**Using e-learning to support primary trainee teachers'
development of mathematics subject knowledge: an analysis of
learning and the impact on confidence**

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Abstract

In this article we explore the effectiveness of a mathematics subject knowledge development model that integrates conventional distance learning with an e-learning coaching and peer group conferencing environment. The effectiveness of the model in supporting 194 primary (pupils aged 5-11 years) trainee teachers' achievement of the subject knowledge standards (DfEE 1998a) required for qualified teacher status is evaluated and the impact of the model on trainee confidence is explored. Features of the model that trainees, tutors and post-qualifying teachers identify as critical factors for success are outlined and the relevance of the model for teacher professional development is discussed.

1.0 Context

In the USA, Australia and the UK there is political concern about the teaching of mathematics (Third International Mathematics and Science Study [TIMSS] 1996). This issue underpins international activity focusing on the improvement of mathematics subject knowledge among trainee teachers and practising teachers.

Research in the USA has identified the importance of what prospective primary (elementary) teachers bring to training courses. Ball (1988) has argued that a lack of attention to what teachers bring with them to learning to teach may account for the reason why teachers tend to teach mathematics as they were taught themselves. In Australia, Hill (2000) has explored why mathematics education programmes appear to have only a limited effect on trainee teachers' capacity and willingness to learn and teach mathematics for relational understanding (knowing both what to do and why). She argues that even though trainees are trained to teach for relational understanding they often revert to the instrumental methods they learnt in school.

In the UK, the period 1998-2002 saw an unprecedented rise in national regulations (DfEE 1998a) governing initial teacher training (ITT) programmes, including an extensive prescribed subject knowledge curriculum that each trainee was to be taught and assessed against. This was a response to the perceived decline in mathematical performance by English school pupils when viewed in a comparative international context (Second International Mathematics Study [SIMS], 1993; Third International Mathematics and Science Study [TIMSS], 1996).

For practising teachers, this was paralleled by the introduction of national strategies¹ to promote pupil achievement in literacy and numeracy in England (DfEE 1998b; DfEE 1999). This has involved all primary schools in training and professional development activities to improve the teaching skills and subject knowledge of teachers. Evaluation reports on the introduction of these national strategies (OISE/UT 2003) suggest there have been improvements in the teaching of literacy and mathematics. However, there is still much variation across teachers and schools in terms of expertise, and the task of sustaining improvements in subject knowledge and teaching skills will require continued professional development input over many years. Research by Basit (2003) suggests that the issue of developing and improving subject knowledge is a particular issue for newly qualified teachers entering the profession which has not been resolved by the introduction of the National Numeracy Strategy (NNS). Proposals for accredited postgraduate professional development and reform of mathematics teaching (TTA 2004, DfES 2004) confirm that teacher development emphasising subject expertise remains a key government priority for England.

The Open University's Postgraduate Certificate in Education (OU PGCE) subject development model was developed in response to this context, in order to support primary trainee teachers in achieving the mathematical subject knowledge standards required for qualified teacher status. Two major characteristics of the OU PGCE cohort shaped the development of the subject knowledge development model. First, the

¹ Put in footnote about NLS and NNS

programme operated nationally across England, Wales and N. Ireland and trainee teachers were widely geographically dispersed. The logistical demands of providing individualised training, support, assessment and monitoring for a high volume, geographically dispersed trainee teacher population are challenging (Banks and Shelton Mayes, 1998). In this context, distance-learning with programme specific text materials and e-conferencing is the most appropriate mode of delivery to allow trainees access to the curriculum and support from tutors and other trainee teachers. Second, the cohort's entry qualifications, in terms of mathematical subject knowledge, were highly variable. This meant that the approach to developing subject knowledge needed to be highly differentiated, allowing individual trainees to focus on and develop in specific identified mathematical areas in relation to personal need.

These issues of variable access to professional development linked to geographical dispersal and diversity of professional development needs are shared by practising teachers. The model may have relevance, therefore, to those planning professional development opportunities for teachers in the context of the continued national focus on improving mathematics teaching.

2.0 Research Study

The research presented in this article relates to a cohort of 194 primary ITT trainees on the OU PGCE² (1998-2001) who were the first, in the UK, to undertake the formal process of subject knowledge development in mathematics and English for qualified teacher status, through integrating e-learning with conventional distance learning materials. The OU PGCE programme pioneered the use of an e-environment in ITT for trainee communication and support purposes. The e-environment annually received the highest trainee course approval ratings (OU PGCE 1996-2001). The mathematics subject

² Open University Postgraduate Certificate in Education is an accredited initial teacher training programme leading to qualified teacher status.

knowledge model reported in this study, evolved from the continual refinement of this e-environment.

The study considered these questions:

Was this subject knowledge development model effective in supporting trainees in achieving the mathematical standards for qualified teacher status?

What features of the model contributed to successful trainee development?

What relevance does the model have for teacher professional development?

The research evidence is drawn in part from a larger study (Burgess & Shelton Mayes, 2001) undertaken to analyse the developing subject knowledge of primary trainee teachers on this programme. Data are also drawn from a follow up questionnaire sent to this cohort of qualified teachers in their third year of teaching as part of an ongoing longitudinal study. This was critical in determining whether successful features of the model identified by trainees and tutors were confirmed from the perspective of qualified teachers. The following sources of data were used to assess the effectiveness of the subject knowledge development model in terms of trainee achievement of national standards.

- 194 primary trainees were involved in e-conferencing producing data consisting of 1403 messages relating to mathematics subject knowledge (Burgess and Shelton Mayes 2003)
- entry and exit mathematical subject knowledge trainee outcomes were compared as the basis for judging the effectiveness of the subject knowledge development model. The exit outcomes were independently confirmed by the national inspection agency (Office for Standards in Education (OfSTED) 2001)
- interviews with the mathematics subject knowledge tutors
- programme questionnaires
- a follow-up questionnaire to the 194 graduates in 2003 (Respondents N=63) (See Table 1)

In addition to the specific data sources identified above, the ITT programme was set up to generate ongoing data for evaluative and improvement purposes (Banks and Shelton Mayes 1998). Programme specific quality assurance procedures provided sources of evidence, including trainee monitoring and observation records, and reports from tutors and school-based mentors. Information from course questionnaires completed by trainees were also included. Benigno and Trentin (2000) identify questionnaires for on-line course evaluations as a valuable source of research data. In addition, the requirement by national external inspection agencies (e.g. OfSTED) to provide information on trainee progress led to the development of detailed trainee case studies and quantitative data on trainee outcomes. Research evidence, therefore, is taken from a variety of sources providing both quantitative and qualitative data. The use of different research methods and detailed analysis of evidence allows for triangulation of data and provides research outcomes that are both verifiable and trustworthy (Wilcox 1993, Burgess and Shelton Mayes 2003).

3.0 The Subject Knowledge Development Model

The mathematics subject knowledge development model was conceptualised as a three stage process of identification, personal development and directed support. (See Figure 1) Alongside a conventional distance-learning self-study text (Centre for Mathematics, 1998, *Passport to Mathematics*) and face-to-face workshops, the e-environment was organised as a hierarchy of conferences for specific teaching and learning purposes, such as mentoring, peer support and coaching, to reflect a mathematics subject culture. E-conferencing provided the integrative dimension in this model, functioning throughout the course as the primary mode of communication and support as well as, at different points, a direct teaching medium and a monitoring tool for quality assurance purposes.

INSERT Figure 1

(Burgess and Shelton Mayes 2003.)

The e-community was organised around e-conferences reflecting the mathematics subject culture. . In stage 1 of the programme, the trainees shared ideas relating to their pedagogic subject knowledge and supported each other in preparation for teaching experience. In stage 2, a mathematics subject knowledge e-conference was set up. Trainees developed the subject knowledge required by the national standards, through responding to directed tasks set by tutors. In this e-learning environment both peer group and tutor support were strongly in evidence, facilitating discussion and mathematical problem solving. In stage 3, the mathematics subject knowledge conference was extended to form a series of six specialist sub- conferences focusing on discrete mathematical areas to support direct trainee-tutor coaching. Trainees also had access to their own personal mailbox for more private communication, for example, communicating assessment outcomes and setting targets. This e-environment is broadly supporting two different modes of working - a community of practice involving collaborative working with peers, facilitated by tutors and individual direct teaching and assessment (Burgess and Shelton Mayes, 2003).

Using an e- environment made it possible to design an open-ended model where teaching and learning were not tied to a series of fixed sessions in a classroom or allocated to a space on a timetable. Instead, the model was premised on multiple opportunities for trainees to re-visit and re-test subject knowledge with support and without penalty until the standards required were successfully achieved. Research by Burgess and Shelton Mayes (2003) has indicated that subject knowledge development in mathematics requires an environment of support for trainee teachers and the opportunity to return to concepts again and again, without the threat of failure. A learning environment that encourages

increased confidence in subject knowledge will also encourage trainee teachers to be more confident in their teaching

The philosophy underpinning the model was premised on minimizing negative emotional responses to mathematics as a subject; promoting connections between subject content knowledge and school pedagogical knowledge; and providing opportunities for collaborative working, peer and tutor support and direct coaching.

There was an emphasis on developing the trainee mathematics teacher as a thinking professional who knows and understands the subject matter and pedagogy of mathematics. As Edwards and Collinson (1996) have argued:

Training to be a thinking professional demands more than reflection on practice. It needs opportunities for the consideration of wider professional issues and the creation of a cast of mind which regards initial training as the start of a long process of professional development. (Edwards & Collinson, 1996, p.158).

The role of emotion in the dynamic of learning and teaching is widely acknowledged and yet it was not until 1980 that researchers began to use theoretical frameworks and methods to evaluate emotion in the classroom (Boekaerts, 1996). Research by Elbaz (1983) has suggested that the images that teachers have of themselves, their role in the school and their academic and personal criteria, all have considerable influence on how they use and present knowledge to their pupils. Images of the self and professional self are inextricably bound together (Nias, 1989) and therefore, how trainee teachers construe their developing understanding of mathematics teaching and learning needs to be understood in the context of personal belief about mathematics teaching and emotional response to the subject. Schuck (1998) argues that one of the reasons for lack of success in challenging trainee teachers' views of mathematics and mathematics teaching is that the engagement between trainee and teacher educator is an engagement with an inappropriate 'self' of the trainee. She proposes that trainees engage in different ways with their mathematics education courses through the perspective of three 'selves': 'student-learning-to-teach'; 'primary-school-student'; and 'teacher'. Brown et al (1999)

argue that for primary teachers, the initial transition from school learner of mathematics to the trainee teacher of mathematics is an important part of the complex process of learning to teach. If the transition is to be successful, it involves for many 'a considerable degree of 'unlearning' and discarding of mathematical baggage, both in terms of subject misconceptions and attitude problems' (Brown et al, 1999, p.301). This is also evident in Meredith's work (1993), whose research suggests that there is a need to clarify the relationship between prior learning and attitudes towards pedagogical content knowledge. Other research on affective issues in mathematics education has focused on high levels of anxiety (Newstead, 1998) and protection of self-worth (Thompson, 1993). Such emotional responses to knowing and doing mathematics has also been recognised by Bibby (2002), who argues that shame is a reaction to other people's criticisms. The model of interaction between tutors and trainees within this e-environment draws on the issues that emerge from the research outlined above.

We considered it essential that this subject knowledge development model should not increase negative responses to mathematics as a subject. Trainee teachers' comments drawn from the e-conferencing environment are very revealing in terms of the feelings and emotional responses to beginning teaching.

I was dreading the mental maths session as I had been told to keep it brisk. My first couple of lessons I warmed up my brain by giving myself questions and checking them using different methods. I made sure I really challenged the top attainers in Y6 by asking two or three part questions. For lower attainers I still asked two/three part questions but made the steps slightly easier. This also gave children the opportunity to work together on parts or help others out. Different children could answer different parts. I have come away from three weeks of fast mental maths with new strategies and an ease with numbers that I do not think I have ever had before. Just shows that more work with mental maths makes one much more proficient – give me 17X table any day.

Successes were shared alongside problems as trainees identified with the ‘dread’ of the unknown and elation at success.

Ditto! I’m on SE3 at the moment in Y5/6 and every Friday they have an hour (!) of mental maths!! Today’s lesson was great. They love it, my strategies are improving too.

Developing subject knowledge and practical teaching skills and ideas for lessons were shared with vivid descriptions of experiences in numeracy lessons.

My own mental maths improved so much over (second placement) – I saw patterns I did not know exist before – talk about learning with the children! (I used to be the sort of person that could work things out as long as I had a piece of paper and pen). They particularly liked “darts score” – doubles and triples – I was particularly pleased when most hands went up – it was a job to stop them calling out and making those grunting noises when they know the answer and want to be chosen. Even the children who did not put their hands up worked the answers out when I picked them. I found myself really looking forward to the sessions.

The e-environment encouraged the trainees to be specific about activities in teaching numeracy and some shared sharply observed experiences. A lesson that was planned at an appropriate level meant all the children in the class could respond to the activities and resulted in the mutual pleasure of teacher and pupils. As well as individual comments about experiences and sharing ideas, whole strands of applying subject knowledge to practical classroom situations were developed as the trainees supported each other in their developing professional practice. Often, the conversational strands were initiated by tutors who would encourage the trainees to focus on a particular aspect of numeracy. In the example below, a tutor has set up the strand by providing trainees with a list of mental strategies, taken from the NNS, to be introduced year by year. The trainees were asked to draw on their third school experience to focus on methods of developing mental strategies with their pupils, and to identify their problems as well as their successes.

Trainee 1.

.....after one or two days practice at using the cards, we could maintain a fast pace during these sessions, due to the enthusiasm of the class and a clear introduction to the sessions, so that all knew what they were to do. I have since had some positive feedback from the Head (my mentor) who felt that these mental maths sessions appeared to be both very beneficial as well as being fun. This has spurred me on no end, particularly as I have never considered maths to be one of my stronger subjects!!

Trainee 2.

I was interested to read your comments on using cards with Y1 classes. I tried with my Y2 class and found it very difficult. The children were not used to using this type of resource and it took some of them a long while to find the correct cards - then they often reversed the numbers when they held them up. While waiting for all the class to find the correct cards other became restless and started chatting, however if I moved on too quickly then the lower attainers became bored as they couldn't keep up. I thought a solution to this may be to differentiate questions between tables, but this too became confusing, as they were then unsure of which questions to answer. Can anyone suggest how this system worked for them?

Trainee 3.

I have used Number Cards in the past and found that the first thing I had to do was take away the elastic bands! After this I had the same problem but I got the children who had the answer to put one hand on their head so I knew they had the answer and with the other hand use their pencil and write down the answer to doubling it tripling it etc. Perhaps you could just ask your Y2 to add or subtract?

This short strand identifies how important it is for trainees to have feedback from experienced teachers as in the case of Trainee 1 who was greatly encouraged by the

positive response from the headteacher. The trainee identified mathematics as one of her weaker subjects and yet was ‘spurred on’ to develop and extend her knowledge and teaching skills. Trainee 2 had attempted a similar activity with her Year 2 class and found her numeracy lesson to be far more problematic. She had issues linked to management of the activity yet to resolve successfully and maintaining the interest and enthusiasm of the children was also problematic. Unable to solve the problems herself the student sought help from her peers and tutors in the electronic environment. The response came from one of her peers, Trainee 3, who had noted the despair in the message and began by trying to lift her spirits by making a joke about elastic bands. The advice that followed was both practical in terms of managing the pupils while at the same time gently suggesting that her peer simplify the activity.

Tutors intervened or commented in a variety of supportive, practical and encouraging ways on the subject knowledge strands. On some occasions the tutor simply reinforced the positive feelings of the trainees and made a link back to subject knowledge to reinforce what the trainee was learning.

You feel good – and I expect the children do too. Great. And perhaps you understand something about fluency that might help with subject knowledge!

On other occasions more practical advice was offered. A discussion of children’s misconceptions linked to 3D shapes led to the following advice from a tutor:

It’s a good idea to build up your own collection of 3D shapes. (You need a good box to keep them in). Get the children to look out for good ones – reward donations with smiley faces etc and your collection will soon expand. A good home-school activity.

The electronic environment enabled trainees to extend their knowledge in a supportive environment through allowing them to comment on their feelings and experiences of their teaching placements. Emotional responses to teaching were accepted as valid comments alongside more practical and mathematical issues. The recognition of trainees as

individuals who need emotional support and understanding, as well as practical knowledge and intellectual inspiration, helped to engage the trainees as active participants in their own developing professional practice in mathematics teaching. The comments from trainees demonstrate the emotional benefit gained from their peers and their tutors in the electronic environment. In addition, there is strong evidence that the model was very effective in terms of developing mathematics subject knowledge.

4.0 Successful features of the model

The following evidence points to the effectiveness of the OU subject knowledge development model in supporting primary trainees in achieving the prescribed national standards in mathematics subject knowledge.

The OU PGCE primary cohort of 194 trainee teachers were all postgraduates with a diverse range of first degree subject specialisms. Ninety trainee teachers had a degree specialism in a mathematics/science/design & technology area however more than 50% had only the minimum entry level of mathematics (GCSE C grade or an access equivalent³). The challenge for the majority of trainees, who had an average age of 35 and had achieved the basic entry mathematical qualification at age 16, was significant. Nevertheless, by the end of the programme, 99% of all trainees had achieved the required standard for mathematical subject knowledge with 76% judged ‘good’. This successful outcome was confirmed through an external independent OfSTED inspection (OfSTED 2001) by the award of a Grade 2 (good) on a four-point scale for trainee mathematical subject knowledge. The OfSTED criteria for this grade states that all trainees, who pass the course, must achieve the standards for mathematical subject knowledge and that more than 70% of the cohort must achieve a ‘good’ subject knowledge outcome (OfSTED/TTA 1998). This independent inspection confirms that the subject knowledge development model was highly effective, particularly given the broad base of trainees’

³ GCSE is the national examination for 16+ years and graded A*-E

entry level knowledge. Indeed, an analysis of the final subject knowledge grades showed that 57.6% of those trainees identified as requiring the highest level support (i.e. lowest diagnostic assessment scores – 29.6% of the cohort) had achieved a ‘good’ subject knowledge outcome. This suggests that the programme was able to provide a ‘value-added’ dimension where trainees perform better than might be expected based on their entry level of subject knowledge.

The views of practicing teachers who had trained using this model were sought during their third year of teaching. 77.8% of respondents rated the OU subject knowledge development model as useful or better in developing their personal subject knowledge, with 14.3% rating it at the highest level. However, when asked to rate the model’s impact on their self-confidence to teach mathematics in their first teaching post, the responses were markedly more positive with 85.8% rating the model as helpful, with 19.2% rating it at the highest level. Those who rated it less useful were those who identified a personal high level of mathematics subject knowledge on entry, for example a prior degree with a mathematics or science specialism.

The interviews with tutors revealed that lack of confidence was a major issue for many trainees, confirming research undertaken by Bibby (2002) and Thompson (1993). MacNab & Payne (2003) have researched the beliefs and practices of Scottish primary school mathematics teachers and found that their trainees felt more confident teaching the more structured aspects of mathematics and that they were least confident using problem solving strategies and mathematical procedures. It has also been argued by Stipek et al (2001) that those who have greater self-confidence in their mathematics ability are more likely to use inquiry oriented methods in their teaching of mathematics. Their research supported our research findings by demonstrating that teachers’ self-confidence as mathematics teachers was significantly correlated with trainees’ perceptions of their own competence as mathematics learners. The primary teachers, who had been OU trainees, commented that the methods used to support their subject knowledge development in mathematics helped with solving problems, maintained their motivation and enabled a

transition to using new methods to understand and teach mathematics that they had not previously used.

All the above [electronic conferences, text materials, tutor & peer support and face-to-face] linked in with each other very well: e.g. problems were resolved by any of the above being referred to – the face-to-face days being the reliable ‘last resort’.

I felt that I was very much responsible for my own learning and was very self-motivated.

It provided an excellent transition between the ‘old’ maths I learnt at school and the ‘new’ maths taught now ’

This link between self-confidence and perception of competence is corroborated by the responses of the OU cohort, indeed the majority of comments related specifically to the issue of confidence. Their responses resonate with the work of Stipek et al who suggest that greater confidence as a learner of mathematics leads to teachers who are more likely to be confident of their teaching ability in the classroom. The positive approach by tutors and peers as trainees developed their mathematics subject knowledge helped most OU trainees to avoid adverse responses to teaching the subject, as suggested by Bibby (2002) in research that explored the impact of negative criticism on the emotional responses of mathematics learners to the subject.

I felt most confident when working through subject knowledge with my peers/fellow students and when supported face-to-face – I need interactive learning

Developing confidence in my own ability, my growing enjoyment of the subject and seeing children's knowledge grow and 'fear' of maths disappear.

I was confident that there would be nothing in the primary maths curriculum that I would be unable to teach in a variety of ways.

' Having completed the maths 'on-line tests and worked through all the maths module activities as well as having read the suggested references (...)I was confident from day one'

'it gave me the confidence to develop plans (for my class) that moved in very small steps so that I was able to bring a huge range of entry to school into a much closer knit cohort at the end of the year'

'as a mature PGCE student I had learnt maths the 'old way' I could do it but not understand (and therefore explain) it.'

'I battled with self-doubt because I had such poor maths tuition as a schoolchild myself'. (...) Studying maths was an eye-opener for me (...) I had only ever 'done' maths in one certain way – it was almost scary to suddenly de-construct numbers and mix up strategies –it helped take away that debilitating fear of 'getting it wrong' and maths became enjoyable at last.

Some commented that they believed that their self-confidence was linked to the practical application or delivery of the subject rather than the development of personal subject knowledge. They were critical of a national policy that had forced a separation of subject knowledge and pedagogy through the assessment of personal subject knowledge requirements of trainees (DfEE 1998a). Despite the unanimous acknowledgement (100%) that good personal subject knowledge is important to the effective teaching of primary mathematics, there were a number of negative comments on the OU subject

knowledge development process. These reveal the frustration of a cohort subjected to external government subject knowledge standards, which they believed required greater levels of personal mathematics subject knowledge than was necessary for the demands of teaching in primary schools. Comments included:

'KS1 (teaching) does not lend itself to improving subject knowledge –only methodology'

'what I was taught would benefit those teachers working with older pupils'...

'Some aspects were above the level which is appropriate'

This is further illustrated by the significant difference between Key Stage 1 (KS1) and Key Stage 2 (KS2) teachers' responses. 70% (N=30) KS1 teachers reported that the OU subject development model was useful or better in developing their personal subject knowledge for teaching rising to 84.8% (N=33) for teachers working in KS2. Similarly 80% KS1 teachers reported that the model was helpful or better in developing their confidence for teaching rising to 90% for KS2 teachers. This suggests that neither the government standards, nor indeed the OU PGCE programme team, had been successful in persuading trainees and teachers of the importance of developing personal subject knowledge that extends beyond that directly required to teach a specific age-group. The separation of pedagogy and subject knowledge in the national subject knowledge standards exacerbated this perception. It is interesting to note that the revised national standards (DfES 2002) removed the prescriptive atomised subject knowledge curriculum and replaced it with a standard that requires only that qualified teacher have appropriate subject knowledge to teach specific age-groups.

Alongside confidence-building, other features appear to be successful in supporting trainees learning. First, the staging process of self-auditing and diagnostic auditing, inherent in the model, allowed tutors to focus on specific trainees and target their coaching to individual need. This is likely to be a critical factor in the support of those trainees who entered the programme with low levels of subject knowledge. Specific case

studies on the progress of some trainees in this category support the success of this strategy.

Second, the high levels of support that were provided because trainees were geographically isolated and because the model was based within an e-environment were undoubtedly a factor that helped to make it effective. The cohort rated levels of peer support (68.3%) as highly as the tutor support in e-conferences (71.4%). Direct coaching was one of the supportive strategies used by tutors. In this strategy the trainee works directly one-to-one with a tutor. It is both intensive and supportive. Research by Oldroyd and Hall (1991), has demonstrated that coaching is likely to have a greater impact on practice than simply a presentation of the theory. The key word is doing, being engaged in the activity of working a problem through. In many respects this is similar to mentoring and shares some of the positive and negative features of this activity. One of the essential differences is that a mentor will counsel and listen but not necessarily tell a trainee what to do while in direct coaching the tutor is directing the trainee, through their interventions, towards a particular outcome. Direct coaching was a common strategy in the specialist sub-conferences where trainees were required to prepare answers to questions set by tutors in specific mathematics areas linked to the outcomes of the diagnostic assessment and directed towards a deeper understanding through detailed feedback provided by the tutor (see Burgess and Shelton Mayes, 2003, for an appraisal of tutor support strategies).

Third, in using and developing strategies of peer support and collaborative working the trainees were committed to helping each other achieve success in their mathematics subject knowledge and assignments. They shared the common goal of improving their mathematics knowledge in order to improve the quality of their teaching. Swafford (1998) has argued that peer coaching is non-evaluative and non-judgmental encouraging a community of learning where teachers can investigate and explore alternatives, implement new strategies and explore again. We would argue on the basis of evidence from our research, that such strategies build confidence in trainee teachers and therefore can have a positive impact on the outcome of mathematics subject knowledge

development. It is interesting to note that 60.3% of OU PGCE graduates were still in contact with alumni from their cohort three years into their teaching career. This suggests that even though the trainees were on a distance learning course and rarely met, the electronic environment as a community of learning was a very powerful medium with enduring consequences.

Fourth, all the modes of learning and support operated within a common mathematics framework. Six mathematical areas provided the common structure for the subject knowledge learning and support model through the self-study text, the e-conference environment and face-to-face teaching sessions. An individualised subject knowledge development plan was created from a diagnostic profile. Trainees were able to move easily between different modes of learning and support and make connections. Of the various components of the OU subject knowledge development model, the cohort rated the *Passport to Mathematics* as most useful (87.1%) followed by face-to face support (79.4%), which was offered primarily to those trainees who required additional support. All other forms of support received an overall positive response with mentor support gaining the lowest positive response (61.9%). This supports Ofsted inspection reports (Ofsted,1999) which suggests that school-based mentors do not play a significant role in subject knowledge training in ITT.

Fifth, high levels of tracking and quality assurance were built into the model with the progress of all trainees monitored in the e-environment. Additional face-to-face support was provided for trainees who did not appear to be making sufficient progress in the development of their subject knowledge. The cohort rated this strategy very highly (79.4%) in terms of positive support for their subject knowledge development. It was evident in the questionnaire responses that maintaining good mathematics subject knowledge continued to be important to these trainees in the early years of their teaching careers.

6.0 Teacher professional development in early career

Overall this research suggests that perceptions of mathematics and trainees emotional responses to the subject and to the e-environment in which they learned and extended their subject knowledge all appear to play a part in a successful outcome. The challenge beyond qualifying is for teachers to maintain their confidence in their mathematics subject knowledge, extend that knowledge and continue to enhance their teaching skills and professional practise.

The responses of the OU cohort in the third year of their teaching career raises some interesting points for planning teacher professional development. 87.4 % of the cohort report improvements in their subject knowledge during the first years of teaching and identify a range of strategies undertaken to improve their understanding, illustrating a commitment to ongoing professional development.

Conventional modes of teacher professional development, such as school-based and external in-service training and published materials remain the most commonly accessed strategies (93.7%, 87.3% and 85.6% respectively) and received the highest ratings in terms of usefulness. Given this cohort's experience in using e-learning as trainees, there was little indication that this was a preferred strategy with only 57.1% reporting using teacher specific e-environments as a medium for learning. This may be a reflection of the current paucity of e-environments for teacher professional development or given the features that the cohort rated most strongly in terms of the OU model, including peer and tutor support and structured support for individualised progress, this may reflect the design of e-conferences for teacher education. Surprisingly too, 60.3% of the cohort continue to use OU PGCE training materials to support their professional development.

Maintaining and developing subject knowledge as a practising teacher was not universally recognised by the teachers, who followed the OU programme, as their teaching roles were not demanding in this respect. Here there was a strong difference between Key Stage 1 (5-7 age range) and Key Stage 2 (8-11 age range) teachers. The latter less inclined to value a breadth of personal subject knowledge extending beyond that directly relevant to teach their specific 5-7 age range. However, it was revealing to note that 96.8% of teachers, who had qualified with the OU, felt confident to informally support other teachers in teaching mathematics and 80.6% felt confident to undertake more formal support, for example through leading school-based training. This has important implications for the future of school-based initial teacher training where these teachers would be able to play a stronger role than is currently expected of mentors in subject knowledge training. It also suggests there is a developing reservoir of teachers who feel confident to engage in supporting colleagues. This would accord with the Teacher Training Agency proposals (TTA 2004) to prioritise the collaborative nature of teacher professional development.

6.0 Conclusion

This study makes a significant contribution to the debate on teacher education pedagogy (Edwards & Ogden 1998). In the context of international focus on the importance of personal subject knowledge in the area of mathematics for primary teachers, this study offers a model that has successfully supported UK trainees with low levels of personal subject knowledge on entry to a teacher training programme. The follow-up study seeking the views of practising teachers, who qualified on this programme, helps to establish why it has potential as an effective model for practising teachers. The teachers rated the mathematics subject knowledge development model, an integrated conventional distance learning with an e-learning coaching and peer group conferencing environment, very highly. In addition, a surprising number of teachers were still using the training materials in their scheme and lesson planning for teaching mathematics.

It offers a distance learning and e-learning approach to subject knowledge development which may provide greater access for potential teachers to enter the profession through undertaking part of their professional studies part-time and at a distance. There was evidence that trainees who had used this approach to their subject knowledge development were committed to further professional development in subject knowledge training. The research also indicated that the teachers wanted to see much more integration of subject knowledge training with classroom pedagogy and this was particularly evident in the responses from the KS1 teachers. The practitioners considered that some of the subject knowledge they had been required to learn was not relevant to their teaching of very young children, and they would have appreciated greater concentration on links to practical application in early years settings.

An analysis of the subject knowledge development model in the context of other research suggests significant features that can support trainee learning, particularly through enhancing self-confidence in mathematics. Our research emphasises the importance that peers have in the learning process. A key feature in the learning processes in the electronic environment was the support, advice and knowledge gained and shared between trainees. A number of trainees continued to use the OU's e-learning conferences after they had completed the programme and remained in contact with each other. Peer support, tutor mentoring and coaching can be successfully embedded in e-learning environments and as part of the TTA strategy for teacher professional development could significantly enhance continuous learning for practising teachers. The teachers in our study demonstrate the self-confidence to take on a development role in schools. However, the analysis showed that few teachers had been able to continue their professional development through e-learning and there appear to be limited opportunities for teachers to continue their development through this medium.

Finally, it should be noted that UK (England) government agencies, such as the TTA, have stipulated high level entry qualifications as an indicator of quality on initial teacher training programmes and all initial teacher training providers are required to provide annual data for publication (TTA, 2000). However, this study has shown that trainees

with a broad range of entry qualifications can achieve equally good subject knowledge outcomes. The evidence from the qualified teachers in this study indicates that such trainees do maintain high levels of confidence in their subject teaching in the early years of their teaching careers. This has implications for government policies on setting entry requirements to teacher training programmes and future professional development programmes for practising teachers.

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Table 1 Questionnaire to post qualifying OU PGCE graduates (Respondents N=63)

- Percentage respondents rating usefulness of the OU PGCE mathematics SK training in developing the mathematical SK required for teaching mathematics in first teaching post.

Not very useful 1	2	Useful 3	4	Very useful 5
9.5%	12.7%	28.6%	34.9%	14.3%

- Percentage respondents rating usefulness of OU PGCE mathematics SK training in developing confidence to teach mathematics for first teaching post

Not very useful 1	2	Useful 3	4	Very useful 5
6.3%	7.9%	33.3%	33.3%	19.2%

- Percentage respondents rating different aspects of the OU PGCE mathematics model useful or better.

Distance learning text (Self-study)	87.1%
Face-to-face workshops	79.4%
E-conferences	71.4%
Peer support	68.3%
School-based Mentor support	61.9%

- Percentage respondents rating personal subject knowledge improvement post-qualifying

No improvement 1	2	Improved 3	4	VG improv. 5
6.3%	6.3%	30.2%	33.3%	23.9%

- Percentage respondents rating confidence in personal mathematics subject knowledge to informally support other teachers in teaching mathematics?

Not very confident 1	2	Confident 3		Very confident 3
3.2%	0%	28.5%	41.3%	27.0%

- Percentage respondents rating confidence in personal mathematics subject knowledge to formally support other teachers in teaching mathematics (e.g. leading school-based training)?

Not very confident 1	2	Confident 3	4	Very confident 5
12.9%	6.5%	32.3%	30.6%	17.7%

- Percentage respondents using identified strategies to develop personal mathematics SK post qualifying

School-based INSET	93.7%
Published material	87.3%
External INSET	85.6%
OU PGCE materials	60.3%
OU PGCE Peer support	60.3%
E-conferences for teachers	57.1%
OU PGCE alumni e-conference	54.0%

- Percentage respondents rating usefulness of strategies in developing personal mathematics SK post qualifying.

Published material	98.2%
External INSET	96.3%

School-based INSET	94.9%
OU PGCE materials	50.0%
OU PGCE Peer support	50.0%
E-conferences for teachers	47.2%
OU PGCE alumni e-conference	17.6%

Figure 1 OU PGCE Subject Development Model (Burgess and Shelton Mayes 2003)

● STAGE 1 Identifying Subject Knowledge Targets

● STAGE 2 Developing Individualised SK

● STAGE 3 Individualised Support for Developing SK