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The changing 'beliefs' of Pre-ITE students on how mathematics should be taught

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The changing 'beliefs' of Pre-ITE students on how mathematics should be taught

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In this paper I will present the work from a small-scale research project undertaken with participants from a pre-Initial Teacher Education (ITE) Mathematics Enhancement Course (MEC) at the University of East London (UEL) between January 2008 and July 2009. The emerging results are in their early stages and are a continuation and development of the work addressed in two previous conference papers; one presented to the British Educational Research Association (BERA) conference in September 2008 (Clarke 2008a) and another presented to the British Society for Research into the Learning of Mathematics (BSRLM) conference in November 2008 (Clarke 2008b). The project appears to show some limited evidence that participation in a MEC, and hence exposure to a variety of teaching approaches, does change "beliefs" concerning the way in which participants think mathematics should be taught.

Keywords: Mathematics; Beliefs; Teaching; Pre-Initial Teacher Education; Mathematics Enhancement Course; Subject Knowledge.

Introduction

Recruitment and retention of secondary school mathematics teachers, the provision made for student teacher learning on pre-service, or Initial Teacher Education (ITE) courses and the quality of mathematics teaching in schools are issues of concern in a number of countries (Adler and Davies 2006), in the UK these concerns date back to at least the Cockcroft Report (1982).

A recent UK Ofsted report 'confirmed the narrow nature of much of the teaching' (Ofsted 2008, 5), while an earlier report had, as one of its main conclusions, that the 'quality of teaching was the key factor influencing students' achievement' (Ofsted 2006, 1). The Training and Development Agency (TDA), which regulates pre-service courses in the UK, their numbers and training quality, initiated Mathematics Enhancement Courses in 2004, to help address these issues. A MEC is a 26 week mathematics subject knowledge for teaching course undertaken by graduates who do not possess a mathematics degree, but who wish to teach mathematics at secondary level (aged 11 and over). A MEC is a step on the road to mathematics subject knowledge, understanding and performance, which is completed before commencing a course in ITE. Using Shulman's (1986) terms the aim of a MEC is to develop pedagogical subject knowledge through a focus on content knowledge.

Enhancement Courses and the ITE pre-learning which take place in them, as part of becoming a teacher, are an under-researched area. Yet Enhancement Courses are very important in today's ITE landscape in the UK. In other countries different solutions to the shortage of mathematics teachers have been tried. In South Africa, for example, mathematics courses have been constructed for in-service teachers whose subject isn't mathematics (Adler and Davies 2006). In the South African model qualified teachers (post-ITE) effectively retrain to become teachers of mathematics;

having already qualified as teachers in another subject. Alternatively, in the UK the transformation into ‘a mathematician’ takes place before ITE or formal qualification as a teacher.

As the programme leader of a pre-ITE MEC, I have seen students exposed to a wide variety of teaching pedagogies which they had not previously experienced as learners. From discussion with the MEC 2007 cohort of students I was provided with anecdotal evidence that this exposure had impacted on their ‘beliefs’ concerning how they thought mathematics should be taught. I presented papers to BERA in September 2008 (Clarke 2008a) and BSRLM in November 2008 (Clarke 2008b) in an attempt to place my early anecdotal ideas in a more evidence based, critical framework. I felt, and still feel, that changing the beliefs of mathematics teachers will eventually impact on the ‘quality’ of mathematics teaching in the classroom.

Schoenfeld (1992) tells us that beliefs underpin personal thought and behaviour. Beliefs underlie reasons why we engage in certain practices and not others. However, beliefs can also become too comfortable and too resistant to change (Green 1971; Rokeach 1960). Swan (2006) pulled much of this work together and has indicated that any attempt to develop mathematical teaching practices must attend to the beliefs of mathematics teachers and to changes in these beliefs. Swan’s work is primarily based on quantitative methods and has been aimed at in-service teachers. I’ve attempted to replicate some of his work with pre-service teachers and, in addition I’m complementing the quantitative nature of this work by using qualitative ideas.

The research question to be answered by this paper is: Does participation in a pre-Initial Teacher Education, Mathematics Enhancement Course, and hence exposure to a variety of teaching approaches, change the ‘beliefs’ of pre-ITE students concerning the way in which they think mathematics should be taught? My evidence leads me to tentatively say ‘yes’.

Literature

Models of teacher learning (Bourdieu 1977, Bourdieu and Passeron 1990 and Hodkinson et al 2004) theorise on how learning is constructed within a particular context and transformations of that construction occur during transitions between different contexts. A particular teachers’ mathematical knowledge can be thought of as being constructed for their own learning, however that construction will be changed as the context changes from their own experience as a learner, into pre-ITE learning, then through into the ITE learning environment and lastly into teaching pupils in the classroom. The construct will also change during interactions with ITE tutors and school mentors. An emphasis on learning within, and across, contexts is essential in the understanding of the processes of the learning of mathematics (Peressini et al 2004) in pre-ITE and ITE.

The literature concerning what has become termed Mathematics Knowledge for Teaching (MKT) is a growing area within the field of Mathematical Education. The following quote embodies an emerging consensus:

‘A new discourse is emerging, attempting to distinguish and mark out Mathematics for Teaching as a distinctive form of mathematical knowledge, produced in, and used for, the practice of teaching. And this discourse is fledgling.’ (Adler and Davis 2006, 272).

In line with others in this field (Adler and Davis (2006), Ball & Bass (2000), Ball, Bass & Hill (2004)) I have underpinned my work with the epistemological

assumption that there is specificity to the actual mathematics which teachers need to know in order to teach mathematics. That is, there is a specific mathematics used in mathematics for teaching and it is specific to the situation of teaching. In other words specific mathematics is produced in and through the teaching process. In addition to this epistemological assumption, Ball & Bass (2000) along with Ball, Bass & Hill (2004) have identified that the unpacking of mathematical ideas is an important element of practice undertaken by teachers of mathematics. These ideas of the situativity of MKT have been supported by empirical studies (Hoyles, Noss & Pozzi 2001, Noss 2002) and in addition Ball & Bass (2000) have postulated that the way teachers need to hold and use mathematics differs greatly from the way mathematicians need to hold and use their mathematics. Ma (1999) theorised that the mathematics used in ITE is a distinct activity, different from mathematics encountered on an undergraduate mathematics programme or mathematics studied by scientists or engineers. It is different, but of comparable value. Ma theorized that the content knowledge of teachers was important but not necessarily in absolute terms, more mathematics isn't always better mathematics as far as secondary mathematics teachers are concerned; she stated that a 'profound understanding of fundamental mathematics' was of more value to the mathematics school teacher. Ma doesn't see more mathematical knowledge for the school teacher (in a very broad sense) as a good thing, but emphasized that less mathematical knowledge known to a greater depth as being the way forward. The ideas of Ma (1999) can also be aligned with much of the philosophy behind the MEC, in that MEC's are intended to help create a corps of mathematics teachers, who are not themselves, graduate mathematicians.

It was Shulman (1986) who introduced the phrase *pedagogical content knowledge* and started a wave of scholarly activity based on teachers' knowledge of their subject matter and the importance of this knowledge for successful teaching. The concept of pedagogical content knowledge advanced thinking about teacher knowledge by overturning the accepted norm of treating teachers' subject knowledge and pedagogy as mutually exclusive domains within research (Shulman 1987, 6). In addition, Shulman (1986, 1987, 1992) created a model of pedagogical reasoning, which comprised a cycle of several activities which a teacher may have to complete for good teaching to be judged: comprehension, transformation, instruction, evaluation, reflection, and new comprehension.

Shulman suggested that teachers draw on three types of knowledge in order to be an effective teacher: Subject Matter Knowledge, Curricular Knowledge and Pedagogical Content Knowledge. The concepts behind these three types of knowledge are both very simple and very sophisticated.

Subject Matter Knowledge (SMK) is an idea originally based on the acquisition of the understanding of mathematics, and has come to describe a 'deep' understanding of key mathematical concepts. Skemp (1977) would use the terminology of having a 'relational understanding' of mathematics rather than an 'instrumental understanding'. To have true SMK one must move beyond a mechanical or rote view of mathematics and mathematical processes.

Curricular Knowledge (CK) is best thought of as the extent to which a teacher is able to articulate the demands of the curriculum framework within which they work. It is an idea which was overlooked for a while, however in their recent paper on the relationship between mathematical knowledge for teaching and the mathematical quality of instruction, Hill et al (2008) indicated that teachers' MKT was linked to gains in student achievement, but knowledge of the curriculum was also deemed to be a crucial construct. In some respects the findings of Hill et al (2008)

tend to partly contradict the findings of Ma (1999) over the extent to which mathematical SMK of a teacher can be correlated with the achievement of their pupils; however this may all be put down to semantics.

Pedagogical Content Knowledge (PCK) is in many ways a difficult idea to comprehend. On a basic level, using a Venn diagram, we could represent Shulman's idea of PCK as the interconnection of two circles; one representing pedagogy and one representing subject content. In Shulman's words, this intersection would contain within it "the most regularly taught topics in one's subject area, the most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, explanations, and demonstrations - in a word, the ways of representing and formulating the subject that make it comprehensible to others" (Shulman 1986, 9). By naming it PCK, however, he identified the complex nature of the actual knowledge, along with the use of this knowledge used within teaching and the nature of integrating it within teaching and learning. In addition, PCK as a descriptive term attempts to describe the complexity of the interdisciplinary issues which are the very nature of successful teaching.

"If beginning teachers are to be successful, they must wrestle simultaneously with issues of pedagogical content (or knowledge) as well as general pedagogy (or generic teaching principles)" (Grossman, as cited in Ornstein, Thomas, & Lasley 2000, 508).

It is debatable whether Ma's (1999) idea of a 'profound understanding of fundamental mathematics' and Shulman's (1986) original ideas of SMK are actually one and the same. Ma's ideas sit equally well with some aspects of both SMK and PCK, however for my purposes I will assume they are merged.

More recent work suggests that teacher subject knowledge is 'pedagogically situated within the sociocultural community of practice' (Poulsen 2001, 44) and that it is grounded in, and possibly constrained by, classroom experience, values and beliefs (Aubrey 1996, Meredith 1993). This tends to suggest that the situation is far more complex than the original triplet model put forward by Shulman.

I have used the ideas of Shulman (1986) to develop a conceptual framework for this research. This conceptual framework is being used to gain insights into the relationship for a trainee mathematics teacher between prior experience of pedagogy as a learner, current experience of pre-ITE pedagogy, in a transition phase from learner to teacher, and future beliefs concerning their pedagogy as a teacher.

Methodology, Methods, Research Instruments & Sources Used

As Thompson (1992) noted, most research into beliefs is interpretative and uses qualitative methods. In this project I have followed some of the quantitative work of Swan (2006) and complemented it with qualitative data. The emerging results are providing insights into the relationship for a trainee mathematics teacher between prior experience of pedagogy as a learner, current experience of pre-ITE pedagogy in a transition phase from learner to teacher and future beliefs about their pedagogy as a teacher.

The research draws on a mixed research design consisting of a mixed methods study of MEC students. The research method had two distinct parts:

1. Quantitative data from a sample of 20 MEC students collected via two identical questionnaires during the 2008 MEC course; one at the start of the course and one at the end of the course, the resulting analysis looked at the

difference in responses. The sample was almost a census of the 2008 MEC cohort and the questionnaire included information on the biographies, schooling and education of the participants.

2. Qualitative data from a purposive sample of four MEC students from the 2009 MEC cohort, using guided/semi-structured interviews and performed towards the end of the course. The interviews aimed to explore if, how and why the participants beliefs changed during the MEC.

Findings from both parts of the study were analysed using both descriptive statistics and grounded theory to identify insights into the relationships for trainee mathematics teachers between personal learning, constructions of mathematics as a subject and developing pedagogical knowledge.

The 2008 Quantitative Study

In 2008 I collected 20 paired data responses to two questionnaires from the 2008 MEC cohort. The questionnaire consisted of 25 statements concerning teaching practices on which the participants had to express a 'belief' in (scored 1 to 5 on a Likert scale). The 'belief statements' used to form the questions in the questionnaire were based upon statements previously used by Swann (2005) and the Standards Unit (2005) and are listed elsewhere (Clarke 2008a, 3-4). The first time the participants filled in the questionnaire was on day-1 of the MEC and the second time was on the very last day of the MEC. I did not discuss the research with any of the participants between these occasions. In addition, I collected data on the group concerning gender, age range, the highest qualification obtained in mathematics and their 'place of origin'. For the 'place of origin' I asked for the country and continent where they received the majority of their secondary school teaching aged 11-16.

I am aware of the disadvantages of using Likert scales (Forrester 2008, 27) and the problems of effectively treating ordinal scaled data as a continuous ratio scale for the purposes of my statistical analysis. However, to paraphrase Rorty (1994, 59) I am attempting to obey 'the normal conventions of (my) discipline', while 'not fudging the data too much' but also 'not blocking the road to enquiry.' In other words, I know that my statistical work is not entirely robust here, but I will continue to analyse it pragmatically.

During the 2008 study, there were 500 possible changes in belief (20 students x 25 statements). 240 responses (48%) showed no change in beliefs. Of those responses which represented a change in belief 160 (32%) were positive changes representing a change towards a less didactic approach to teaching and 100 (20%) were negative changes representing a change towards a more didactic approach to teaching. At this basic level the evidence leads me to tentatively state that participation in this pre-ITE MEC, and hence exposure to a variety of teaching approaches, had changed the 'beliefs' concerning the way students think mathematics should be taught.

This change was not a strong change and it is not consistent throughout the statements. Some statements have much more change than others and some statements even have relatively strong negative changes. For example statement 10 (I believe I need to teach each maths topic separately), statement 18 (I believe I should jump between topics as the need arises) and statement 19 (I believe I should find out which parts learners already understand and don't teach those parts) exhibited strong positive change for half the group. These may be 'beliefs' which are easily changed in

the context of the students themselves being learners. While statement 1 (I believe Learners should start with easy questions and work up to harder questions), statement 5 (I believe Learners learn maths through doing maths exercises) and statement 22 (Even though I'll plan my lessons thoroughly, I believe I'll be constantly surprised by the ideas that come up during my lessons) exhibited very little change. Many of these beliefs were already at the top end of my scale and therefore difficult to exhibit more positive change. It was interesting that statement 6 (I believe I should try to cover everything in a topic) exhibited a negative change in 50% of the group. This is causing me to return to my interpretations of which statements display belief bias towards didactic or non-didactic type teaching.

I analysed the 2008 data by age, sex, geographic origin and highest qualification in mathematics. It was not possible to identify a strong correlation of age to belief change. However, in this particular group the older participants did exhibit more change away from didactic teaching. There does appear to be some gender difference in belief change and some in belief change correlated with geographical origin. Europeans did appear to have a much stronger move away from didactic beliefs than those of African origin, however females made up 29% of the African group and 55% of the European group; so this variation in belief changes may be due to a gender effect rather than a 'place of origin' effect. A very interesting feature of the data was the lower the highest qualification in mathematics attained by the participants prior to MEC the stronger the move away from didactic beliefs.

Overall the beliefs of the 2008 MEC participants appear to have changed away from didactic teaching towards less didactic teaching.

The 2009 Qualitative Study

I selected four students as a purposive sample of the 2009 MEC cohort and collected qualitative data using guided/semi-structured interviews. The interviews took place towards the end of the course and a grounded theory approach (Golding 2002) was taken; with the findings grounded in the qualitative data collected. The transcripts of the interview texts were initially open coded (Strauss and Corbin 1990, 61) before analytic decisions concerning the data were made. A more focused approach followed after highlighting the more frequently appearing codes.

I will call the four participants subject A, subject B, subject C and subject D. Subject A and D were both male and had received their secondary education in the UK. Subject B and C were both female and had received their secondary education outside the UK; subject B had received her secondary education in India and subject C had received her secondary education in the Caribbean.

Subject A was very articulate and had been educated in the independent sector. He had not done too well in mathematics examinations (in his opinion) at aged 18 and had completed an Engineering degree before undertaking an engineering based career. He had firm ideas of what he thought of as 'good' mathematics teaching at the start of the MEC and considered one of his own secondary mathematics teachers as inspirational in his choice of teaching as a career later in life. He had thought deeply about the philosophy of his new career and saw mathematics teaching as a fine balance between keeping the government or management happy with examination results and delivering creative type teaching. He saw these two as mutually exclusive issues and activities.

'There is a real tension for me here, we are trying to say you need a sort of driving licence in mathematics that everyone can do but you

also want brilliant mathematicians of the future, all from one teacher, all from the same lesson. Can I steer a line through this in my teaching? I don't know. ' (Subject A).

Before joining the MEC subject B had had an earlier career in sales and marketing. Subject C had previously worked as a team leader for a mobile phone network but since arriving in the UK she had been a supermarket sales assistant. Both subject B and subject C were currently non-working mothers and both stated that their children reaching school age had stimulated their interest in mathematics teaching. In addition, both described their own secondary education mathematics teaching as being didactic in nature; neither saw this as a good model of teaching but were convinced that it had worked well within the examination driven cultures in which their secondary schools appeared to be immersed.

'They basically taught us stuff about formulae and plugging things in. You were taught you had to pass the exam, but never told anything about why.' (Subject C).

'I viewed my maths lessons as number crunching, sort of accounting, tedious, laborious.....' (Subject B).

Subject D had been educated in the state sector (a London, inner city comprehensive school) and felt he had been let down by the system; he considered that any mathematics he knew had been learnt without the help of his teachers. He did have one teacher who inspired him to enjoy mathematics, but he was with that teacher for only for a short time. He had undertaken an engineering based career, and he related stories of gradually growing to enjoy mathematics through personal challenge while studying in Higher Education. He seemed very concerned with using the right textbook and the right examples in his future lessons as a teacher. He had a firm idea of what secondary school mathematics teaching should look like, which tended not to reflect his own experiences but did nevertheless reflect a rather didactic view. It was based on fixing the mathematics material within 'concrete examples'.

'Practical things like dropping objects off buildings in Mechanics, practical hands-on things. Like a bit of string, a can of beans and you can see the pi thing; actually see it.....Something you see and do; that's the way.' (Subject D).

I identified three themes which appeared to run through all four of the interviews, there were other themes present but most were not related to my field of focus.

The first theme, as revealed by the qualitative data, concerned what may be termed: subject knowledge issues. The participants all acknowledged that they didn't see themselves as mathematics experts and tended to be concerned about what they described as 'confidence' in their own mathematical ability. They all acknowledged that the MEC course had helped them 'build' their mathematical confidence and three of the four felt that they had learned significant amounts of mathematics which was new to them. They failed to expand on what mathematical confidence was but did give examples of places where they believed their mathematical grasp had moved on and where their confidence had been built.

'It has opened up my horizons about what maths is. I'd only really done engineering maths before and suddenly there is like lots of other maths.' (Subject D).

Certainly the subjects had all acquired a wider mathematical vocabulary and seemed reasonably fluent in expressing themselves in mathematical ways; however I found it hard to separate out implied references to SMK and PCK. In practice SMK and PCK didn't appear implicitly or explicitly in the interviews; they both merged into a sort of generic 'teaching' or 'subject knowledge' vocabulary. Only one of the participants described themselves as a 'mathematician' following the MEC. Here I could see sociological ideas of 'identity' coming in; however I had deliberately put this beyond the focus of the project.

The second theme, as revealed by the qualitative data, concerned issues of transition from a learner of mathematics to a teacher of mathematics. On one level this theme was explicitly acknowledged and addressed by all the subjects at some stage of the interview. Only one (subject A) had explicitly approached the course from a metacognitive perspective realizing that he was learning to know about knowing. The theme appeared implicitly in many areas particularly when the subjects spoke of what they thought mathematics was.

'It has rekindled a passion for maths in me and I haven't had as much fun with learning for 20 years. But there is much more here than just learning maths.....There are ethical issues concerning how you teach.....There are opportunity costs associated with teaching styles.....There are.....' (Subject A).

Three of the four participants realized that their relationship with the mathematical subject matter had changed but had not begun to engage with this idea of change in a sophisticated way.

The third theme, as revealed by the qualitative data, concerned issues of teaching based upon the participants own experiences as a learner during their own secondary school career. All participants stated that they had started the MEC with the idea of planning to teach as they themselves had been taught at secondary level; after all, such instructional practices had worked for them! It was while reflecting on the question: 'What impact do you think the MEC has had on you?' that three out of the four claimed to have assimilated the idea of less didactic means of teaching into their own ideas of how to teach. The fourth participant stated that he wanted to inspire young learners and already had ideas of teaching in less didactic ways based upon an idealized teacher from his own school days. The examples of less-didactic teaching given by the participants included group work, interactive teaching, collaborative work and discussions of common misconceptions.

'My view of mathematics has changed a lot since the start of the course.....I think my way of thinking has as well.' (Subject B).

'I think I have a better view of applying my own maths....apply it rather than just getting marks in an exam.' (Subject C).

I was rather surprised that all four still clung to the idea of text book driven examination courses as a necessary experience for their future teaching, despite all of them criticising it at some stage during their interview. Worryingly, I felt they saw this as some form of status quo that they would have to adapt to.

Looking at an overview of all the three themes and the four interviews I can see my findings support the 'apprenticeship of observation' (Lortie 1975, 61) which students have undergone through their own learning in schools. This phenomenon is one whereby student teachers arrive at teaching having spent thousands of hours as schoolchildren observing and evaluating teachers in action. Lortie (1975) argues that

this apprenticeship is very different from other professionals, such as doctors or lawyers, and is largely responsible for many of the preconceptions that pre-service teachers hold about teaching.

Lortie (1975) wrote that a student 'sees the teacher frontstage and centre like an audience viewing a play'. He added that, while students can view the 'frontstage' behaviours (teaching, marking etc), they do not see the 'backstage' behaviours which are central to a teachers performance:

'Students do not receive invitations to watch the teacher's performance from the wings; they are not privy to the teacher's private intentions and personal reflections on classroom events. Students rarely participate in selecting goals, making preparations, or post-mortem analyses. Thus they are not pressed to place the teacher's actions in a pedagogically oriented framework.' (Lortie 1975, 62).

The participants in my interviews appear to be entering their teaching career with some reflections on their own experiences as a learner. This is acknowledged through an explicit desire to change their 'style' of teaching to a less didactic one; it is here that the impact of the MEC appears to be taking place on the participants 'beliefs'. One could debate on degrees of reflection, however they are still relying heavily on their early experiences of early secondary school teaching as an indication of what they want to do in their own classroom, themselves. At most their MEC learning experiences have been assimilated into their overall sum of teaching and learning experiences which appear to be driving their own 'apprenticeship of observation.' The MEC appears to be instigating a change in beliefs, but not a great change.

Conclusions

The research in this project is limited by the size of the participation group. Small numbers are impossible to generalise from, therefore any conclusions I arrive at can only really be applied within the context of this small group of individuals.

The belief changes observed in my study need not be a function of the teaching on the MEC course and I am fully aware that the students may have been giving me answers they felt I wanted. Even if the belief changes observed in my study turn out to be a function of the teaching on the MEC course, I am aware that the students may not eventually be turning their beliefs into action when they arrive in schools. In fact recent work (Clarke 2009) tends to support the hypothesis that they are not turning their beliefs into action in schools.

We know there is evidence that many teachers begin their careers with previously constructed, often naive, theories about teaching (Powell 1992). In fact Harel (1994, 115) notes, reflecting comments made by Thompson (1992), that: "teachers' beliefs of what mathematics is and, in particular, how it should be taught are tacitly formed by the way they are taught mathematics in their precollege and college mathematics education".

It needs to be noted that this piece of research was a pilot study and that data analysis is still in its early stages with further work being undertaken with the 2010 MEC cohort. That said, triangulating between the two parts of this study does appear to give evidence that participation in a pre-Initial Teacher Education, Mathematics Enhancement Course, and hence exposure to a variety of teaching approaches, does

change the 'beliefs' of pre-ITE students concerning the way in which they think mathematics should be taught. That change is not large and, in addition, that change appears to be a change away from didactic type teaching towards less didactic forms of teaching. The initial evidence, particularly from the qualitative aspects of this study, does indicate that there are complex relationships between how students understand mathematics as a subject, their own experiences of learning the subject at school and in Higher Education, their constructions of what kind of mathematics teacher they wish to be and their experiences of mathematics learning on the MEC. These relationships are still being explored.

I would like to end with some tentative recommendations for the future pedagogical approaches of MEC's: As practitioners in ITE and pre-ITE it is difficult to influence the way in which mathematics is taught to our students prior to their arrival on our Teacher Education courses. However, we do have an influence over the way that mathematics and particularly mathematics subject knowledge is taught on our ITE and pre-ITE courses. Maybe this is where the 'quality' of the mathematics teaching could start to change.

One final thought: Enhancement Courses are very important in today's ITE landscape. These courses and the ITE pre-learning which take place on them, as part of becoming a teacher, are an under-researched area. The whole area of subject knowledge has recently attracted political interest and it is important that as a profession we take the lead in figuring out which professional knowledge, and just as importantly which pedagogy, matters most for the effective teaching of mathematics. It is hoped that if this paper does nothing else it will stimulate dialogue in this area.

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