wanted to engage the teachers with relevant research. Another aimed for teachers to evaluate their experiences through action research. Research also informed many of the initiatives in a variety of ways.

In some cases, connections with the research basis of the CPD were particularly tight and explicit. The teachers thus became aware of the theoretical underpinnings of the work they were engaged with. The lesson study initiative described in Case Study 4 (see page 56) was an example of an NCETM-funded teacher enquiry project, initiated by a teacher who learned about lesson study from reading research. This was his second teacher enquiry project and built upon his knowledge of research about enquiry based classrooms (P. Cobb, Wood, & Yackel, 1990) as well as Japanese Lesson Study. All members of the department in the secondary school involved were made aware of the research underpinning the initiative through the enthusiastic dissemination by the leader, and some of the other teachers had been encouraged to read the research for themselves. A similar connection occurred in the EYFS initiative described in Case Study 5, where the teacher who set up the network had begun to read about research related to children's mathematical graphics as a result of her attendance at conferences run by the researchers involved. This teacher then used her knowledge as the basis for the network group meetings, became involved in further research in her own classroom and supported her colleagues in the network to do the same.

Research inspired CPD

These are instances where research findings and literature are used implicitly rather than explicitly. Often this concerned theories about 'ways of working', such as learning collaboratively, without making explicit reference to which research or publications it was based on. An example is when the organiser of the CPD, who might have in-depth knowledge of the research that inspired the CPD, plans the CPD activities by building on that research but without exploring the research itself with the teacher. At other times,

research papers were used as a starting point, as a vehicle for triggering discussion, exploration, reflection and experimentation, which might no longer be immediately relevant to that initially read research, such as described in Case Study 1.

Reading research literature

This refers to participants reading specific research literature. This literature can be in the form of published research papers by the author (for example (Hallam & Ireson, 2006)), summaries of learning theories compiled by organisers of the CPD who have a background of working in HEIs (for example in Piaget (J. Piaget, 1950, 1953; J. Piaget & Szeminska, 1952)), summaries from other documents (for example from Swan (2005; 2006)), chapters from books or short publications (for example Black, Harris et al. (2002)).

Several illustrations of this can be found in the case studies. For example, in Case Study 1 (see page 31), Peter talked about putting the theory of the Black Box (P. Black et al., 2002) into practice. In Case Study 2 (see page 47), teachers were given their own copies of *Primary Mathematics Developing Subject Knowledge* (Cooke, 2007), Teaching and Early Number (I Thompson, 2008) and *Enhancing Primary Mathematics* (I. Thompson, 2001) and were thus given opportunities to read about research on children's learning of mathematics as part of the CPD. In Case Study 5, Sarah reported that she read literature about children's mark making and in Case Study 6, David reported that he was aware of the eight principles of Active Learning as described in the research of (Swan, 2005).

The literature was usually selected by the organisers of the CPD who had more (expert) knowledge of existing research than the other participants. In a few cases, the readings also included non mathematics-education research, such as research methods and other more academic research. Although this might be seen as not directly relevant to issues raised by the participants, it was relevant to the aims of the CPD initiative. 'Reading' varied from reading literature as 'gap'[64] tasks in the 'gap of time' between sessions, to reading in meetings, discussing and interpreting the text, and discussing how it applied to practice.

We think it would be useful to investigate further the kind of research that is used in CPD, the way it is used and the effects these have on the professional development of the teachers.

Using resources that have been developed based on research

These are resources that have been developed as part of research and/or have been refined and evaluated as being effective learning resources through a research process. Examples of these resources and the research they are based on are an 'active' learning approach (M. Swan, 2006). Realistic Mathematics Education originating from the Freudenthal Institute in The Netherlands (Van den Heuvel-Panhuizen, 2003).

Being part of a research project

Three of the initiatives involved teachers taking part in research projects. One was an action-research project funded by an outside organisation and led by an HEI. It offered optional accreditation towards a Masters degree. The research project focused on teachers evaluating the introducing of an ICT resource on their teaching practices and students' learning. This also entailed developing activities and tasks for the students. The professional development took place through the teacher's active engagement with the project. The second research project concerned being part of a doctoral research study. In this case, the doctoral researcher, who is also the organiser of the CPD, worked collaboratively with the teachers, who acted as co-researchers. They collected then discussed data relating to interpreting children's mathematical graphics. The professional development of the teachers occurred through that process. The third case concerns a two-year Masters course in mathematics education that involves undertaking a research project.

Doing research as CPD

We could identify clearly eight initiatives where teachers were given the opportunity to develop professionally by conducting their own research projects. In these instances doing research was part of the organisation and planning of the initiative, in that they led or could lead to accreditation towards a Masters degree which required doing research. Three were part of a Masters degree, five were potentially so in that the teachers could opt for Masters level accreditation.

In a further initiative, teachers were involved in a research project as active co-researchers (which is also described in the category above). This initiative did not offer accreditation.

Other initiatives included, to different extents, trying out new ideas and reflecting on professional activities. Descriptive illustrations of this can be found in Case Study 4 (see page 56) and Case Study 5 (see page 60). In Case Study 5, Sarah reported she is 'becoming more of a researcher in her classroom'. Also, as a group they were developing an 'enquiry approach' in this initiative. David in Case Study 6 and 'does action research'.

[64] 'Gap' tasks are also described in footnote 11.

7.2 The effect of research-involved CPD on teachers

These data come from the qualitative answers to questions in the online questionnaire (n=92) which was completed by teachers participating in the RECME project. It had one specific question related to research: 'You indicated that you are aware of research underpinning some of the CPD you have undertaken. We are interested in whether this influenced the way you felt about the CPD. Please explain here'. Further data were found by searching for the word 'research' in all the qualitative responses to this questionnaire. The data were coded and analysed by looking through a lens of 'what changes are teachers reporting as a result of working in a research-based or research-informed CPD initiative', 'what are the teachers expectations from being involved in the CPD in terms of research aspects' and 'barriers to doing research'.

As a result of participating in a research-informed CPD initiative teachers reported changes in terms of:

Raised awareness

This relates to what research, current thinking and information on existing practice there is 'out there' about teaching and learning that can be of use in the classroom. For example, one teacher reported that she liked knowing that she was keeping up with current thinking and research, and another related her raised awareness of research to her classroom practice:

> I am taking part in a Masters in Maths Education and it has made me realise what a wealth of research there is to read and use in teaching.

Stimulation

This refers to thinking about teaching and learning, and comments the teachers made seem to suggest that teachers found it very stimulating to research their own practice and also to engage with the research literature:

> *It's like a zoom lens that is based around everyday practice and involves observations and recording that I would do in any case. It has stimulated my own thoughts re practice and introduced me to academic research I might not otherwise have accessed. It has stimulated thinking and debate amongst us three participants in the research.*

> *I have read about how Chinese teachers are taught how to enable children to learn mathematics, particularly with regards to ensuring that their own subject knowledge is sufficiently developed to enable them to explain concepts correctly. This has caused me to question my own subject knowledge and develop it further in the context of enabling me to teach maths more effectively.*

Affirm and/or develop the teacher-self

The teachers reported how the research aspect of their CPD affirmed their perceptions of their teacher-self, leading to confidence in their professional self. They also reported how working on their existing interests and understanding led to a deepening development of their teacher-self and felt satisfying. For example:

> *The research validated what I already knew and therefore gave me increased confidence to use new techniques – i.e. Swan.*

> *It has made me research an area of the curriculum about which I am strangely passionate, reflect on my own understanding and practice, collect and collate evidence and share this with fellow maths enthusiast within my school and the group.*

Confidence

This refers to the teachers feeling confident to act: to take further part in CPD and to apply it to their practice as it has been shown to 'work'. As one teacher explained, 'I feel much more motivated by CPD that is underpinned by research as I know that people have really tried things out with children rather than made something up and hoped for the best!'. Another teacher referred to a specific project:

> *Pathfinder project provided the evidence that collaborative practice was the way forward in improving mathematics teaching – gave me and the other teachers confidence.*

Gain status

Teachers reported that research based/informed CPD gives credibility and status to the CPD initiative itself and to the teachers' professional thinking and activities. For example:

> *I think it gives the programme more status, it isn't just a maths club it is something important.*

> *Having research that underpins the CPD that we are doing shows us that there are already results which will prove that what we're doing is likely to benefit both teachers and pupils.*

> *It adds more credibility to what you are learning.*

> *It makes me feel that I can justify my interest in the approach to those above me in the line management structure.*

Teacher expectations

Another aspect of the teachers' responses addressed expectations that teachers had from their CPD initiatives, which involved a research element. These all concerned learning to gain the skills to do research, to implement research findings in the classroom and to learn and do collaborative research. For example:

> *Helping me to understand research and perhaps prepare me for further studies.*
>
> *I hope to be able to put the research into the new KS3 scheme of work.*
>
> *To share with some practitioners with a different perspective or more experience and expertise linked to research than myself.*

Barriers

In the on-line questionnaire, teachers were asked about possible barriers to undertaking CPD. Some of the responses explicitly mentioned barriers to being involved in research. They concerned lack of time and the tensions this causes, lack of opportunity to do research in the classroom and, in one case, finding it hard to read research papers. For example:

> *I am unable to give the amount of time to research which I had hoped to do. We are expected to do a lot of testing and marking at my school which coupled with planning impacts on a reasonable work-life balance.*
>
> *I find it difficult to follow my research through because I work part time and often find that plans are changed without me being told and I am unable to get continuity when working with my groups of children.*
>
> *I do not particularly find it easy to read many of the articles about improving teaching practice.*

7.3. The involvement of Higher Educational Institutions in research-involved CPD initiatives

Twelve CPD initiatives had HEI involvement[65] (see Figure 10).

In six initiatives the HEIs were the organisers of the CPD and all these courses were accredited or could be accredited towards a Masters degree.

In one case, the CPD took place in, and was organised by, an in-school department with occasional visits by an academic of an HEI and optional accreditation towards a Masters degree was available to participants.

Three other initiatives involved the collaboration of HEIs with local authorities, with the HEI contributing to the design of the CPD initiative. One of these instances also led to optional accreditation towards a Masters degree.

The remaining two involved taking part in research projects: one was funded by an outside organisation with the HEI contributing to the design of the CPD and offering optional accreditation; the other was part of the doctoral research study of the organiser (which automatically places it under the auspices of an HEI institution and is reported on in subsection 1).

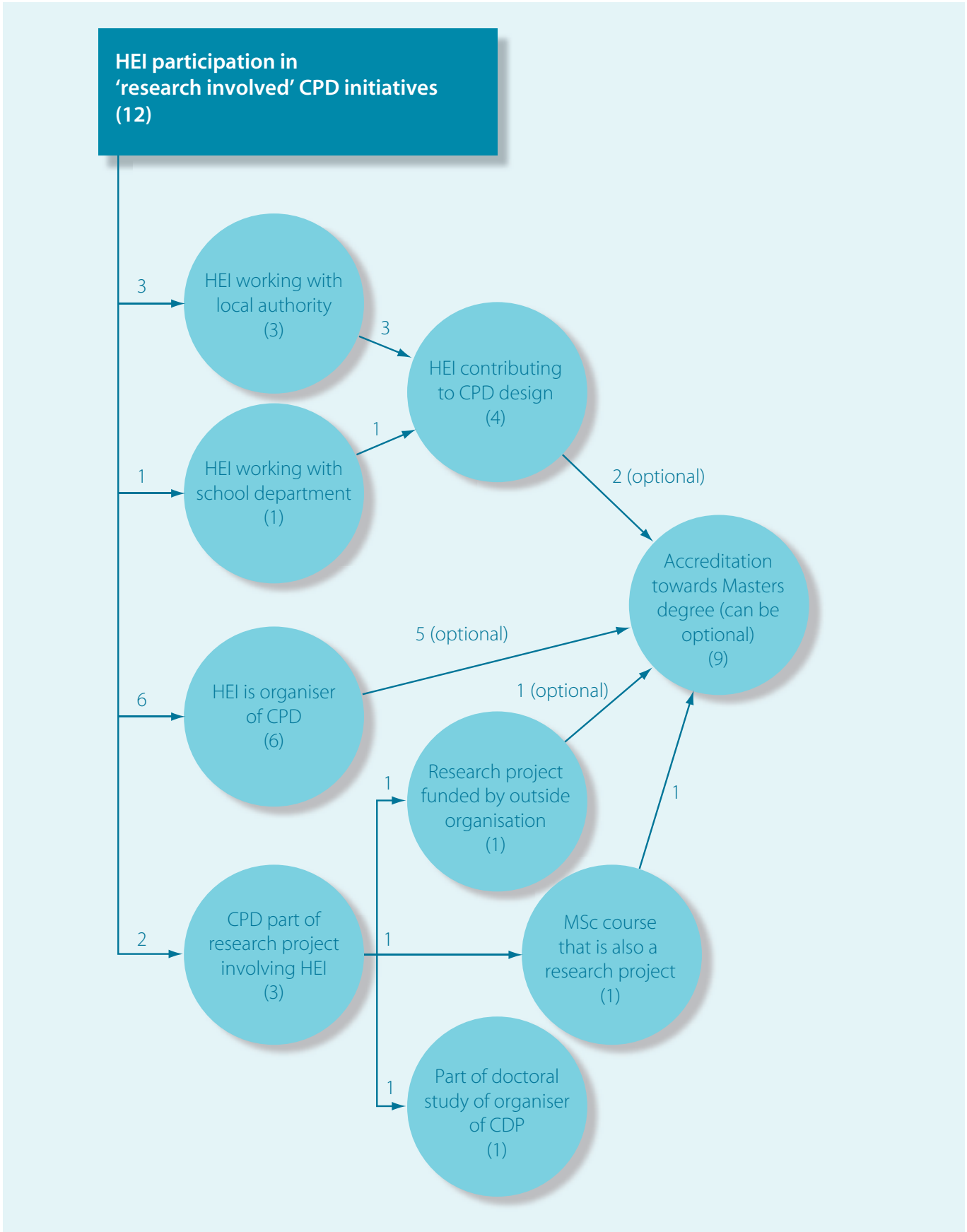
The nine initiatives which offered accreditation (all towards Masters qualifications) required the teachers to undertake some research and to read research and reflect upon this. In all but one of these cases this Masters accreditation was an optional element of the CPD. Figure 10 below provides this information in a diagram.

Furthermore:

In three cases, the CPD initiative followed on from at least one of the participants or organisers having been a teacher-researcher in the past: from having been involved in a HEI led research project; building on research from doctoral work from the organiser; or following on from working as teacher-researcher in their own classroom.

[65] HEIs were also involved in two more non-research-involved initiatives and concerned level 4 accreditation in FE

Figure 10 HEI participation in research-involved CPD initiatives



7.4. Conclusions

'Research-involved' CPD included:

- research-informed CPD, where research findings explicitly inform the organisation and planning of the CPD
- research-inspired CPD, where research findings are used implicitly rather than explicitly
- participants reading professional and research literature
- participants using resources that have been developed based on research
- participants being part of a research project
- participants carrying out research as part of their CPD (often called action-research).

Benefits of research

Overall, using research seemed to offer teachers effective means of becoming aware of different perspectives about teaching and learning, to gain confidence about their own thinking, to be confident about the validity of new ideas to try out in the classroom, and to give status and credibility to the CPD initiative itself and to the teacher. From the data it is clear that in the CPD initiatives that involved a research aspect, the teachers were asked to think and reflect about the research that was presented in the CPD. Teachers valued such opportunity to think and reflect positively. Teachers participating in some CPD expected to learn skills to do research and ways to implement research findings into the classroom. Barriers to undertaking research were similar to other barriers and concerned lack of time and the tensions this causes, lack of opportunity to do research in the classroom, and finding reading research too challenging.

Influence of research

Research sometimes influenced CPD initiatives for teachers of mathematics directly, and this could include involvement of HEIs which encouraged participants in the initiatives to read research literature and sometimes to carry out their own research. HEIs work in a variety of ways in contributing to CPD: offering courses themselves; working in collaboration with local authorities to provide tailor-made CPD; outside funders; through research projects, networks. Research also seemed to influence CPD more indirectly, for example, a CPD initiative using resources that have been developed based on research.

The pragmatic use of research

Research was used in a pragmatic way, whether it was relevant to the aims of the CPD or to identified issues in the teachers' professional practice, or whether it was used as a focus for professional development. Whereas in this process the original meaning of the research and its findings may have been reconstructed, research was nevertheless being used as a starting point or vehicle for exploring issues identified as problematic or interesting by teachers.
We recommend further research into the kind of research that is used in CPD, the way it is used, the effects this has on the professional development of the teachers and the extent to which these differ from non-research involved effective CPD.

8. The role of the NCETM and the portal in CPD for teachers of mathematics

8.1. Introduction

This chapter addresses Aim 5 of the study: to investigate the influence of the NCETM portal on professional development for teachers of mathematics.

The NCETM's role is to enhance professional development for mathematics teachers in all education sectors in England and was set up to ensure all teachers of mathematics, from early years to the post-compulsory sector, have access to high-quality CPD. The Centre undertakes several activities to achieve this: it offers teachers and educators in schools and colleges across England face-to-face contact with a team of Regional Coordinators, who run events, create and support networks and provide advice. It organises conferences on aspects of professional development in mathematics education. It funds and publishes research into effective mathematics teaching practices and CPD. Teacher enquiry in the classroom is supported. The NCETM also offers professional learning through its portal, a web-based site which provides resources to support professional development, including self evaluation tools, and offers a platform where people can 'meet' and share experiences on-line. It also signposts other resources and information.

The RECME project investigated how the portal influences teachers' CPD with the aim of providing recommendations to inform future NCETM initiatives. The focus was on the teachers' voice to get their perceptions and understandings of how they use the portal and how it was influencing their CPD. Data comes from in-depth interviews with teachers who participated in the RECME CPD initiatives.

8.2. Interviewee sample and methods

The interviewed teachers were selected from the respondents to the on-line questionnaire (n=92). The questionnaire included questions to provide insights into the usage of the portal: what sections of the portal the individual teachers were using and how useful they found these. These responses were used as a starting point for choosing the sample teachers.

The selection process was based firstly on the teachers having provided consent for further involvement in the research and secondly on the level of usage for each portal section (a lot, some, not much, not at all). Scores relating to portal use were calculated and these results were ranked. The 10 teachers with the highest overall reported usage were invited to take part in the interview and the first four respondents were chosen as the interview sample.

The interviewee sample consisted of four teachers: one female and three males. Two of the teachers were between 41 and 50 years old, the other two between 51 and 60. Two were classroom teachers and two heads of mathematics; one worked in FE, the other three in secondary schools. Two of the teachers had taught mathematics for 15 to 20 years, two for over 25 years.

The semi-structured interview schedule was based on the main sections of the portal. These included Blogs, Communities, Courses and Events, Mathemapedia, News, Personal Learning Space, Research, Resources, Self-Evaluation Tools (SET) and Search Tool. The interviews were conducted over the telephone and recorded. They were then transcribed and the data analysed and developed into four case studies which can be found below. This is followed by a summary of our findings and conclusion.

8.3. Case Study 1: Helen

8.3.1 Background

Helen has been teaching mathematics for more than 25 years and is currently working in FE. The NCETM portal has over the last two years provided her with 'lots of ideas' and an 'interactive way of doing things'. Her approach has been mainly to browse for example news items or blog entries, as well as to search for information. The frequency of use was defined as 'once a week', but this varied depending upon time.

8.3.2 Using the NCETM portal

- Helen currently contributes to other people's blogs although she intends at some stage to develop her own.
- She has signed up to four online communities, these relate to specific topics such as FE, STEM and Post-16.
- The Courses and Events section was used to check dates and times, although she said that 'these entries needed to be updated more regularly'.
- Helen was not a frequent user of Mathemapedia, though future involvement in teacher training may mean this approach will change: 'I think there will be aspects that I'll want to look up and it's a good way to start'.
- The News section helped her to keep up-to-date with current events and interests, for example she had recently heard about the changes to Standard Attainment Tests (SATs) through the NCETM portal.
- One area of the portal Helen did not use was the Personal Learning Space. Helen indicated that 'we've just got a virtual learning environment at work that I'm learning how to use and obviously, if I put things I've prepared there the students can directly use them'.
- Research took place mainly via Mathemapedia, for instance a recent search for information on the word 'constructivism' led to a series of links and based on these she was able to download relevant publications.
- Following attending a two-day course, Helen used the Resources section of the portal to access certain information. A set of online activities was made available, and she downloaded some of these and adapted them for use in the classroom. She mentioned problems finding certain resources and said that more guidance could be provided as to how teachers could generally use such sections: 'often I find resources and I'm not sure how I can use them'.
- Helen has looked at the Self-evaluation Tools (SET) but would like more time to investigate what is involved in using them.

8.3.3 Influence on continuing professional development

Helen described Communities as being 'useful', as they provided her with the opportunity to 'find out about things'. For example, in one community someone mentioned that there was a television series on the history of mathematics and this caused her to take an interest in the programme and set aside time to record it. Her use of the Courses and Events section was affected by the fact that she felt the information was not being kept up-to-date: 'I think it would help me if it was really up-to-date, but as I said, I find that it's not'. Although Helen was not a regular user of Mathemapedia, she mentioned that it had provided her with 'good information', also 'it's a great way to start to get guidance on where to look next'.

The main barrier in terms of using the Research section was time: 'if I had time to do it, I would'. For Helen this part of the portal was described as being 'need-led, if somebody talks about something I don't understand at a conference, then that's when I look up things'. Helen reported limited use of the Resources section, although she considered the resources that she had used 'very good', explaining that 'they've often been adaptable to lots of different areas'. Helen thought that the current quantity of available resources that would fit her purposes was limited.

The use of the NCETM portal had influenced Helen in different ways, but mainly 'in basic skills numeracy, 'I've begun to feel like a professional rather than somebody who teaches people who are illiterate and innumerate'. She went on to say that the portal had given her the sort of professional help that she required and went on to say that 'I will be very disappointed if it (the NCETM) disappears …it feels a bit like a security blanket, when I feel I'm out of my depth, it's one place I can go and read about something and find out about something to do with numeracy or maths'. Helen's main criticism of the portal centred on 'keeping things up-to-date'.

8.4. Case Study 2: John

8.4.1 Background

John is head of mathematics, has been teaching for more than 25 years and is currently working in a secondary school. The NCETM portal was not used on a day-to-day basis but 'probably once a week'. He tended to browse for information and from this he would find aspects that interested him. He said that the portal was a good way of, 'getting background material, the bigger ideas, the key, all embracing ideas that cover all aspects of maths.'

8.4.2 Using the NCETM portal

- John did not use the Blogs section; as he said, 'I don't have the time'. He said that it did not relate to the way he worked.
- John had joined 'about half a dozen' communities. One was the NCETM Bowland Maths Forum, which is an initiative providing a series of case studies which are said to appeal to pupils at Key Stage 3. The role of the community was to discuss the materials. John made a contribution but he was also interested in the 'other case studies and seeing what kind of practical issues people have had, what kind of classroom issues and what kind of IT issues people have experienced when trying some of the case studies'. John described himself as 'a reader and an observer rather than an active participant in the communities' adding that he valued them being there even though he does not actively contribute.
- One section John used 'fairly regularly' was the Courses and Events part of the portal. John found this a good way of 'finding out what's going on locally, nationally and regionally'. His interest lay in looking at 'National' as well as 'NCETM-sponsored activities.' He attended a number of conferences on mathematics and ICT during the year; he found it valuable to meet policy makers and people who had 'research evidence to offer'.
- Although he had used the Mathemapedia only 'occasionally' John had found 'interesting things.' He described this part of the portal as being 'a bit deeper than the communities …a more extended view if you like, of what is happening in maths education'. Overall, he said it contained more 'reflective pieces'. Limited usage was put down to lack of time – 'it's just not having the time …at the end of the day to look at these things'.
- John did not use the News section as he received a hard copy of a particular newspaper which covered the educational information he required.
- In terms of the Personal Learning Space he was not actively involved in this part of the portal but he intended to investigate at some stage.
- John's use of the Research section was due to his involvement in the NCETM Research Project, RECME. As the study progressed he used this part of the portal for updates and downloading the newsletter.
- John very rarely used the Resources section. He commented that there were 'so many sites out there that offer things that I tend not to go there as a first port of call'.
- John used the Self-Evaluation Tools (SET) and found them very useful. Due to a change in circumstances at his school he had also tried to encourage colleagues to use them, 'as a kind of non-threatening way of looking at their own subject knowledge'. As a result of changing from an 11-16 to a 11-18 school, some staff were having to train to a higher level of mathematics, John therefore recommended that they should try using the SET as a means of 'teasing out' levels of confidence. For a group of student teachers, he advised that it would be a very good way of linking their professional development with 'a check list of things that they have to be aware of'.

8.4.3 Influence on continuing professional development

John 'enjoyed' reading the information on the Communities section, finding out about the material people had been using as well as their successes and failures. The Courses and Events listed provided him with access to information on materials, speakers, contacts and networks which normally he would not have had. Furthermore, through these connections it provided him with access to a 'maths community' where he found people were working on the same things; that they had to deal with the 'same issues, struggles and problems'. He described this as 'a very powerful thing' Over the last two years the portal had presented him with a sense, 'that we are a community of teachers working together'.

Through Research findings and studies, John has been able to reflect on other people's work as well as 'the pathways they have pursued to improve what happened in the maths classroom'. Such information 'provoked' him into thinking about things, for example how he used 'questioning in the classroom'. Through looking at research on this particular topic or what other people within the National Centre had been thinking or doing, John was able to consider other ways of handling this activity. As a final point, the SET had enabled John to look at his 'own knowledge' or 'tease out where I feel most comfortable and then go and do some independent work that supports that'.

John said that the portal represented at this stage 'a small community'. He said that it had not as yet 'sold itself to the wider maths community' and he attributed this to a lack of 'time'. Initially he had thought that when the National Centre was set up it would be purely a virtual thing and that would be the only source of connection. He was pleased to find that as well as the portal, 'there is a human side to the National Centre, I think the two need to work hand-in-hand. I mean I don't think you can get everything through the portal; you still need regular contact with practising teachers to get the kind of professional development that I think the government want to see and the people at the National Centre want to provide'.

8.5. Case Study 3: Matthew

8.5.1 Background

Matthew is a classroom teacher who has been teaching for 15 to 20 years. He reported that up until a year ago he was a regular user of the NCETM portal, browsing the site for resources, ideas and general information. These days his approach tends to focus more on looking for specific information and visits to the site are not frequent.

8.5.2 Using the NCETM portal

- As a result of receiving an NCETM grant, Matthew had been asked to contribute to a blog, having recorded several entries he decided to contribute to different blogs. He found some were more useful than others.
- Upon signing up to the portal, Matthew joined as many of the Communities that 'sounded interesting'. He engaged in several exchanges of information, which he found 'very useful.'
- Matthew used the Courses and Events section of the portal. He recently attended the Institute of Mathematical Pedagogy, having found the information about this course on the NCETM portal. There had been a number of free courses posted on the site and although he did not go, he passed this information on to people within his department and three attended.
- As part of a group, Matthew went to the Mathemapedia writing days which had been organised by the NCETM; they contributed by writing one of the entries.
- The News part of the portal was described as providing a means of 'keeping in touch with developments' and with what was new in mathematics education.
- When asked about Research, Matthew said that he 'downloaded and read other people's research projects.'
- In terms of Resources through the NCETM portal, Matthew had accessed the appropriate website for the 'Improving Learning in Mathematics' (The Standards Unit Box), and this was now being used for teaching from Year 7 through to Year 13.

8.5.3 Influence on continuing professional development

Matthew found that the NCETM portal provided him with a 'really good source of ideas', it had led him to think about his teaching and 'how I might teach as an alternative to whatever I am doing at present.' He said that on the whole it had a 'huge impact' on his professional development.

Matthew said the whole experience of using the Communities was like being in the maths department, where discussions would take place about mathematics and mathematics teaching. He said the Communities enabled 'a continuation of that conversation about how we'd approach topics and this is the way to do things and what you do you think about this.' As with the blogs, he mentioned that tracking the threads of conversations through vast quantities of information could be problematic. Part of the reason why he stopped using the Communities was the limited number of people involved in the discussions, which affected the diversity in conversations. He also said the exchange tended to be 'quite slow moving' and responses could take days, weeks or even months. He mentioned that he had used Communities that then 'died', i.e. the contributions to the discussion halted. He stopped using these and did not go back.

Matthew said that he 'explored' the Mathemapedia section of the portal and found it to be 'quite thought provoking.' He was, however, overwhelmed by the vast number of entries and found them to be quite abstract. He said there needed to more practical examples which could be applied in the classroom straight away, and a more direct link with resources.

Following the success of achieving an NCETM grant, he attended the conference which was specifically for grant holders. He saw this as an opportunity to 'sit with other people who have been involved in research and talk to them about what they've been doing – it's much more immediate and easy to grasp I think than actually trying to take it from a written report'. He was aware of a number of different research projects, one in particular was the Cornwall Maths Project. The approach that had been used in the lessons he found 'really helpful…it's given me some ideas that I've been able to take away'.

Matthew is using the portal less frequently because of the size and amount of activities now taking place on the portal are making it very difficult 'to know what's on there and to know where to find things.' He does not find the site easy to navigate. His use of the portal has changed in that he now uses it to search for something specific, whereas previously he used it frequently and browsed.

8.6. Case Study 4: Tim

8.6.1 Background

Tim is head of Mathematics and has been teaching for the last 15 to 20 years. On average he has used the NCETM portal 'once or twice a week'. Over the last two years, it has given him 'somewhere to look' for ideas, to see what others have done in the classroom, and through reading people's contributions it has led him to 'try new things'.

8.6.2 Using the NCETM portal

- Tim used blogs to remind people of what had been agreed following a meeting or to post an action plan. He would use them to respond to what others had done and he would also contribute his own ideas.
- Tim is part of a 'local teacher's community'. As a working group they would meet and contribute ideas about 'teaching and learning mathematics'. It was an opportunity to share information on particular topics and to discuss techniques people had used. After each meeting, those who attended were encouraged to post information about the resources that they had brought to the meeting, as well as what they had enjoyed, and their evaluations and actions plan. Tim saw this opportunity to share practice and knowledge through such Communities as 'very useful'.
- Tim used the Courses and Events section of the portal. For example, he managed to get support from the NCETM to go to a conference last year, which he described as an excellent experience, and he was able 'to meet like minded people' The experience was both refreshing and inspiring.
- Tim has used Mathemapedia through his involvement in a focus group which was looking at the topic of 'Boy Centred Learning'. He has used Mathemapedia to 'find things that are relevant to our discussion and new things to try'. It gave him 'some starting points', it provided him with people's research on how boys respond best. However, it did not give him 'specific examples of putting that research into practice'.
- Tim did not use the Personal Learning Space on the portal. He did however store links in his Favourites, as he found this part valuable in terms of finding things again quickly.
- In terms of Research, Tim mainly looked at information on the topic of 'Boy Centred Learning'. He used the portal to look at learning styles with a view to finding out how boys learnt compared to girls and which styles were appropriate.

- Tim has used the SET however. As quite an experienced mathematics teacher he mentioned that he would use them selectively, identifying headings that looked interesting. He finds the hints part of these tools very useful. Tim said that this section of the portal was particularly useful for teachers who were less confident in their subject knowledge. If he had a new teacher coming into the school, he would encourage them to use the tools. When working with primary teachers who are not mathematics specialists they were encouraged to do the Self-evaluation at Key Stage 2 and 3.

8.6.3 Influence on continuing professional development

Communities were used as an 'aid for collaboration', for support following a meeting, for ongoing communication, for showing what had been achieved subsequent to the meeting, and how things have been put into practice. For instance, Tim recently attended a meeting where a group of mathematics teachers had focused on the matter of 'questioning styles'. They considered, 'open questions, closed questions' and 'general questioning styles'. To help the teachers collate and share their findings following the meeting, it was suggested that they create an NCETM community. Tim said that the portal was ideal for this kind of task; it provided 'a national portal for sharing'.

Last year, through support from the NCETM, Tim attended the ATM/MA[66] conference. In mixing with 'specialist maths people' he described it as a means of 'professional refreshment'. He said that the experience enabled him to think about how he could modify classroom practice, how it could evolve and 'you see things that you could do differently'. The event also provided him with the chance to pool resources with other teachers, for example to talk about new software to do with dynamic geometry. Based on conversations with other people he looked at resources on the net. Following the conference, he networked with others, he also emailed and asked questions or enquired as to how colleagues taught a particular topic.

Being part of a focus group, Tim used the Mathemapedia section of the portal to look for information about 'Boy Centred Learning'. He used it to find things that were relevant to current group discussions and to look for 'new things to try'. Tim mentioned that he was trying to inject into his lessons the element of competition and energy – 'boys like competition and enjoy energetic lessons'. He was looking for 'specific ideas' that people have put into practice and how the outcomes in such lessons may impact on his professional development'. He was looking for things to catch the interest of students rather than 'a conventional didactic lesson' – techniques to engage them and get the competitive element in but not at the expense of rigorous learning. In his opinion, 'there is always a certain tension – engaging the pupils quickly but not allowing them to under-estimate the rigour or the depth of the current topic. This is the kind of thing the portal encourages you to reflect on'.

Tim said that the NCETM portal made him, 'reflect on the craft of teaching'. He always used to think that if he made the mathematics interesting then the rest would just follow. Recently, he spent a lot more time thinking about what the pupils were going to be doing and 'how would I respond if I were in their shoes and how long can I expect them to concentrate on this particular theme before moving to something else?' He described it as a 'reflective process' but went on to say that 'it doesn't mean that just because you think about your teaching, you get it right and produce a perfect lesson- sometimes you need to add the experience of the lesson to what you had planned to achieve and think about good and bad parts'. These are the kind of thoughts the portal has prompted in Tim's current focus.

Overall, Tim saw the NCETM portal as having a positive impact on his professional development. It was 'somewhere to look if I'm looking for ideas', a place where he could see what other people had done, also to find new ideas. It had enabled him to 'expand' what he was doing and 'if I'm looking for a bit of inspiration I suppose, I look there'. He mentioned that it was sometimes difficult to find things on the site; he found he relied on having to put links into his favourites. For instance, in looking for a Pupil Selector Tool, he was having difficulties obtaining one – 'I've been trying for half an hour, so I'd like to be able to just go online and get up a Pupil Selector Tool with a bit of music, download it, bang, and I'm away'.

He said that in terms of getting busy teachers to use the portal more frequently, 'time' was an issue. Tim thought that they needed to be part of a project or have some kind of community involvement that affected them and their pupils directly. Teachers need to be convinced of the positive impact on their teaching, their pupils learning and their CPD.

[66] This was a joint conference run by the Association for Teachers of Mathematics and Mathematical Association. These are both professional bodies for teachers of mathematics.

8.7. Overview of the teachers' use of the portal

Based on the case studies, the following section summarises the portal sections being used by the teachers, for example Blogs, Communities, Courses and Events, Mathemapedia, News, Personal Learning Space, Research, Resources and the Self-Evaluation Tools.

- The teachers were using Blogs to mainly contribute to discussions rather than developing their own.
- The teachers had signed up to a number of relevant Communities and these were found to be useful.
- The teachers were using the Courses and Events section to check details about up and coming conferences, workshops, meetings and courses. They were interested in both national as well as NCETM-sponsored activities.
- Mathemapedia was used, although not on a regular basis. It was found to provide interesting facts and extended views of what was happening in mathematics education.
- Helen and Matthew both used the News section of the portal; this was providing a means of keeping up-to-date with current events and interests and with what was happening in mathematics education.
- None of the teachers had used the Personal Learning Space (PLS)[67].
- The teachers used the Research section. Frequency of use related to their own interests and requirements.
- Three of the teachers used the Resources section: John very rarely; Helen had used it to access certain information following the attendance of a course, as relevant online activities had been made available; Matthew had used this section to find links to appropriate websites where resources could be downloaded and used in the classroom.
- Two of the teachers used the Self-Evaluation Tools (SET). These were proving to be most useful for teachers who were less confident in their subject knowledge.

[67] The Personal Learning Space (PLS) is a recent addition to the portal and had only been available for six months at the time of the interviews.

8.8. Conclusions

Many of the teachers reported that the NCETM had influenced their CPD in various ways, through its organisation of events and conferences and through supporting teacher enquiry projects, as well as the outreach work of the Regional Coordinators.

The NCETM portal was reported as being valuable in providing information and opportunities for communication and in providing tools and resources to support professional learning.

Providing information

The teachers were positive about the ways in which the portal had contributed to their professional development, providing them with ideas and information and enabling them to learn from other teachers. In particular, they reported that the Courses and Events section provided them with valuable information about conferences, meetings, speakers, contacts and networks. They used this section to identify events to attend, which provided them with opportunities to meet 'like-minded' people, policy makers and researchers. The News section allowed the teachers to keep up to date with current developments in mathematics education. The Resources section provided practical help for classroom practice and Mathemapedia provided important links to the research world.

The Research section related to the teachers' interest in a particular topic or project. They reported that learning about research findings could provoke them to reflect on other ways of doing things in the classroom, for example questioning in the classroom.

Overall, the teachers reported finding the information on the portal useful but they indicated that the large quantity of information now found on the portal was hindering their ability to find relevant information.

Communication and interaction

Valuable networking opportunities were offered by the Communities part of the portal. This also provided a means for sharing practice and knowledge, sharing ideas, seeing different perspectives, and getting support. The SET offered teachers the opportunity to interactively assess their own mathematical knowledge in teaching. Some teachers suggested that it could be useful for less confident teachers. In conclusion, one of the most important outcomes of the teacher's engagement with the NCETM portal was that it enabled access to a wider range of different mathematics teaching and learning communities. Through the Communities and Courses and Events section, this had

prompted not only involvement online but it had also instigated teacher attendance of meetings, conferences and workshops. The research found that participation in such events had impacted on the teachers both from a practical and motivating perspective. We see this as an important part of what the National Centre can offer teachers and it should be developed further to provide a valuable framework for teachers' professional development.

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10. Appendix 1: Members of the Research Advisory Group

The full research advisory group includes the authors of this report and administrative staff from the NCETM. Other members:

Alison Clark-Wilson	University of Chichester
Diana Coben	Kings College London
Maria Goulding	University of York
Jeremy Hodgen	Kings College London
Celia Hoyles	NCETM
Jane Imrie	NCETM
Steve Lerman	London South Bank University
John Mason	Open University
Candia Morgan	Institute of Education
Hilary Povey	Sheffield Hallam University
Kenneth Ruthven	University of Cambridge
Rosamund Sutherland (chair)	University of Bristol
Malcolm Swan	University of Nottingham
Geoff Wake	University of Manchester
Anne Watson	University of Oxford

11. Appendix 2: Complete list of CPD initiatives

The RECME project sample consisted of 30 CPD initiatives, short descriptions of each were provided by the organisers these can be found on the NCETM portal: see **http://www.ncetm.org.uk/Default.aspx?page=41&module=research&researchid=9368**

The following table describes each of the 30 CPD initiatives in terms of structure, phase and region

Early Years Foundation Stage (EYFS)

South West Initiative 1	A network offering a grass-roots model for teachers of children in Early Years Foundation Stage (EYFS). The network supports teachers in developing their professional knowledge of young children's learning and development of mathematics and in linking evidence-based research and theory with practice. They encourage teachers to take ownership of their learning and professional development as they learn about and develop their pedagogy. For the purposes of this research we focus on three aspects: • A collaborative Children's Mathematics Network group (See CASE STUDY 5) • Mathematics CPD at a Children's Centre • A group of teachers involved in EY mathematics research project (also professional development) at the same Centre.

Primary

East Midlands Initiative 2	A within-school initiative led by the Numeracy leader and deputy head of the primary school. As part of their on-going practice, teachers in the school conduct weekly reviews of their numeracy work in school. Through using the renewed primary strategy they are looking at how they can develop their curriculum so that it is more engaging for all pupils.
East Midlands Initiative 3	A within-school initiative in a primary school involving two Year 6 teachers in implementing a change in the ways in which the children were grouped for mathematics lessons. The initiative was initiated by the head teacher who supported the two teachers and the teachers reported to the rest of the staff at weekly meetings, discussing the changes they were making and reflecting on their changed practice.
North East Initiative 4	A network involving leading mathematics teachers in primary schools in developing resources to address teaching early counting, addition and subtraction, multiplication and division, fractions. The project is working on a pedagogic approach which is based around the idea of interrogating different representations as a means of working on understanding concepts.
London Initiative 5	A within-school initiative focusing on the work of an advanced skills teacher to support two colleagues in her school in embedding approaches to teaching mathematics focusing on Speaking and Listening in Mathematics. Both teachers had previously attended a course promoting this approach.
London Initiative 6	A course, with six one-day meetings, based on publicly available materials for Key stage 1 and 2. The course allowed consultants and teachers a) to simulate specimen activities and adapt them; b) to team-teach in classrooms focusing on children's thinking; c) to reflect on shared practice to highlight issues in curriculum and pedagogy; and d) to connect the new learning and teaching culture to current mainstream practices, initiatives and research.

South East Initiative 7	A 10-day course for 20 primary teachers run by a local authority as part of a county-wide initiative. It involved an HEI and could lead to accreditation. The course offered the teachers eight days of face-to-face tuition and two days' non-contact time. In most cases, two teachers attend from each school. The initiative aims were to: • build capacity across the county by building confidence and expertise in teaching mathematics • support primary school teachers in developing their mathematics subject knowledge, mathematics pedagogy and understanding of solving mathematical problems and thinking mathematically; and • give the teachers opportunities to work with colleagues to develop their practice. See CASE STUDY 2
East of England Initiative 8	A within-school initiative involving an advanced skills teacher in mathematics from a secondary school working with a feeder primary school on the teaching and learning of mathematics.
London Initiative 9	A whole primary school initiative set up by the headteacher and involving an external commercial provider. The aims were: • to raise attainment in mathematics with a focus on creativity and children's engagement • to develop teacher and teaching assistant subject knowledge and expertise in pedagogical approaches that support children's mathematical learning • meetings happen as twilight sessions and as whole and part days and run throughout the academic year. See CASE STUDY 3
London Initiative 10	A course involving training for Y1 in implementing the renewed Primary Framework for mathematics.

Secondary

East Midlands Initiative 11	A departmental initiative based within a school where students are organised into broadly banded attainment groups and the curriculum is based on extended activities that encourage deep learning rather than frequent re-visiting of topics. The emphasis of the initiative is on developing resources that encourage students to engage actively in learning mathematics and the members of the department work together to produce these resources.
South East Initiative 12	A within-school initiative involving all members of the mathematics department at a secondary school. The initiative follows the Japanese Lesson Study model. The teachers identified an area of mathematics to work on, chosen because they have found it problematic to teach in the past. Members of the team collaborate to unpick the key mathematical ideas and then plan, in minute detail, a lesson on this mathematical area. One of the teachers teaches the lesson, and this is video recorded, then reviewed and discussed in detail by the team.

South West Initiative 13	A within-school initiative involving the entire mathematics department. The members of the department were researching ways to encourage pupils to develop their writing skills in mathematics, led by the subject leader and second in the department. They usually met formally every four weeks using some of their departmental meeting time to discuss and share ideas. Individual members of the group brought their updated evaluations of writing in mathematic. The desired outcome was for pupils to be able to communicate their mathematical knowledge more effectively by improved writing skills and strategies in mathematics.
North West Initiative 14	A within-school initiative involving all members of the mathematics department in professional development based on a lesson study approach. The teachers plan lessons collaboratively, teach them, then observe and evaluate them before repeating the cycle of planning, teaching/observing and evaluation again. See CASE STUDY 4
London Initiative 15	A course focused on helping teachers to understand the underlying principles of assessment for learning and applying these to embedding effective practice in the classroom. It included five one-day conferences which enabled teachers to explore research as well as reflecting on and developing their practice. This was done by considering a variety of rich classroom activities and through discussion with colleagues. Teachers were asked to carry out school-based tasks and to contribute to a personal ongoing reflective journal. See CASE STUDY 1
North West Initiative 16	A network for secondary school teachers which aimed to develop resources to support a specified approach to teaching and learning mathematics based on 'Realistic Mathematics Education', with teachers of KS4 Foundation Tier GCSE, using interactive whiteboards to support interactivity in the mathematics classroom. The teachers were expected to use the resources in their classroom and to report on their experiences in order to develop the resources in an iterative way.
West Midlands Initiative 17	A 17-month, part-time course which was designed to support teachers of GCSE mathematics who wanted to teach A Level Mathematics for the first time. It was run by a publisher and organiser of CPD along with four participating universities which each worked with teachers in their regions. Typically teachers attended four pairs of study days at the university, spread across the school year when they discussed the major issues in the teaching of A Level Mathematics and were visited twice in their schools/colleges. In addition, teachers undertook a substantial amount of private study with website and email support; they also had the option to take part in virtual lessons in an on-line classroom.
South East Initiative 18	A TDA-funded course providing subject knowledge support for those teaching secondary mathematics who originally trained for a different subject. The focus at the University was on subject knowledge with teachers attending for four days in July, then two days and some twilight sessions in each half term of the subsequent academic year. Several local mathematics departments collaborated to deliver some of these twilight sessions. This offered the teachers a taste of a 'culture of mathematics' that was different from their present schools. They also considered how teaching mathematics differed from teaching the subject that they trained in. The course led to accreditation for the participants as qualified mathematics teachers.

National Initiative 19	A course run jointly by a technology manufacturer, a university and an educational trust. The course was an action research project based on introducing an innovative ICT mathematics platform into the classroom. Teachers were developing activities for the classroom initially on individual applications, leading to more sophisticated multiple representations. Their involvement in the action research provided them with CPD experience.
North West Initiative 20	A course involving non-specialist secondary school mathematics teachers and aimed to improve and enhance their mathematics subject knowledge. The course led to accreditation for the participants as qualified mathematics teachers.
South East Initiative 21	A Masters course which involved teachers taking a mentoring role in secondary schools. The aim of the course was to assist in the development of teachers' careers, to equip teachers with knowledge and understanding of educational theory and its application. Six units were studied, each valued at 20 credit points, followed by a 60-credit dissertation involving research carried out in each teacher's school.
East of England Initiative 22	An initiative based on identifying, supporting and disseminating good practice. It was led by a Lead Practitioner whose aim was to lead by example, support and inspire others and disseminate best practice through strong regional and subject networks, events and learning visits. In this way new opportunities to share were built and ideas and strategies developed to impact on classroom learning.
National Initiative 23	A course, supported jointly by several professional organisations, designed for teachers who were new to the role of mathematics subject leader or who hoped to move into the role of subject leader. It provided teachers with expertise and confidence to lead a department effectively. It consisted of five face-to-face training days and five days working in other ways.
South West Initiative 24	A course involving central training for subject leaders in implementing the renewed National Curriculum for mathematics in secondary schools in the South West.

Further Education

North East Initiative 25	A one-year, part-time evening course which was designed to offer CPD for teachers in the Post Compulsory Sector (work based learning, education, community and voluntary sector). Entry was via Cert Ed/PGCE, appropriate qualifications and interviews. Delivered at Levels 5 and 6, the course consisted of three modules (1) numeracy and the learners, (2) developing numeracy knowledge and understanding and (3) numeracy learning and teaching.
North West Initiative 26	A network involving teachers in FE who have formed an action learning set consisting of non-specialist teachers of numeracy and teaching/support staff. They previously attended an 18-hour CPD course which introduced them to resources designed to develop personal numeracy skills and confidence levels and also offered individual sessions with the subject learning coach. Staff are sharing best practice and cascading awareness across the college and borough through action learning sets which will be ongoing. The initiative will evaluate the impact on teaching and learning amongst the staff and students.

North East Initiative 27	A network of teachers of mathematics and numeracy in the FE sector who had termly meetings. Teachers explored approaches to teaching and learning as exemplified in specific resources. They also worked collaboratively to plan sessions which they try out in their schools and colleges and then report back on at subsequent meetings. All sessions at the meetings modelled the approaches being promoted and coaching techniques, such as action learning sets, are used. See CASE STUDY 6
East of England Initiative 28	A network focused on mathematics for learning, life and work. Participation in its professional development activities is open to anyone with an interest in the teaching and learning of mathematics/numeracy to adults in the East of England. With funding from the LSC and EEDA the project includes among its aims the provision of direct support to practitioners to help them to improve their own professional practice.

Cross phase

North East Initiative 29	A within-school initiative aiming to improve teaching and learning by introducing the Mathematics Enhancement Programme (MEP) into Years 5 and 6 at the school. This CPD uses a Hungarian approach and resources are provided free to the school by an HEI.
South West Initiative 30	A network involving teachers from primary and secondary schools aiming to explore a particular model of professional development based on teachers working collaboratively and directly from their own practice and their own lessons – taking Japanese Lesson Study as a starting point. Although exact details vary across schools, the professional development of the teachers involves teachers planning a lesson collaboratively. One teacher then teaches this lesson while others observe. This is then followed by a review meeting where the lesson is discussed, revised and then taught again by another teacher with colleagues observing. The group consists of at least two representatives from each of six schools (two primary and four secondary) and meets once a term.

12. Appendix 3: The online questionnaire (paper version)

QUESTIONNAIRE FOR TEACHERS (May 2008)

This questionnaire is about your professional development. It includes questions about the professional development you are currently involved in, as well as questions about other professional development you have experienced. All your responses will be anonymised and no results will be fed back to the providers of your CPD for their participants. Please answer the questions as fully as you can. This should take about 30 minutes.

Part 1: Your Professional Development (This initiative)

Project Name:

Early Years and/or Primary		Secondary, FE and /or Adult		More than one phase or not phase specific	
Names of the initiatives to tick-box		Names of the initiatives to tick-box		Names of the initiatives to tick-box	

2. How far are you through this CPD?

Beginning ☐ Middle ☐ End ☐ Ongoing ☐ N/A ☐

3. Do you consider this CPD to be effective? Yes 0 No 0 Partly Please explain

4. What is your main reason for taking part in this CPD?

I chose to		Please go to question 4a and then to question 5
I was encouraged to		Please go to question 4b and then to question 5
It is compulsory/ I was sent to the CPD		Please go to question 4c and then to question 5

4a. You indicated that you chose to take part in this CPD. Please explain (by ticking ✔ all that apply)

I like learning		I think my students will learn better if I change my approach to teaching	
I would like my students to achieve better grades		I would like to improve my classroom management skills	
I would like to develop my knowledge and understanding in specific areas of mathematics		It will contribute to the development of a stronger department	
I would like to learn about some new ideas for teaching mathematics		I agree with the educational principles this this course is based on	
I am teaching mathematics but never received any formal mathematics education		There was a financial incentive	
I need to develop my knowledge and understanding in specific areas of mathematics		I would like to gain a qualification to help develop my career in teaching	

I would like to understand more about how my students learn mathematics		I would like to improve my teaching	
I feel that I ought to keep up with developments in teaching		Other (please explain)	

4b. You indicated that you were encouraged to take part in this CPD. Please explain (by ticking ✔ all that apply)

My head teacher, local authority advisor or subject leader suggested that I should take part in this CPD		I am teaching mathematics but never received any formal education in mathematics	
I need more training to keep abreast of new developments in mathematics teaching (I need to implement something new or different in the classroom)		I ought to keep up with developments in teaching in teaching	
A colleague suggested that I should take part in the CPD project		I need to improve my classroom management skills	
The school (or local authority) would like my students to achieve better grades		There was a financial incentive	
I need to develop my knowledge and understanding in specific areas of mathematics		Other (please explain)	

4c. You indicated that this CPD is compulsory/you were sent on this CPD. Please explain: (by ticking ✔ all that apply)

I need to be aware of new developments in government guidance and/or statutory change		I was sent as a representative from the school/college	
It is run by an examination board		It is part of the National Strategies training programme	
Other (please explain)			

5. When you began this CPD, what did you hope to learn by taking part in the CPD? Choose up to three.

Knowledge in specific areas of mathematics		New ways of teaching mathematics	
How to use new technology in the classroom		About assessment methods/procedures	
About using resources or curriculum materials		That I am doing things correctly	
About updates on current developments such as curricular change or new examination specifications		Other (please specify)	
About classroom management skills			

6. When you began this CPD, what did you hope to experience? ✔ all that apply.

To compare methods and share tips with other teachers		To develop resources e.g. worksheets, equipment	
To become part of a community or network of learners		To get some time away from the classroom (non-contact time)	
To do some of my own research		Other (please specify)	

7. How might this CPD impact on your career? Choose the one that applies most.

By helping me break into a new subject area		By achieving personal development	
By assisting in my overall career development		By giving me skills or accreditation that may help me to move out of teaching	
By meeting the requirements of professional bodies		Other (please specify)	

8. Please explain about how you see your professional-self by completing the following sentence:
In an ideal world I would like to be a mathematics educator who would

9. Please explain about how you hope this CPD will develop your professional-self by completing the following sentences:

I think this CPD will in the long term help me achieve this by

I think this CPD will in the short term change my professional practice because I will

10. Is there anything that gets in the way of you getting the best out of this CPD (barriers)? Tick ✔ all that apply

It is difficult to get to CPD meetings		School makes participation difficult	
I find the activities we are asked to do too difficult		I don't have enough time	
I am not able to put the new learning into practice		Curriculum and/or assessment requirements restrict experimenting with new ways of teaching	
I am not interested		The CPD doesn't meet my expectations	
I do not agree with the CPD		Other (please specify)	
There are financial constraints			

If you would like to explain any of your answers above, please do so here.

11. Please indicate the extent to which the following are supportive of your involvement in CPD: Please tick ✔ one in each row.

	Very supportive	Quite a lot	Only to some extent	Not at all	N/A
Family					
Students					
Colleagues					
Head of department/subject leader or co-ordinator					
Senior management					
Local Authority					
Government policy					
Higher Education Institution for example, universities, colleges					
Subject associations					

Part 2: Mathematical CPD focus

12. To what extent does this CPD address the following? Tick ✔ one in each row.

	A lot	Quite a lot	Not much	Not at all
Knowledge about mathematics				
Knowledge about the way students make sense of mathematics				
Knowledge about the ways of teaching mathematics				

Please explain how this CPD addresses these three different sorts of knowledge i.e. knowledge about mathematics, knowledge about how students make sense of mathematics and knowledge about ways of teaching mathematics.

Part 3: Communication and interaction

13. If the following took place DURING the CPD sessions, please indicate how useful they were. Tick ✔ one in each row.

	Very useful	Useful	Not very useful	Not useful	N/A
Whole group work					
Working in small groups (four or more)					
Working in twos or threes					
Individual work					

14. If the following took place DURING the CPD sessions, please indicate how useful they were. Tick ✔ one in each row.

	Very useful	Useful	Not very useful	Not useful	N/A
Presenting to group					
Listening to a presentation from another participant					
Discussing student work from classroom					
Brainstorming					
Mind mapping					
Sharing knowledge					
Listening					
Making posters/displays					

15. If you used any of the following DURING the CPD sessions, please indicate how useful they were. Tick ✔ one in each row.

	Very useful	Useful	Not very useful	Not useful	N/A
Television					
Video					
Scholarly articles					
Books					
Curricular resources					
Mathematics software (e.g. dynamic geometry)					
Other new technologies					
Students' work					
Policy documents					
Practical equipment (e.g. Cuisiniere Rods)					

16. If you used any of the following DURING the CPD sessions, please indicate how useful they were. Tick ✔ one in each row.

	Very useful	Useful	Not very useful	Not useful	N/A
Reflecting on teaching					
Doing mathematics					
Attending to students' thinking and/or reasoning					
Selecting resources					
Planning teaching					
Designing tasks					
Creating resources					

17. If the following has taken place in your classroom AS A RESULT of the CPD, how useful were they? Tick ✔ one in each row.

	Very useful	Useful	Not very useful	Not useful	N/A
Experimenting in classroom					
Interviewing students					
Teaching with colleagues					
Researching your own practice					
Using different resources in the classroom (e.g. software, Cuisiniere rods)					

18. If the following has taken place in your classroom AS A RESULT of the CPD, how useful were they?
Tick ✔ one in each row.

	Very useful	Useful	Not very useful	Not useful	N/A
Working with colleagues for planning					
Working with colleagues to develop resources and strategies for specific topics					
Discussing mathematics with colleagues					
Reviewing students' work with colleagues					
Observing colleagues					
Being observed by colleagues					
Simulating/modelling practice for colleagues					
Discussing your CPD with colleagues					
Discussing your CPD with a member of the senior leadership team (e.g. head teacher or subject leader)					

19. If you have been engaged in any of the following AS A RESULT of the CPD, how useful were they?
Tick ✔ one in each row.

	Very useful	Useful	Not very useful	Not useful	N/A
Reading an article					
Solving mathematical problems					
Using the Internet for research					
Using the Internet for communication					
Writing a reflective log/journal					
Formal assessment e.g. written assignment					

20. Please consider this CPD in terms of the following.
Tick ✔ one in each row.

	Strongly agree	Agree	Disagree	Strongly disagree	N/A
It is well organised					
It meets my needs					
It is well presented					
It is relevant to my teaching					
It is practical					

How does engagement in this CPD make you feel?

21. Thinking back to your last engagement with this CPD, please indicate the extent to which you found it challenging:
Choose one

High ☐ Medium ☐ Low ☐

Please explain

22. Thinking back to your last engagement with this CPD, please indicate the extent to which you felt that you used your skills, which includes thinking skills.
Choose one

High ☐ Medium ☐ Low ☐

Please explain

Part 4: Teacher and student change

23. Please indicate how the CPD has influenced how you feel about teaching mathematics.
Tick ✔ one in each row.

	Strongly agree	Agree	Disagree	Strongly disagree	N/A
I am more confident in my own mathematical knowledge and understanding					
I am more enthusiastic about collaborative working with my colleagues					
I know more about current developments in mathematics teaching					
I feel that I can make more of a difference in terms of students' learning					
I am more enthusiastic about students working together					
I know more about my pupils' thinking and reasoning					
I know more about how to use new technologies in the classroom					
I am more reflective about my practice					
I behave more like a teacher - researcher					

24. Please indicate how the CPD has influenced the ways you teach mathematics. Tick ✔ one in each row.

	Strongly agree	Agree	Disagree	Strongly disagree	N/A
I use new mathematics teaching techniques					
I am more flexible about using different teaching strategies					
I use a wider range of resources and curriculum materials in the classroom					
I use new technologies more in the classroom					
I use a wider range of assessment methods and techniques					
I offer students more opportunities for discussion					
I allow students to get involved in mathematical play more often					

Please describe any changes in students' behaviours, attitudes, attainment and learning that you have observed which you consider to be a result of the changes in your practice.

Part 5: Your professional development history

We would like to understand more about your career-long professional development experience.

25. Please could you describe a significant experience from your professional development history?

We are interested in how informal, incidental or unplanned teacher learning takes place.

26. How important have the following sorts of activities been in your professional development (or teacher learning) history? Tick ✔ one in each row.

	Very important	Important	Not very important	Not important	N/A
Sharing professional experiences at meetings					
Incidental conversations at teacher network meetings					
Joint forward planning					
Web-based network					
Staffroom chat					
Incidental conversations/ observations e.g. in the corridor					
Photocopier conversations					
Other (please specify)					

If you would like, please add an anecdote here as explanation.

27. Are you aware of any research evidence underpinning any CPD which you have been involved in?

Yes ☐ go to question 27a and then to question 28 No ☐ go to question 28

27a. You indicated that you are aware of research underpinning some of the CPD you have undertaken. We are interested in whether this influenced the way you felt about the CPD. Please explain here.

Part 6: Portal

28. This question is about the NCETM portal. We are interested in the extent to which you use it, the ways in which you use it and how it has influenced your professional development generally and in terms of the CPD you are currently involved in.

How much do you use the portal for each of the following? Tick ✔ one in each row.

	A lot	Some	Not much	Not at all
Discussion				
Information				
Co-constructing meaning				
Sharing resources and ideas				
Contributing to the Mathemapedia				
Referring to the Mathemapedia				
Using the self evaluation tools				
Being part of a community/network				
Using your personalised learning space				

Once again we are interested in your use of the NCETM portal. If you use it, please indicate how useful you find each of the following. Tick ✔ one in each row. (If you do not use it, skip this question).

	Very useful	Quite useful	Not very useful	Not at all useful
Discussion				
Information				
Co-constructing meaning				
Sharing resources and ideas				
Contributing to the Mathemapedia				
Referring to the Mathemapedia				
Using the self evaluation tools				
Being part of a community/network				
Using your personalised learning space				

Part 7: General Background Information

30. Gender **Female** ☐ **Male** ☐

31. Age group **20 – 30** ☐ **31 – 40** ☐ **41 – 50** ☐ **51 – 60** ☐ **>60** ☐

32. Position in school: Which of the following best describes your present post? Tick ✔ one of the following.

Classroom teacher		Learning support staff	
Advanced Skills Teacher		Consultant/Advisor	
Head of Mathematics		Other (please specify):	

33. Please choose the TEACHING qualification(s) you have. Tick ✔ all that apply.

PGCE		Master of Education	
First Degree with QTS		City & Guilds 7307 Teaching Certificate	
Teaching qualifications FE		Literacy & Numeracy Qualification (e.g. Adult Learner Support (Literacy / Numeracy) Certificate)	
Teaching qualification HE		IT teaching Qualification (e.g. Certificate in Education Practice: ICT skills)	
NNEB		Basic Skills Qualification	
No qualifications		Ph D related to education	
Access qualifications		Other (please specify)	

34. Please indicate the highest mathematics qualifications you have. Tick ✔ of the following.

No mathematics qualifications		First Degree majoring in mathematics	
GCSE/O level/CSE grade 1		Further degree in mathematics	
A Level, Scottish Higher or equivalent (NVQ/SVQ level 3)		Other (please specify)	

35. Indicate how long you have been teaching. Please tick ✔ one of the following.

36. Indicate how long you have been teaching mathematics. Please tick ✔ one of the following.

0 – 5 years		0 – 5 years	
5 – 10 years		5 – 10 years	
10 – 15 years		10 – 15 years	
15 – 20 years		15 – 20 years	
20 – 25 years		20 – 25 years	
25+ years		25+ years	

37. Please indicate the age groups you are currently teaching:
(please tick ✔ all those that apply)

Early Years (<5 years)		Key stage 3 (11–14 years)	
Key Stage 1 (5 – 7 years)		Key stage 4 (14 – 16 years)	
Key stage 2 (7 – 11 years)		Post 16 (16 – 19 years)	
Middle school (9 – 13 years)		Adult education (post 19)	

Please indicate the age groups you are qualified to teach.
(please tick ✔ all those that apply)

Early Years (<5 years)		Key stage 3 (11–14 years)	
Key Stage 1 (5 – 7 years)		Key stage 4 (14 – 16 years)	
Key stage 2 (7 – 11 years)		Post 16 (16 – 19 years)	
Middle school (9 – 13 years)		Adult education (post 19)	

Part 8: Contact information (optional)

It would be helpful if you could provide contact information. We would like to reassure you, however, that we will treat all data anonymous. Note that if you do not provide contact information, you cannot be entered in the prize draw.

First Name	Last Name

Telephone	Mobile

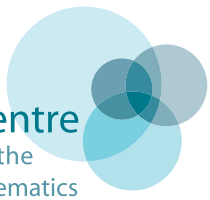
Email address:

Would you be willing to talk to a researcher in more depth about your CPD? Would you be willing to talk to a researcher in more depth about your CPD? (Please note that if the answer is yes, we will need to be able to contact you!) Yes/No

Thank you for completing the questionnaire. The RECME team appreciates the time you have given to do this, and we value your contribution to our project.

Notes

Notes



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Teaching of Mathematics

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A Department for Children, Schools and Families initiative to enhance professional development across mathematics teaching.