Studying the process of teacher research in the development of mathematics teaching

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The Mathematics Teacher Enquiry Project (MTE)

The purpose of this project is to investigate the development of mathematics teaching which occurs when mathematics teachers undertake research or enquiry as part of their practice of teaching.

Previous research Gaworski 1991, 1994) suggests that teachers' overt reflection on the practice of teaching mathematics, resulting in informal enquiry into aspects of their practice, leads to the development of their knowledge of teaching and its practice. There is a growing body of research by teachers (mostly not in the area of mathematics) which indicates the parallel development of teaching knowledge and practice with the research/enquiry (see for example Elliot 1991; Vulliamy and Webb 1991; and the journal, *EducationalAction Research*).

The purpose of the MTE Project is to study the development of *mathematics* teaching by identifying processes involved in teachers undertaking classroom enquiry and the issues it raises for the teachers. It involves the active exploration by teachers of their own practice in the mathematics classroom. Teachers decide the basis of their own enquiry. They conduct research and explore issues relevant to this enquiry. The role of the university researchers is to act variously as an observer, listener, questioner, and possibly as an adviser in terms of methodological issues. Included in the study is a scrutiny of the teachers' own development of methodological issues of research, the social factors impinging on the research, and the relation of findings of the research to its own situated nature and context. An important feature of the research design involves periodic meetings of all participants to discuss ongoing practice, share issues, and develop a research 'partnership'.

The methodological basis of the project involves reflexive reporting of the issues which the teachers' research raises for the conducting of such research and its contribution to, and implications for, the development of mathematics teaching. The role of the university researchers in this process is central to the study. Thus, it is intended to explore

1 the processes involved, and implications and issues for teachers of mathematics who undertake enquiry into aspects of their own teaching practice or of children's learning;

2 the methodological issues which the teachers address;

3 the relationship between the classroom enquiry and the development of teaching of the teacher undertaking the enquiry;

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4 the role and involvement of the university researchers.

The research aims, also, to find out more about mathematics teaching approaches and pupils' learning of mathematics through the enquiry of the individual teachers, and to bring research closer to the classroom - making it more meaningful for teachers.

A pilot study

Small scale funding has been received from the University of Oxford to undertake a one-year pilot study. Currently, five teachers from four schools are taking part and their research/ enquiry is being supported and studied by two university researchers (the authors).

The aim of the pilot study will be to highlight issues and to enable questions to be raised and refined. Its purpose will be to provide indicators for further study.
In the rest of this paper we shall discuss aspects of the very early stages of this pilot study and issues which are starting to emerge.

The four teacher-research enquiries

We offer brief accounts of the teacher research which we have observed so far; the events and issues raised in Adam's Enquiry. In this account I focus particularly on the second of two meetings with Adam which took place in September and October this year.

I set up the first meeting by telephone, when I arrived he said he had not had time to think about what he wanted to research but as the meeting progressed he developed ideas about what was concerning him and what he would like to investigate. We arranged a date for a second meeting but he telephoned to postpone the meeting, feeling he had not had time to address the questions we had thought of in the first meeting. I rearranged the date and this time we met. He was still, however, very conscious of not having given as much time as he would like to getting some results. This raises the first issue for me: what does he see as my role in his investigation? I know my role is not straightforward. Adam sees me as someone interested in his research, in the results he has obtained. I am, of course, interested in this but my focus is on what developments there are in this person's thinking as he tries to research an issue that is important to him. I try, in this second meeting, to put across to him that I am very happy to come and see him however much, or little, he has done.

Adam's research questions are centred around *differentiation.* At the OFSTED inspection that Adam's school underwent last year, his Department was criticised for their lack of differentiation in Year 7. Adam is a Head of Department and to use his words" as Head of Department I am driven by things I see as important and the most important thing to happen in this school is the OFSTED inspection." He wants to study how effective he and his staff are in dividing up the ability groups and offering appropriate work. He wants to look at Year 7 particularly but also see whether it is still *"OK.* and firm" in the other Years.

As we rehearse some of the ideas we spoke about during our first meeting Adam's attitude becomes more positive. He says that he does feel that things have progressed since our first meeting. The new scheme that has been devised by the Second in Department for Year 7 is now in place and running. It is working quite well and he sees as the next stage the putting into place of mechanisms that will test how well the differentiation is working.

In his Department the new scheme has been effected in different styles. Some teachers, like Adam himself, retain flexibility within the three ability groupings envisaged by the scheme. Others have divided the class rigidly into three groups. Adam would like to see whether his flexibility was a good thing or not. As Christmas approaches he would like to find out how well the new scheme has worked.

As we talked he began to focus on what he was looking for in finding out whether the scheme was working well. "I guess the whole point of differentiation as I see it is actually having youngsters working to their potential, and so in terms of initially talking to them, part of that can come out of how they think about work. .. that they feel they have been challenged by the work, that they enjoy what they are doing because they have been challenged ... to me that's one aspect of showing that differentiation is working." Adam felt that this aspect of how well the differentiation was working could be addressed in a short interview with some of the students.

We then sidetracked to another issue which concerned him. This was his uneasiness that the most able students were getting the breadth of education they deserved. He said:

> *I think it would be interesting* to *see how much we assume they know because they're bright and therefore how much we miss out ... take a topic I'm teaching at the moment Bearings ... you go into that work assuming they know .... all the notation and all the jargon about angles symbols and stuff like that and that possibly the only thing your going* to *have* to *teach them about is how a bearing is measured ... they practise that and away they go whereas middle and lower ability youngsters will still be struggling with the idea of what an angle is and how it is measured ... I would imagine an able youngster would have no trouble with this. I think there's some mileage in this.*

Adam's Department enters their most able mathematicians for GCSE a year early at the end of Year 10. He comments on the possibility of justifiable criticism of this on the grounds that the youngsters lack some width to their knowledge. "one target of this research could be to check that early entry really is the best policy." He would like the research to provide grounds for him to be confident youngsters don't forfeit the breadth of their knowledge.

Adam begins to draw things together at this point. He definitely sees interviews as one way to get at answers to his questions. He would like to focus on the able youngsters and begin with Year 7. He will look at the assumptions he thinks he can make in terms of what they already know as they embark on a new topic. He would possibly involve another member of staff in this. He will then devise a series of questions he can ask these Year 7 pupils in an interview situation to find out more

about their thinking. We conclude the interview with Adam feeling quite optimistic about the continuation of his research.

What issues and questions does all this raise? The first seemed to be my role in what Adam is doing. Whenever I ask him, and I have several times, he declares himself keen to do this research and sees benefits to himself in doing it but, would he have ever got around to starting if I hadn't been there? Would constraints of time ever have allowed it to rise to the top in his list of priorities?

There do however seem to be real reasons for saying that even at this stage, where things have hardly begun, I can see development in Adam's thinking. At the first interview he was using the word' differentiation' but could not give a satisfactory explanation of it. He hoped his research would give him a better understanding of the meaning of the term. As I have already quoted he has now developed a definition of this word with which he feels fairly happy and this definition is what he wants to test in his research.

Another issue that needs exploring is my expectations about the research questions that would be asked. Adam's area of interest covered a broad concept not solely the concern of mathematics teachers. This came as some surprise to me as I had expected him to focus on something more explicitly mathematical. I have tried to be supportive of the ideas coming from Adam, but I wonder if my expectations may have coloured my interactions with him? How much of my ideas have been incorporated in the decisions he has made? How many of those decisions would he have arrived at on his own? He is to a large part dependent on my knowledge of research methods as he has no personal experience to draw on. I try to respond to what he wants to know and am very aware that what I suggest could send him in a direction contrary to one that he would have chosen if he had that same knowledge of research methods.

The events and issues raised in Julie's Enquiry

I wrote, after an early meeting with Julie, that 'she felt a need for developing a more investigative style of teaching, but was not really sure how to begin. She wanted to engage in something she could see as being practicable and achievable, not just idealistically desirable'. She was worried that she did not really have a clear idea about what her research might involve, or even whether she would be able to sustain any research. She felt very tentative, and unsure about whether to get involved, although she had volunteered originally ..

After our second meeting, at which I observed two of her lessons with classes in YlO and Y8, she spoke much more confidently of her areas of interest. She talked about her belief in the importance of encouraging mathematical talk, of students arguing about answers. She wants to monitor how much mathematical talk is going on, to discourage non-mathematical talk, and wonders about the practicalities of this in the classroom. She talked about the value of group work: for practical reasons, she said:

> *I like them to be in groups. Pairs are good but can be limiting. The more students you put together the more scope there is for non-mathematical talk, but also for mathematical sharing.*

If one student, or group needs 3-4 minutes of Julie's input, she needs to be sure that other groups are not slowly degenerating - that they are using time sensibly without a big stick approach.

She wonders about how to monitor the *quality* of students' thinking, feeling that mathematical talk is involved in an evaluation of quality (Whose word was this originally - was it mine or Julie's? Is this important?). She also said' my conviction before I start is that the way they're grouped has some effect on quality' - 'how good the mathematical chat is compared with the non-mathematical'. She recognised some need for recording proportions of different levels of chat, and some sort of value system for mathematical participation. She wanted some concrete ideas of how to do 'some sort of monitoring', and wondered what research there is already in this area. I agreed to help her to find some relevant research, and we have since provided her with some books and articles. She indicated that she was now more aware of what she wanted to find out and that she had started to ask herself some questions.

During our next meeting, where I again observed lessons with the Y10 and Y8 classes, I summarised some of the above objectives and questions from J an's words in order to ask her about her progress:

1 Encouraging and monitoring mathematical talk;

2 3/4 min. input to 1 pupil or group - what are the others doing? 3

Classroom arrangement in groups - how effective?

4 'Quality' of students' thinking - how would she judge?

We addressed these questions after my observation of the two lessons as part of a semi-structured interview. (This was recorded on audio tape and I now have a script from the tape.) The questions were addressed with respect to the two lessons, and it was clear that Julie was starting to recognise particularities of her practice which related to her areas of concern.

For example, the Y10 class were drawing and finding areas of parallelograms counting squares and looking for patterns in their results. Julie felt that her questions such as "How are you getting on?", "Can you see what's happening?" were about 'monitoring mathematical talk'. She was surprised at "not having to make more input" and I asked if 'talk' was contributing to that. She felt that it was, referring to particular interactions we had observed and suggesting that "people monitoring" was involved (students monitoring each other). On 'quality' she said "I can't judge .... The outcome I wanted has appeared ... met partially my objectives. Most people are quite happy with the relationship they've discovered. I can only make overall judgment of how successful it's been if next year they can ... "
She went on to say, "today's work was very structured". She intended this to build up confidence in investigational approaches. However, she wanted to work towards

less structured work, with students taking more responsibility. I asked if this was part of her agenda, and she said, forcefully, "YES".

I feel that my presence had been instrumental in eliciting all I have quoted from Julie, here. I asked her about her own recording of her developing thinking but she showed reluctance to record at this stage, saying that her thoughts were yet little more than" gut reactions" which were not sensible to record. She seems to be relying on me to some extent for her own structuring, and it will be interesting to see how this develops.

The events and issues raised in Alex and Nick's enquiry

In this account I focus on two meetings with Alex who is a Head of Department and Nick who is a newly qualified teacher in Alex/s Department. They have worked together for about a year and have offered to work together in this research. My initial meeting was with Alex on his own. It is difficult for them both to be free together during the school day.

When I first met Alex he seemed to have already a clear idea of what he wanted to do and how he wanted to go about it. He appeared to be familiar with some research tactics and be confident in his ideas. The notes he took during our discussions were headed" Action Research" although I can/t remember this term being used in connection with this research project. He had decided on his research question in discussion with Nick. The research question is: "Who takes responsibility for learning in the classroom?"

I asked Alex how he was going to investigate this question. He replied that he would firstly ask the students and the teachers and maybe, if it seemed appropriate, parents and other interested parties. He would then go on to observe what actually happened in a classroom and try to identify who caused them to happen and who had responsibility for putting them in motion. The classes that Alex and Nick will focus on are Nick's. They hope to look at different age groups but will start with a Year 7 class.

Alex talked about the questions he might ask of Nick before questioning the whole class. He might ask "Why are you doing fractions there?" to which he felt Nick may give one of two types of answer either "because I think it fits in with decimals" or "because I was told to." These answers would reflect on Alex's role as Head of Department.

We went on to discuss what Alex called his philosophy of research. He feels a good research design does not rely on one tool as this could by it's nature lead to bias. He proposes to use several ways of looking at the situation and draw conclusions using all of them. These ways of looking at the situation would probably include questionnaires, observations and interviews. The questions they would include on their questionnaire were still to be discussed with Nick. They will pilot their system with one class and then move onto other age groups after reflection and modification of their methods.

At this stage I felt that Alex was focusing on his role in the learning in his Department. I expect this was because his questions were about his own responsibility. I was concerned about his questionnaire - that he would put in a lot of effort and find out very little of value to him. However this was the method he felt comfortable with so I waited to find out what would happen.

As a result of Alex's discussion with Nick, they produced a sheet that Alex sent to us outlining his research proposals. In this he clarified some of the ideas we had talked about in our first conversation. He expanded on the questions he is seeking to answer and the means by which they intend to collect information.

The next time I heard about the events in Alex and Nick's research was at a gathering of the MTE participants six weeks later. Alex and Nick had been busy. They had devised their questionnaire and a complex system of distribution in order to evaluate it. They gave some members of the group the first half of the questionnaire, some the second half. Some had the whole questionnaire, some had the second half and then the first half. They reported that the students had cheerfully answered the questions and they felt had given honest, thoughtful answers. They hadn't yet evaluated it but felt that the questions in the second half were the most important ones.

At this meeting Alex said that they were interested in the "ownership" of the work that went on in the Mathematics Department of their school. They had obviously put a lot of thought into what they were doing and the approach felt quite different now. The focus was definitely on the students not on the hierarchy of responsibility. Alex explained that the system they used in the first two years at his school relies heavily on students taking responsibility for the work they do. The students are encouraged to feel they have a large part to play in deciding what they do and how they do it. Alex wants to study whether the students recognise this and really feel that they have ownership of what they do.

Alex and Nick are currently studying the answers the students have given to their questionnaire. They hope to identify which questions were answered most fully and which caused most problems. They are looking at the length of it as well. They also plan to select some students to interview in order to expand their knowledge of the situation.

Although Alex seemed very confident when I spoke to him at first, he and Nick are still finding their way to a definition of what they really want to know. I feel they may be using the questionnaire and it's complexity as something to be busy with as they make their way through this tentative stage.

The events and issues raised in Sam's enquiry

Sam is interested in thinking about, "How can I incorporate research with the students I teach, in order to develop my style of teaching." He's interested in a 'match' between 'what I think they know and what they actually know'. He wants to identify two classes of pupils: one who do things in 'a way I consider productive', and one who are 'resistant' (in a style of learning).

My approach is setting difficult problems and getting them to solve those, rather than just to reproduce techniques. I'm interested in what they're doing/thinking when I'm not there.

Sam wants to use an external researcher (or the student-teachers in his department) to observe groups within his class and report to him on their activity / thinking when he is not present with the group. He wants to gauge whether their style of learning matches his expectation of their style of learning. He plans to work with a year 10 (productive) and a year 9 (resistant) class. I shall quote from one episode where I observed two girls in one of Sam' s Year 9 lessons.

The class was working on a spreadsheet problem involving input of data and formulae related to the Fibonacci sequence. The task had been set the previous lesson and students were to continue their work on it. The two girls pressed a few keys and then said 'it doesn't work'. They put their hands up, but Sam was busy at the other side of the classroom and did not notice them. For half an hour they intermittently pressed a few keys, put their hands up, looked over at the work of the nearby group, looked expectantly at me, but achieved very little with their spreadsheet. I did not want to get involved because this would have disturbed what Sam wanted to find out. Meanwhile, Sam had worked his way around the class, one group at a time, and eventually arrived, to discover the problems the girls were having.

He said, after the lesson, that it had been a surprise, and something of a shock to him, that the girls had been able to do so little, and that they had wasted half an hour. He had expected them to be able to proceed with the task. He had not attended to hands up because he wanted to talk with each group. He had started at the opposite end of the classroom to where I was seated, wishing to avoid me initially. He wondered why the girls had not actively sought help from other students in the class. He found the experience salutary.

He reported later that he had started the next lesson with these two girls in order to be sure of their ability to work on the problem. To his surprise they had not only completed it, but had made progress with further problems. They had taken it on themselves to go into the computer room at lunchtime, to 'catch up' with their work. Subsequently Sam interviewed the girls to find out more about their thinking. He found this a most positive experience, and reported enthusiastically about it at our project meeting. He felt that the interview was so valuable that he hoped to find time for such interviews as part of future lessons.

I wrote in reflection on my work with Sam at this stage:

I recognise that Sam has a strong philosophy which he articulates freely, but is still very vague about what he wants his research actually to involve. For example, he wants to promote an ethos which includes students asking for help from others in the group when they are stuck. Does this ethos exist in the way he wants? How does he promote this ethos? How does this relate to his research/ How do my observations contribute? What happens when there's no one to observe?

> *I recognise in myself an urge to pin Sam down and get him to be more precise about what he wants to enquire into, and a methodology. Am I trying inappropriately to make things happen, or force the pace?*

There are clearly issues here concerning the relationship between the partners in the research. We are supporting the teachers in various ways in our visits, as well as studying the teachers' research processes. What are the implications of this?

Issues arising for the researchers

What are the issues we feel have arisen as we have considered what has happened so far? The first thing to strike us was the tentative approach the teachers took to their research. None of the teachers had a firm idea of what they wanted to explore. Initial discussions with each teacher showed them focusing on some word which represented an area of interest or concern. Adam's was "differentiation", Julie's was "investigative", Sam's was "productive" and Alex and Nick's was "ownership", Their research centres around an exploration of these ideas and at this stage, our research is a "finding out" of what these ideas mean to the teachers involved.

This seems to us very natural, what we would expect, although we had envisaged that areas of exploration would be more explicitly mathematical. However one issue for us here is whether the teachers would have progressed past their tentative "ideas" stage if we were not working with them. Would they begin to find their way to more specific investigations if they did not have the motivation of our visits? Alex had a clear idea of what he wanted to do and the research question he wanted to answer, but he acknowledges in his research proposal that he will be planning and adapting as the project goes on. Our recent project meeting of all participants appeared to have a reassuring effect on the teachers. There were many common concerns. Sam and Julie decided that they would meet to collaborate on some aspects of their research.

As the teachers began to explore their ideas, we were struck by their need to have a definable research tool to allow them to explore. I felt that they were looking for exactly the right tool for the job - a spanner for a nut. Alex and Nick's questionnaire was something tangible to start them off. They felt that this was the appropriate research tool for exploring people's opinions. Having carried out their questionnaire, they now want to refine it by making the questions more focussed. They are also aware that they need to talk to the students if they are to find answers to their research questions. They are now setting up interviews with the students. Julie wants to use an observation sheet, ticking off who talks to whom and about what. It will be interesting to see where this tangible "spanner" will lead her.

Another issue concerns our own role as researchers and its affect on the teachers. How might our expectations colour what happens as the teachers explore their interests? Our aim was, and still is, to observe and interact with teachers as they conduct their own research into an issue that is important to them. The notion of their ownership of the research is very important to us. As we said earlier, one problem is - would their research continue if ours did not?

Adam, with whom I have long and interesting conversations, began by feeling he wanted to administer tests to all his students. He now feels he wants to talk to the students and use their feelings to assess, in part, the success of his differentiation scheme. Is this shift in his thinking due to my "body language" when he discussed using tests? Did I persuade him away from using tests as his only research method even though I tried not to? Did my feelings about the problems of assessing students by using a one-off test affect his decisions? Is the quote about asking the students if they find their work challenging, a way of pleasing me or is it his honest opinion?
It was with considerable relief, then, as Alex and Nick, with whom I have had much less conversation and therefore less input, gravitate towards the kind of in-depth questioning of students that Adam is contemplating. I await Sam's and Julie's next steps with interest.

I also have to admit that I was worried that Alex and Nick's questionnaire would be very "dry". The language Alex used in his initial interviews with me seemed to imply that he was interested in exploring his own role as Head of Department and not exploring his students" learning. Subsequent conversation has changed my opinion. He is very interested in his students' learning and whether they feel "ownership" of it. I know that I value this more but I hope I would have felt as supportive of Alex if he had wanted to take another route.

None of our teacher researchers have, so far, written much. Does this matter? There is a sense that if nothing is written down and made permanent, what has been achieved or discovered may be lost or forgotten. The teachers are resistant to writing at this stage, feeling that there is no point in recording while everything seems so vague. Again, this seems natural, but writing a journal or recording in some other form would provide them with a record of the way their thinking has developed. One of the teachers said that since he would be an older and wiser man after completing his research, he would leave writing until then. At least one of the teachers would, I feel, give up if we made any demands for writing. He finds the thinking demanding enough on his time. However, although the teachers are putting off writing at the moment, it does seem that they consider it to be important and it may be that they will be prepared to write in the future when they feel they have achieved something.

Further Work

We expect to continue visiting the teachers regularly over the next two terms. During this time we shall hold further project meetings. Our recording and analysis will proceed alongside data collection. We shall share our writing with the teachers and seek their responses.

Even at this early stage, we feel that the project is highlighting significant issues in mathematics teacher research and its relationship to the development of the teaching concerned. We look forward to further insights, and invite the comments of anyone who is interested or has related experience to report.

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