PROFESSIONAL DEVELOPMENT FOR TEACHERS OF MATHEMATICS: OPPORTUNITIES AND CHANGE

Marie Joubert[1], Jenni Back[2], Els De Geest[3], Christine Hirst[4] and Rosamund Sutherland[1]

University of Bristol[1], Kings College London[2], Oxford University[3], University of Birmingham [4]

The RECME research was set up to develop understanding of 'effective' Continuing Professional Development (CPD) for teachers of mathematics by looking at a large number of initiatives adopting a variety of models, taking a non-interventionist, non-participatory approach. In addition to building a 'big picture', it also aims to develop an in-depth understanding of the individual initiatives by looking at the structure and organisation and at the responses of individual teachers to their CPD. The paper develops and uses an analytical framework to help us understand one particular initiative and the learning and teacher change of individual teachers participating in this initiative. We conclude with a discussion of the factors contributing to the effectiveness of the CPD.

Keywords: Professional development, mathematics, teachers, CPD

INTRODUCING RECME

In 2006 the National Centre for Excellence in the Teaching of Mathematics (NCETM) was set up in England in order to build a coherent infrastructure to support the continuing professional development (CPD) needs of teachers of mathematics. In 2007 the NCETM funded an eighteen month research project, Researching Effective CPD in Mathematics Education (RECME). The aims of the project include the characterisation of different types of CPD for teachers of mathematics and the investigation of the factors contributing to 'effective' CPD. In order to understand the range and scope of CPD opportunities existing in the UK, the project team researched a sample of thirty initiatives representing different models of CPD in mathematics education, run by a variety of providers, in different locations, and aimed at about 250 teachers of students in pre-primary, primary, secondary, further and adult education settings.

RECME is an ongoing project and has not yet produced comprehensive findings or recommendations. These are due by March 2009. However, most of the data for the project has been collected and this paper introduces a framework for the analysis of the data and uses it to analyse the data from one initiative.

THEORETICAL FRAMING AND METHODOLOGICAL DECISIONS

We adopt a broad sociocultural perspective which suggests that all human activity, including the learning of teachers, is historically, socially, culturally and temporally situated. 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.

Data collected

For each initiative we asked the leader/ coordinator for data concerning the form and structure of the professional development. We also observed at least one professional development meeting and took observation notes. The data we collected included 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 and leaders of the meetings. For some initiatives not all this data was applicable.

With the help of the leaders/co-ordinators, we identified two teachers from each initiative. We visited these teachers in their classrooms and observed them teaching mathematics in order to develop understanding of the context in which they work, and interviewed them after the observed lesson. The interview data included questions about professional background, perceptions of their professional identity, thoughts on the observed lesson, influence of the CPD on the way they teach, motivation to take part and remain involved in the CPD, their CPD histories and how they felt about the CPD.

Analytical framework

An initiative of professional development can be described in terms of the content, context and processes in which participants engage (Harwell, 2003). There is a wide range of different models of CPD (see for example Kennedy, 2005) but most CPD aims to provide opportunities for teachers to become involved in processes of learning and change. We suggest that 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.

The professional development of the individual teachers inevitably relates to the opportunities provided by the CPD initiative (Muijs, 2008), and may lead to learning and changes in attitudes and beliefs (actual PD). Teachers may also change their classroom practice, but it is possible that changes in classroom practice could also be influenced by other formal and informal learning. Changes in practice could lead to changed student behaviours and possibly improved student learning (Guskey, 2002), although once again there are other factors which might influence any changes that do take place. In turn, changes in student behaviour and learning could influence the teacher learning (Cooney, 2001), their perceptions of the opportunities and experiences offered by the CPD, and the opportunities and experiences they decide to take up.

Finally, a sociocultural perspective suggests that we also need to take into account the influences of the school and national context on the design of the CPD initiative (Bishop & Denleg, 2006; Cobb, 2008) and of 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 (Goodall, Day, Lindsay, Muijs, & Harris, 2005)

Figure 1, below, provides a diagrammatic representation of the interrelationships of all these factors.
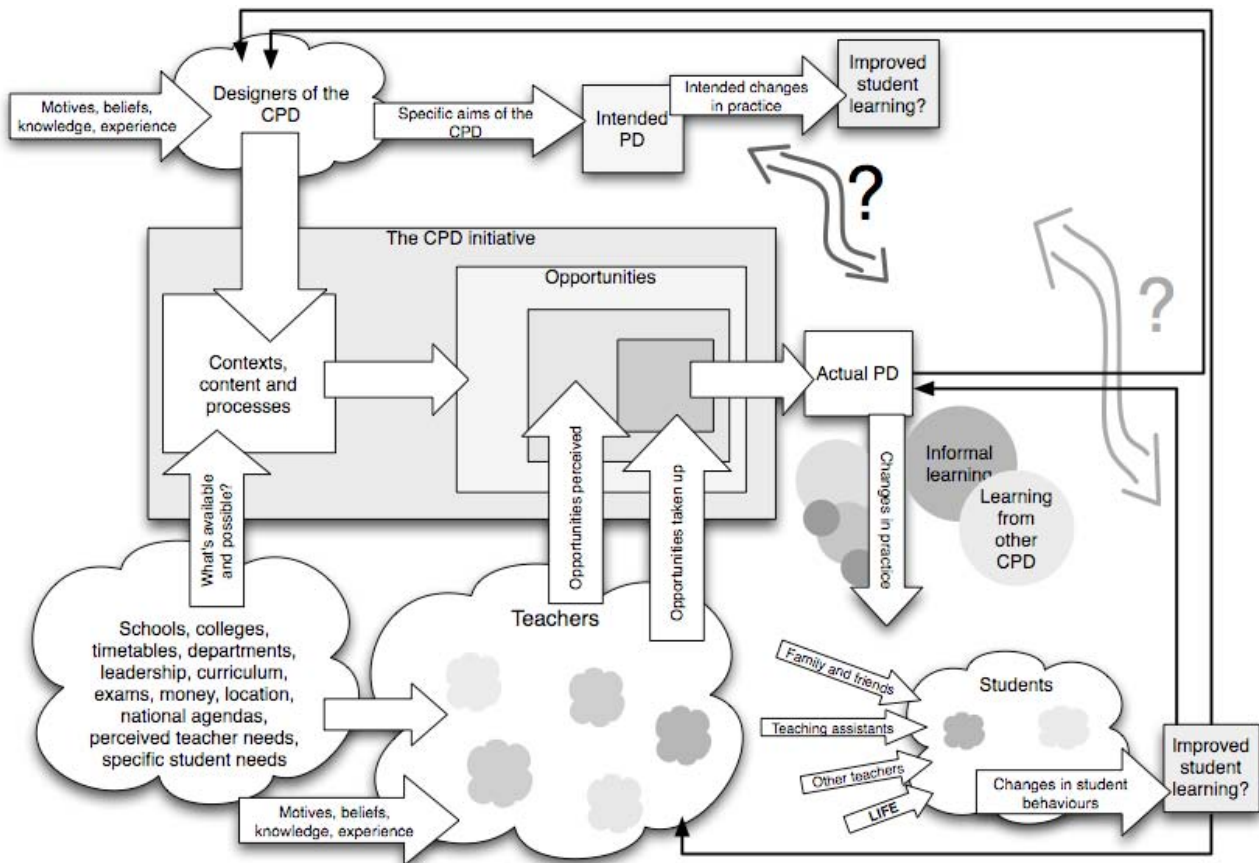

Figure 1: Understanding a CPD initiative

As with many analytical frameworks, this representation could be seen as 'too neat', yet the data is messy and complex. Further, it is a static diagram which cannot represent the ways in which the nature of the CPD may be dynamic and changing in response to feedback from teachers and their changing needs over time. However, we suggest that it provides a useful lens for understanding both the CPD initiative itself and the participation of individual teachers. In addition some of these asrrows could, in many cases, be two ways.

Further it explicitly attends to the teacher professional development intended by the organisers of the CPD and the intended changes in teachers' practice, and to learning and changes that do take place. This is important in our view, because both these can be seen to provide some 'measure' of the effectiveness of the CPD (Garet, Porter,

Desimone, Birman, & Yoon, 2001; Goodall, Day, Lindsay, Muijs, & Harris, 2005; T. R. Guskey, 2000; Thomas R. Guskey, 2003) (although we do recognise that the ultimate aim of the CPD is usually improved student learning).

CASE STUDY: ONE INITIATIVE AND TWO TEACHERS.

Context, content and processes of the CPD initiative

This initiative is 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 are all secondary school mathematics teachers who attend five separate day-long meetings over the course of a year.

During the meetings the course leaders initiate discussion, frequently asking the participants to discuss issues (for example, how they feel about group work in the mathematics classroom) and then to report back to the group. Frequently one of the course leaders notes down the points made on a flip chart and, when each small group has reported back, draws out some of the key points. During the meetings they also introduce new resources to the teachers and discuss how they might be used and hand out research papers and give the teachers time to read them and then lead a discussion about them. Much of the material they hand out focuses on questioning techniques and much of the discussion concerns using open questions and tasks rather than closed questions and tasks.

In addition, they introduce various classroom mathematics activities and ask the teachers to work in small groups to complete them. For example, one of these activities uses small cards with equations, graphs and co-ordinates of points printed on them, although some are left blank. The task is to decide how to group them, but importantly there is no correct or incorrect answer, and consequently can be seen as providing rich learning. Further, when these activities are used in the classroom, they provide opportunities for teachers to assess their students' prior knowledge. The teachers are asked to experiment in their classrooms between the meetings by using either this activity (suitably adapted for their particular circumstances) or some other activity designed by themselves. The activity they choose to use is called a 'gap' activity (because it is to be carried out in the 'gap' between meetings). There is no prescribed type of gap activity; the key point about the gap activity is that it represents something new for the teacher to try out in the classroom. Teachers are asked to bring some of the students' work from these gap activities to the next day meeting to form the basis of discussion.

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

Aims of the CPD

Although the course leaders state 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.nctem.org/recme), they told us that the actual content addressed in each of the days is, 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 do not have any further documented specific aims.

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

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

Intended professional development (teacher learning)

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 and revise it accordingly, 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.

Intended changes in practice

The intention is that teachers will change their practice in the short term by experimenting with the gap tasks. 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.

The teachers: Barbara Bircher and Peter Millward

This section discusses the CPD experiences of Barbara and Peter, the two teachers who were invited to take part in the in-depth part of the research. It reports on what they said when our researcher interviewed them and on the observation of their lessons, and uses the framework developed above to structure the discussion. It begins by describing the backgrounds of the teachers and the contexts in which they work.

Barbara has been teaching mathematics in secondary schools since 1976 and is now subject leader for mathematics in her school. Peter is in his third year of teaching at a large comprehensive 11 – 18 school where he has overall responsibility for the first three year groups in the school (known as Key Stage 3 and culminating in a standardised national test).

Barbara became involved in the current CPD because she had heard a lot about the course, which is now in its third year, and she liked what she heard: the approaches she heard they promote are similar to the ones she believes in. She thought it would be valuable for someone in the department to attend and decided to go herself (rather than sending someone else from the department), because then she could cascade her learning to the rest of the department. She saw this as an opportunity for her to develop herself in order to 'move the department forward'.

Peter said that he decided to take part in the CPD because a member of the senior leadership team asked him if he wanted to go. He said that much of the CPD he had previously experienced had taken place in school and 'seems to be more about technical jargon than new stuff but that he chose to attend this CPD because he was looking for something with more mathematics.

Opportunities

In this section we report on those opportunities provided by the course that Barbara and Peter seemed to value. Both teachers mentioned the resources they had been introduced to, with Barbara saying that she valued having time to investigate them and Peter saying they were useful.

Barbara said that she values the time out of school to reflect and think and discuss, she enjoys having time to read. Peter also said he liked the fact that there was enough time for discussion and he seemed to value the opportunity to meet with other people in order to 'stock up' with ideas to try out in the classroom.

Peter did not mention the value of gap tasks, but he did say that, as a result of the course, he has to 'push' himself to try something out and this is the most useful thing about the course. Barbara told us that she had used most of the gap tasks with her classes and reported back on them. She said that knowing that she 'had to' report back on how she had found teaching these gap tasks meant that she had actually done them, and that otherwise she may not have. She said she enjoyed reporting back to

the group after doing a gap task. She said that the course had given her the opportunity to do what she believes is good maths teaching.

To Peter, the course leaders are very important; 'they prepare the stuff, they help us along'. He says that they provide a link between the theory and practice in both his own classroom and what other schools are doing. The local authority advisor has a good overview of what happens in his local authority, and he says this is useful for the teachers.

Actual professional development

Barbara said that using the gap tasks had challenged her embedded practice of expecting the students to work in a predetermined direction and reawakened her awareness that 'the obvious isn't obvious'. She said that it has kept her interest in mathematics teaching and her desire to be a reflective practitioner continuing to improve. She said that the course had reminded her about what she really liked doing; teaching mathematics, adding that in recent years she has moved gradually away from her passionate interest in teaching, because of the pressures of school and management. Barbara said the course made her very excited and gave her the opportunity to do what she believes is good maths teaching. She finished the course wanting more. More specifically, she reported that she had learnt the value of sharing students' work and of developing a classroom culture in which 'it is ok to be wrong, as long as you are thinking about your learning'.

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

Peter was much less forthcoming about telling us about his learning and changes in beliefs. However, he did report 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'.

Changes in practice

Both teachers reported that they had implemented some new teaching tasks as a result of the CPD. Barbara had tried some of the gap tasks and is now incorporating more open and investigative tasks in her everyday teaching. 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. Over the course of several lessons, the students investigated angles and lengths in the shapes, as well as tessellation properties.

Peter, on the other hand, did not use a gap task but told us that he has tried to integrate some of the ideas from the CPD into his normal practice, rather than relying

on the textbook too much. He has also used ideas for new tasks which came from another teacher in the group. 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 one of his students produced. He said:

> 'I will use this idea again - 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'.

Both teachers reported that they used more open small tasks at the beginning of the lesson (sometimes called starter tasks in the UK). For example, Barbara said she might present a diagram and ask students to write a statement about it; she remarked that previously she would probably have asked a more direct question. She said she allowed them to make any points they wanted before she directed the discussion towards her main teaching points. She chooses some starter tasks in order to promote discussion, such as asking the students to 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?' Peter provided an example, saying he might say 'The answer is a quarter, what is the question?' and he said this provided the students with opportunities for creative thinking.

Barbara told us that in order to share students' work she obtained a visualiser (a device which projects anything put under its lens onto a whiteboard) for her classroom. She now regularly shares student work in lessons. She also told us that because of her participation in the course, she has talked freely with her team about her own learning and she thinks this is 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.

Peter says that since he has been doing this CPD his teaching has changed. He says that he tries hard not to talk to the students from 'high up' and that he likes to get down to them (physically). He has started to move away from writing the lesson objectives on the board, and now has primary and secondary objectives (skills-based and content-based respectively). Sometimes he leaves an objective blank and asks the students at the end of the lesson what it they thought it was. This is an idea that came from someone at the CPD.

THE INTERRELATED FACTORS CONTRIBUTING TO EFFECTIVE CPD

The discussion above provides some evidence that for both teachers some learning and changes in practice took place. In-line with the learning and changes the course

leaders intended (see page 5), both teachers took some risks, using more open and challenging tasks in the classroom, and developing more relaxed interactions with their students. Barbara appears to have developed confidence to allow pupils to follow their own directions more and she had begun to think more critically about her own practice. We argue that this demonstrates that, to some extent at least, the CPD was 'effective'.

This raises the questions of the factors that may have contributed to this effectiveness, and what barriers may have been present to reduce effectiveness. First, both teachers confirmed the importance of experimenting in the classroom as suggested in the literature (see for example, Guskey), and what is perhaps interesting is how the CPD is set up to encourage this experimentation. We suggest that teachers involved in this CPD felt they have to try something new in their classroom, because it is expected and because of the need to report back to the group. There was also some encouragement from the leaders' comment that attending the course gave permission to take risks. It is interesting that Barbara chose to do the gap tasks, whereas Peter decided to try something suggested by one of the other teachers participating in the CPD. This may demonstrate that, although it was expected to do something between meetings, it seems that the way the task was set up allowed a great degree of personal choice in the selection of gap tasks.

The differences between the gap tasks chosen by the two teachers may be explained by the differences in their experience and positions in their respective schools and by the culture of the schools. For Barbara, as an experienced teacher and head of department it may have been much easier to implement the gap task suggested by the leaders of the CPD, but as Peter told us, he was not able to experiment and try out new things in the classroom as much as he wanted (this was partly because of an intervention programme that has been put in place in his school to address the whole school emphasis on raising attainment).

Second, being part of the CPD group was important to both teachers. This does not surprise us, as again the literature suggests that working collaboratively may contribute to effective CPD. However, we are interested in what it was for the two teachers that they valued. What seemed to be important for Peter was having access to new ideas, whereas Barbara's emphasis was on the sharing of what she had done and the out-loud reflecting on it.

Thirdly, and again unsurprisingly (Borasi, Fonzi, Smith, & Rose, 1999; Day, 1999; Olson & Barrett, 2004), it seems that having time away from school to think and discuss was important to the teachers, although we cannot tell what contribution this discussion made to the professional development of the teachers. However, our suggestion is that they found it stimulating and enjoyable, and that this sort of discussion has an important role in retaining the interest and motivation of teachers.

As a final point, our observation of two of the meetings suggests that the participants enjoyed 'doing' the mathematics and our suggestion is that this is an important factor

contributing to 'effective' CPD. However, interestingly, neither teacher commented on the enjoyment they experienced when they were given the mathematical gap tasks to work on in the meetings.

REFERENCES

Bishop, K., & Denleg, P. (2006). Science learning centres and governmental policy for continuing professional development (CPD) in England. *Journal of In-Service Education, 32*, 85-102.

Borasi, R., Fonzi, J., Smith, C. F., & Rose, B. J. (1999). Beginning the Process of Rethinking Mathematics Instruction: A Professional Development Program. *Journal of Mathematics Teacher Education, 2*(1), 49-78.

Cobb, P. (2008). District Development as a Means of Improving Mathematics teaching and Learning at Scale. In K. Krainer, & Wood, T. (Ed.), *International handbook of mathematics teacher education: Vol. 3. Participants in mathematics teacher education: Individuals, teams, communities and networks.* (Vol. 3). Rotterdam: Sense Publishers.

Cooney, T. J. (2001). Considering the paradoxes, perils, and purposes of conceptualizing teacher development. In F. L. Lin & T. J. Cooney (Eds.), *Making sense of mathematics teacher education* (pp. 9-31): Springer

Day, C. (1999). Professional development and reflective practice: purposes, processes and partnerships. *Pedagogy, Culture and Society, 7*(2), 221-233.

Goodall, J., Day, C., Lindsay, G., Muijs, D., & Harris, A. (2005). *Evaluating the impact of continuing professional development*. London: DfES.

Guskey, T. R. (2002). Professional Development and Teacher Change. *Teachers and Teaching: Theory and Practice, 8*(3), 381-391.

Harwell, S. H. (2003). Teacher professional development: It's not an event, it's a process. *Waco, TX: CORD. Retrieved January, 21*, 2004.

Kennedy, A. (2005). Models of Continuing Professional Development: a framework for analysis. *Journal of In-Service Education, 31*(2), 235-250.

Muijs, D. (2008). Where are we at? An empirical study of levels and methods of evaluating continuing professional development. *British Educational Research Journal, 99999*(1), 1-17.

Olson, J., & Barrett, J. (2004). Coaching teachers to implement mathematics reform recommendations. *Mathematics Teacher Education and Development, 6*, 73-91.

Rogers, M., Abell, S., Lannin, J., Wang, C.-Y., Musikul, K., Barker, D., et al. (2007). Effective Professional Development in Science and Mathematics Education: Teachers' and Facilitators' Views. *International Journal of Science and Mathematics Education, 5*(3), 507-532.