



Evaluation Report

on the Realistic Mathematics Education Pilot Project

at Manchester Metropolitan University

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Executive Summary

Realistic Mathematics Education (RME) is realistic in that children learn mathematics through engaging in solving problems in contexts that are meaningful to them. RME originated from the Freudenthal Institute in the Netherlands in the 1970s to meet a perceived need to improve the quality of mathematics teaching in Dutch schools. Following the success of RME in Holland this approach to teaching and learning mathematics was taken up in the 1990s in Wisconsin in the USA within a project called *Mathematics in Context* (MiC). In 2003 researchers from Manchester Metropolitan University (MMU) purchased a set of MiC materials, with a view to training teachers to use them in a project based in some of the local schools. It was considered essential for the success of the project that teachers had an understanding of the philosophy of the RME approach and its underpinning theory of how children learn mathematics.

MMU obtained funding from the Gatsby Foundation to pilot the RME project using MiC materials. This pilot project ran from 2004 to 2006. It was aimed principally at lower ability KS3 pupils, particularly those in Year 7. In 2007 MMU began work on developing the RME approach for KS4 pupils; the project was called Making Sense of Mathematics (MSM), and was, again, targeted at lower ability pupils, aiming for Foundation tier GCSE. It was hoped that this project would help these pupils have a positive and meaningful experience of mathematics as well as helping them to achieve at GCSE. MSM materials are currently being developed for use with more able pupils aiming for the Higher tier GCSE.

The Gatsby funded project was evaluated at the time, but there has been no subsequent evaluation of the development of RME and the MiC and MSM projects. The curriculum development body, Mathematics in Education in Industry (MEI) became interested in the RME approach, believing this approach has the potential to make a substantial contribution to mathematics education and is supporting the projects at MMU. MEI has commissioned this evaluation.

The evaluation comprises both qualitative and quantitative methods.

Qualitative Methods

Interviews, by telephone and face-to-face, were conducted with teachers currently using MiC and/or trialling the MSM materials to discern their experiences, views and any issues involved in using the RME approach. These interviews were enhanced through observation of some of these teachers using the RME approach in their classrooms with pupils and also by interviewing some of their pupils.

Outcomes : These teachers are enthusiastic, and believe in the philosophy of RME, finding it a natural way for children to learn mathematics. They emphasised that it is essential that teachers understand the philosophy and are trained in the use of the materials, highlighting that “you can’t just pick up the books and use them; it will not be effective”. These teachers believe the

RME approach develops a better understanding of mathematics in their pupils than more traditional methods.

Teachers reported that the contexts and related activities interest the pupils and so engage them in the lesson. Their pupils experience a range of activities, including practical work and discussion. Discussion at various levels, in pairs, in a group or whole class is an essential part of the RME approach.

Formal statements of objectives given at the start of the lesson and traditional formal lesson plans can be a hindrance rather than a help in the RME approach, but teachers need to be well prepared, well organised and have appropriate resources for activities to hand. They note it may take several lessons for pupils to internalise the models they work with, but, once they do, they can understand how these models can be applied in a variety of contexts.

Pupils are generally receptive to the RME approach. They enjoy working together to solve the problems and sharing their strategies and solutions with each other. They look forward to mathematics lessons.

The transcripts of interviews with teachers who participated in the Gatsby project were available and analysed, with teachers reporting much the same views about RME as the current interviewees.

Quantitative Methods

Some assessment data from Year 7 pupils from the 2004-06 MiC project were reanalysed using Rasch modelling. This compared achievement and understanding of pupils who had experienced RME with a matched group of pupils who had not. The results indicated those pupils who had experienced RME were not only more likely to solve a problem correctly, but showed considerably more understanding through their ability to explain their strategy.

Emerging Issues

1. Progress and assessment

There is concern, from parents and school management, that pupils write little in their exercise books and so, apparently, do little work in mathematics lessons. There is little formal assessment, as such, with assessment largely based on teacher judgement. There is an issue of what is an appropriate form of assessment for KS3 pupils being taught through RME methods.

2. Preparation for GCSE.

There is concern over perceived incompatibility of GCSE questions and RME type problems. Teachers have to compromise their methods in KS4 to enhance their pupils' chances of success at GCSE. This may be alleviated by the new (from 2010) GCSEs, including the Applications of Mathematics GCSE, and also the functional skills requirement. Teachers believe pupils

taught using the RME approach will be well prepared for these new assessments, but no evidence, as such, is available yet.

3. Pupils experiencing a mix of approaches.

In many schools RME has not been adopted by the whole of the mathematics teaching staff. Some prefer more traditional methods, based on a three part structured lesson plan and an explicit lesson objective, and see no reason to change. Pupils are likely to experience both types of teacher as they progress through the year groups. This may confuse pupils; is it a problem? Teachers are generally agreed that imposing RME on unwilling colleagues will not be successful.

4. Development of the use of RME

For committed teachers who believe in the approach, RME is very successful. However, to develop effectively and to involve more teachers, a support network that can offer initial training and ongoing professional development is essential. The MMU model, with the university project team at the heart of a network of teachers participating in the project, would seem an ideal model.

The success of the project for these teachers and the leadership from MMU needs a mechanism for dissemination to encourage take up and development in other cities. A publication that focuses on the experiences of teachers and pupils who have used RME with positive outcomes, is the recommend way forward, together with presentations at conferences and similar events by the MMU team.

1. Introduction and background

Realistic Mathematics Education (RME) is a way of teaching mathematics that was conceived and developed at the Freudenthal Institute in the Netherlands from about 1970. RME uses realistic contexts and a notion of progressive formalisation to help the mathematical development of pupils. RME spread further in the 1990s when it was adopted in the state of Wisconsin in the USA; this led to growing international interest. This approach to mathematics teaching was called Mathematics in Context (MiC), and the approach was taken up in England in 2002 by Manchester Metropolitan University (MMU). Trials with Key Stage 3 pupils were initiated in 2002, with funding from the Gatsby Foundation. This initial pilot project was evaluated by Anghileri (2006). In 2007, the ideas behind RME were extended to include Key Stage 4 pupils, particularly those studying towards Foundation tier GCSE Mathematics. This project is entitled Making Sense of Mathematics (MSM) and has been running as a pilot project in some Manchester schools since 2007. Since Anghileri's work, there has been no independent evaluation of the RME projects at MMU.

Mathematics In Education and industry (MEI) is interested in developing the RME approach to mathematics pedagogy and in taking it forward towards wider usage across the country. MEI evaluates its activities and so commissioned the Centre for Evaluation and Monitoring (CEM) at Durham University as independent evaluator of the projects at MMU. The evaluation was designed to gather evidence on the impact of the projects and the extent to which they are achieving their aims.

2. Historical Review of Realistic Mathematics Education

The historical background to the Mathematics in Context and Making Sense of Mathematics Projects

The account given below of the development of RME, from its origins at the Freudenthal Institute in Holland to the project currently being conducted at the Manchester Metropolitan University, is largely taken from a paper by the project research staff at MMU¹, where details of the references can be found. That it is an authoritative account is evidenced by much of what is said here being used by the project team at MMU, when seeking grant funding from both the Gatsby Foundation and the Economic Social Research Council (ESRC) to fund their projects; both these applications were successful. The ESRC Project was entitled, "Investigating Effective Strategies for Maths Teaching at Key Stage 3" and ran during 2005/06. In particular this Project assessed the response of teachers to the RME initiative at MMU. The paragraph indentations in the subsequent historical review below,

¹ Dickinson, P., Eade, F., Gough S., Hough, S., *Using Realistic Mathematics Education with low to middle attaining pupils in secondary schools*; from proceedings of the British Congress on Mathematics Education April, 2010.

acknowledges that the review is largely taken from the paper by the team at MMU.

Mathematics in England

The mathematics curriculum in England has undergone radical changes in the last fifteen years with the introduction of a variety of forms of formal and informal assessments, emphasis on functional skills and an increase in advice offered to teachers in how they might support learners. A recent study would suggest that despite the investment in mathematics there is little evidence that the standards in mathematics have improved (Hodgen et al. 2009).

Although the above changes have been effective in altering some of the patterns of behaviour of teachers and in shifting the emphases on different parts of the mathematics curriculum, the work of Anghileri et al. (2002), Brown et al.(2003) and Hodgen et al. (2009) would suggest that there may be grounds to doubt that these changes have been effective. Despite apparent short-term improvements as measured by the end of key stage assessments, Smith (2004), Brown (2003), Anghileri (2002) and Hodgen et al.(2009) all highlight worrying concerns about longer-term conceptual understanding, procedural fluency, and the ability to apply mathematics. Indeed Askew et al. (2010) argue that, in England, procedural fluency and conceptual understanding are largely seen as mutually exclusive aims.

The Smith Report (2004) suggests the need for "... greater challenges...harder problem solving in non-standard situations, (and) a greater understanding of mathematical interconnectedness ...". The report also indicated that the mathematical skills developed by pupils age 16 are not concerned with " the growing mathematical needs of the workplace... mathematical modelling or ... problems set in the real world contexts." Smith also suggested that in comparative terms "England seriously lags behind its European competitors" in terms of the number of pupils achieving an appropriate level 2 qualification. Hodgen et al. (2009), suggest that, while exam passes have risen dramatically in the last 30 years, pupils' underlying understanding of mathematics has changed little.

In summary, we (MMU researchers) see the above as evidence of a need to explore and develop a practical pedagogy of mathematics education that supports pupils' conceptual understanding, problem-solving skills and the use of these in real world situations.

Mathematics in the Netherlands

The Freudenthal Institute, University of Utrecht was set up in 1971 in response to a perceived need to improve the quality of mathematics teaching in Dutch schools. This led to the

development of a research strategy, an approach to teaching and to a theory of mathematics pedagogy called Realistic Mathematics Education (RME). RME uses realistic contexts and a notion of progressive formalisation to help pupils develop mathematically. A strong feature of RME is the simultaneous and integrated development of conceptual and procedural knowledge. Pupils engage with problems and scenarios using common sense/intuitions, collaboration with other pupils, well-judged activities and appropriate teacher and textbook interventions. (See Treffers(1991) and Treffers et al. (1999) for further discussion of RME.)

At a surface level, RME resonates strongly with progressive approaches used in England where investigative and problem-solving strategies are utilised and where pupils are encouraged, as a whole class, to discuss their work to resolve important issues. One difficulty with this approach to teaching in England is that pupils may stay with naïve mathematical strategies and are often unwilling to move to more sophisticated strategies and procedures. The need for a teaching and learning trajectory is clear. Through intensive research, trialling and re-evaluating materials and approaches, Dutch mathematics educators have developed a variety of ways of encouraging and supporting pupils' mathematical progress. So, for example, pupils remain in context throughout and stay with a topic for a much longer period of time than would be usual in England. Discussion and reflection play a significant part in supporting pupil development.

The RME approach is different to the approaches traditionally used in England in a number of respects:

- use of realistic situations as a means of developing pupils' mathematics as opposed to using contexts as an introduction to mathematics or as an application of mathematics.
- less emphasis on algorithms and more on making sense of and gradual refinement of informal procedures
- emphasis on refining and systemising understanding
- less emphasis on linking single lessons to direct content acquisition and more on gradual development over a long period of time
- greater emphasis on research into learning and teaching and of trialling and refining materials in schools.

Mathematics in Context in the USA

In 1991, The University of Wisconsin, funded by the National Science Foundation (USA), in collaboration with the Freudenthal Institute, started to develop a curriculum and pedagogy based on RME, which they called Mathematics in Context. The initial materials were drafted by the staff from the Freudenthal Institute on the basis of 20 years experience of curriculum development. After

revision by staff from the University of Wisconsin, the material was trialled, revised and re-trialled over a period of five years. The trialling not only involved checking a variety of versions of questions for effectiveness but also involved the careful examination of pupil strategies and of teacher needs, beliefs and expectations. The first version of Mathematics in Context (MiC), together with comprehensive teacher materials, was published in 1996/7 and has undergone several revisions since then. There is also in place a comprehensive support infrastructure for teachers using MiC.

Mathematics in Context in the UK

The Gatsby Foundation agreed to fund Manchester Metropolitan University (MMU) to run a project based around trialling RME (utilising MiC) over a three year period. The Economic and Social Research Council (ESRC) also agreed to fund an examination of how teachers' beliefs and behaviours change as a result of engagement in the project (see Hanley et al. (2007) for an account of the research into the changes in teachers involved in the project). The project focused on three main issues: developing an understanding of RME in an English context, understanding how learners develop, and supporting teachers to develop practical skills and a deep knowledge of RME. In terms of pupil development over three years the project team saw evidence that pupils' approach to solving problems changed and that this influenced how they understood the mathematics. More details of this are given below; for other findings of the project see Dickinson and Eade (2005).

Making Sense of Mathematics in the UK

In 2007, as an extension to the work of the Key Stage 3 project, The Making Sense of Mathematics (MSM) project began. This was aimed at Foundation tier GCSE students (Years 10 & 11) with new resources being produced as a result of collaboration between the Freudenthal Institute and MMU. These resources consist of 10 booklets which together cover the Key Stage 4 Foundation tier curriculum. These booklets build upon the experiences gained from the Gatsby project and take account of difficulties highlighted by the Key Stage 3 teachers, such as the need for RME based materials which feature British contexts and are more closely linked to UK national tests. The MSM project has involved Foundation level classes from 6 schools in the first cohort and 10 schools in the second cohort. MMU has supplied resources to these schools and has provided ongoing support in the form of twilight training sessions and school based observations. Feedback given by the teachers has been used to revise the materials which are currently in their second version. Key findings from the MSM project to date show influences on both teachers and pupils.

3. Interviews with current RME teachers

MMU supplied a list of teachers believed to be currently still teaching using the RME approach. They were mostly from 11-16 schools. Of these teachers, thirteen were willing to be contacted, from eight different schools. This resulted in eleven telephone interviews, one response via e mail and one face-to-face interview when visiting the teacher at her school. Most had been and still are involved with MiC and MSM with three teachers involved only with MiC and two only with MSM. It wasn't practical to split the teachers into two groups, a MiC group and a MSM group, as had been the initial intention. All interviews were guided by a pro-forma. The responses to the questions asked are summarised below.

- *When and how did you first come across RME?*

All of the teachers had been involved in the MiC trial schools in some way. Most of these teachers have had personal involvement with MMU. Several did their initial teacher training there, used MiC when on their teaching practice in MiC trial schools, and then took up posts in MiC trial schools. Some deliberately sought second posts in schools where RME was being used. Others took up professional development opportunities at MMU, and particularly mentioned was the Whole Class Interactive Teaching group (WCIT).

- *Why get involved? / What did you hope for from RME?*

The teachers put forward a range of reasons for wanting to be involved in RME and what they hoped would come out of it. Many preferred this integrated, problem solving approach to the traditional teaching by topics approach. They believed it led to greater engagement of pupils and ultimately deeper understanding of mathematics. Various contexts enabled the pupils to make links in mathematics through recognising the use of the same models in the different contexts.

One teacher contrasted this with the dislike and fear of mathematics that the traditional approach can engender in pupils. Another teacher found the traditional approach dry and abstract whereas RME through contexts is intuitive, pupils can visualise problems and try their ideas out in solving problems and discuss them with each other and with the teacher as a whole class. This teacher wants to see a change in perspective of what is "achievement" and "success". Another teacher noted that hers is a relatively low ability, challenging school and she wanted an approach that would interest the pupils; her links with MMU convinced her RME was the way to achieve this despite government inspector advice that it was not the way to raise standards (meet targets). Another teacher noted she had introduced RME into KS3 looking towards the long term when this approach will be used across all year groups; her school is trialling MSM. Another teacher noted the similarities of functional mathematics to RME but noted further that she wanted a problem solving approach to teaching and not one-off projects.

- *What do you see as different about the RME approach and the associated resources?*

The teachers have a variety of perspectives about what is different about RME, but most contrasted it to the traditional approach in which pupils rely on memory to learn rules. They believe the RME approach both challenges pupils and encourages pupils to think and try out ideas out for themselves rather than being “shown how to do it”. The teachers like the way the models evolve from the pupils meeting problems in different contexts, and believe this leads to long term understanding. They find the emergence of models, like ratio tables, and the related problem solving skills in using them are likely to be sustained and pupils can apply them with confidence to new problems. Teachers believe RME promotes links in mathematics through being visual and making sense to the pupils. They noted the need for discussion to promote this, both between pupils in pairs or groups, or a whole class. It is important for the pupils to share their ideas with each other. This is also reinforced with practical work. Generally the teachers agreed that RME makes pupils think as opposed to, for example, being shown how to solve a type of equation, which is then reinforced with practice, but might not be understood and will soon be forgotten with the need to “move on to the next topic”

One teacher noted that RME is a teaching approach that is grounded in research of how children learn mathematics. The teacher noted further that the traditional approach is procedural and depends on memory whereas in the RME approach the contexts are building blocks which the pupils can fall back on. One teacher saw RME as a logical way to teach maths. He found it difficult to explain this but contrasted the integrated approach with the text book and theory approach with the latter being “alien”. Another teacher noted it is a move towards functional maths which is what we need if more are to go on with maths post 16. One teacher highlighted how she saw the traditional approach as back to front; she believed the traditional approach of “this is what you do, now practise it on examples that get progressively harder until they become in-context problems” is the wrong way round and that the maths tools, that is the models, should evolve from real problem solving situations, and then some pupils can develop them and use them in abstract problems, whereas other pupils need to stay in context. One teacher noted she likes the RME resources as they enable her to teach this way; that is the pupils do the thinking and the class can share and explore what they discover and reproduce the same result a number of times, rather than deriving a rule one way.

- *What has been the effect of RME on you as a teacher?
Has there been any change in your values and beliefs about maths education?
In what ways have you changed your teaching strategies as a result of RME?*

These teachers have questioned the effectiveness of the traditional approach to mathematics teaching with the three part structured lesson, showing a belief in the philosophy behind the RME approach. Many, though, noted that there are teachers in their school who reject RME in favour of the traditional approach. Some wondered if these more traditional teachers really think about the question – how do children learn mathematics – whereas being involved in RME has made them think about it and adopt the RME approach. Other teachers, though, observed that colleagues are noting the effect of RME on pupils and are using RME based ideas and strategies, so that whole departments might be adopting this approach. One teacher highlighted how she believes in the RME theory but that it is hard to describe how you know it is working. However, she believes her teaching is improving with practice and that she understands more about how pupils learn.

Many teachers welcomed the opportunity to try a new way of teaching, and they accept the important role that discussion plays, and that it is acceptable for pupils to air their wrong ideas and for conflicts to arise. This can bring out misconceptions that are resolved through discussion and pupils explaining their strategies to each other. Some noted that this is particularly the case with low ability pupils who with RME will try and think how to solve a problem rather than being shown how to do it. It was also noted by one teacher that an enthusiastic teacher who embraces change, can enthuse the low ability pupils with the RME approach. Also these pupils are receptive to there being many ways to the “right answer” and that “teacher’s way” is not imposed on them. There is an acceptance that the RME approach takes time, as one teacher put it, MiC is slow and repetitive but she now accepts this as, in the long term, pupils will have the confidence to tackle original problems. One teacher did highlight what, for her, is an issue at KS4, in that she avoids traditional methods if she can but is wary of the needs of the formal GCSE examination. She now doesn’t think there is one best way to teach maths; she mixes it up wanting to help pupils understand the maths but also to do well in the exams.

- *What has been the effect of RME on your pupils?
Has there been any change in pupils’ attitudes, their progress and attainment?*

These teachers generally agree that pupils are much more positive about mathematics compared to those taught by more traditional methods. They are engaged with the mathematics of both MiC and MSM across the five year groups. Pupils are receptive to visualising problems and that helps them to make sense of them. Pupils are willing to discuss problems and raise questions with each other, particularly the younger ones in KS3, but less so the older pupils in KS4. Some teachers emphasised the long term nature of RME and the need to introduce it from Year 7, so that pupils accept it as the way they will be learning mathematics throughout their time at school. There is a general consensus that being taught through the RME approach leads to a better understanding of mathematics, but it is a long term gain. There was some concern that as pupils move up through the year groups and change to a teacher who uses more traditional methods that some of that gain may be lost. There was also concern that MSM may not lead to the higher, more

abstract, ideas needed for Higher tier GCSE, although this was qualified by the observation that there is no apparent detrimental effect at GCSE. All agreed there is certainly an improvement at the bottom end of the ability range.

One teacher noted that children arrive from primary school used to traditional methods but soon become engaged with RME and are willing to try things out rather than just say “I can’t do it”, and they also accept that, perhaps, there isn’t always a right answer. This was reinforced by another teacher who noted pupils will think around problems and are willing to try new ideas rather than being told what to do. She believes that this builds pupils’ confidence in mathematics. Some teachers pointed out it takes time for pupils to adapt to this way of working, but once they do they enjoy the mathematics and find the contexts interesting.

- *How do you see RME relating to functional skills , problem solving skills , investigative abilities and pupils staying on task*

All teachers agreed that the RME approach fits in well with the requirements of functional skills and the applications aspects of GCSE. Some noted that pupils develop the confidence to have a go at solving a problem, usually by making a suitable drawing in such a way that the problem makes sense to them. One teacher noted it is important that pupils see that the problem is worth solving, which might be a limitation in formal examinations. One teacher noted that GCSE will have a high functional maths content, so pupils learning maths through problem solving will have a good preparation. They will have developed skills in identifying which method to use in a particular problem. One teacher noted that understanding the problem and interpreting it was as important as actually doing the mathematics.

It was generally agreed that pupils do stay on task, but more so the younger ones. They will try the problem again another way if they go wrong. Pupils get interested in a problem, see relevance in it and are motivated to stay on task. The contexts of RME give pupils some firm ground to fall back on; they recognise the similarity of the current problem to one that they have met before. Several of these teachers emphasised again the need to use RME over a long period of time if it is to be successful, in that when not introduced until Year 10, some pupils reject the approach and want to be taught the “rote” traditional methods to pass the examination. However, one teacher said she believed that using the problem solving approach had engendered an interest and enthusiasm for maths which would lead some students to further study of mathematics at A-level. Another teacher noted, in KS4, how some pupils who were hostile to maths became cooperative and were enjoying their maths rather than not wanting to try. She believes traditional methods for some pupils lead to repeated failure. One teacher noted that, in Year 10, the less able will drift off task, and there is some insecurity with not knowing what to do. She emphasised the need to start with Year 7 and develop from there and to let the maths and problem solving abilities grow organically.

- *Has there been any change in workload and curriculum management with the use of RME?*

Most teachers commented that the work load was heavy to begin with, both in terms of working with pupils and also using the books. Several noted that training in the use of the books and how they fit with the RME philosophy was essential; one noted you can't just pick up a book and use it. Another noted that teachers needed to be committed, to invest time and make regular use of the RME resources. Another commented that, without training, using the RME materials would be superficial. Many teachers noted the need to be familiar with the resources and to have worked the activities themselves to gain an understanding of where it is intended to take the pupils and if necessary to use judgement in matching activities to what the pupils are capable of. One teacher noted that there are sometimes gaps in the books which a teacher can fill, with sufficient experience. Another thought the resources to be very good and she is able to just use them with pupils, so that reduces time spent by teachers in preparation.

One teacher thought there is a great amount of work and that lessons need a lot of planning. She noted, too, the need for teachers to be confident in their subject knowledge, to anticipate misconceptions and unpredictable questions. In a school where several teachers are using RME, a teacher noted that self-support and teacher dialogue made the workload and preparation tasks less daunting than it might have been. She noted a need for teacher dialogue on what works and why, and on what doesn't work and why not. The support from MMU in this respect was noted by some. However, the need for good self-organisation was noted, although one teacher pointed out this was needed for traditional teaching as well. One teacher noted that managing the class in interactive discussion is quite demanding but it gets better with experience.

- *Has there been any change to your schemes of work due to use of RME?*

Most of the schools that have been involved with MiC at KS3 have revised their scheme of work, particularly in Year 7 and 8. At KS4, those who are adopting MSM are thinking about revising the scheme, but are wary of the formal assessment at GCSE, however, they note the need to incorporate functional skills. One teacher noted that, at KS4, she has been allowed to organise her own teaching outside of the scheme of work and the school is supportive in her using MSM. One teacher commented that at KS3 the scheme has been re-written to encourage more staff to use the RME approach, with it being insisted upon that some RME ideas, such as ratio tables and the area model for multiplication, now be used by all staff. Another teacher commented, similarly, that their scheme has been completely re-written for years 7 and 8, and is now all investigation and problem solving based, without textbooks, but with problems rich in mathematical tasks. She noted there is resistance from some teachers but the Head of Department supports RME and wants to go this way. Another teacher said that in re-writing their scheme they have noted the need to think about time

requirements and how topics are going to be covered. They are concerned to meet OFSTED inspection requirements and how to fit in formal assessment.

Some teachers noted that, in KS3, the usual spiral curriculum in which topics are revisited each year, is being rejected in favour of spending considerable time in MiC on a particular topic, but noting that some problems may bring in several mathematical concepts. He was confident pupils would be well prepared for KS4. One teacher noted that the RME approach doesn't fit with a concept of "do this by this date and move on to next topic"; The schools has adopted an integrated view of mathematics, rather than maths taught as a series of isolated topics. She noted that several mathematical topics can come out of one problem and also that RME allows for children learning at different rates. This was also contrasted with a "safe" scheme of work based on the national curriculum.

- *Has RME affected the use of lesson objectives, lesson plans and the three part lesson, as might be expected by Senior Management and Ofsted inspectors?*

Most of the teachers commented that having explicit objectives is not compatible with the RME approach. It would spoil the lesson to let the pupils know the expected outcome, when that might, itself, be flexible. They emphasised that pupils should focus on making sense of a problem and solving it and that explicit objectives would give the game away to pupils, when they should be discovering things for themselves. One teacher noted his lesson might be entitled "car parks" rather than percentages, but that is what they will be learning about. One teacher noted that objectives are an expectation of senior management but she compromises as her senior managers are not mathematicians. Other teachers noted that they still had objectives, but they were skills based as opposed to content based. One teacher commented that a lesson is spoilt if objectives are given at the beginning and it is better to review later when some sense has been made of a problem and there is some understanding. One teacher also noted that there is an issue over progress being made every lesson; highlighting that it may take several lessons to see progress and that learning maths is not a memory game. An objective might be met over several lessons or weeks, not in one lesson. She noted this doesn't fit NNS for KS3 and "what have pupils learnt in this lesson". She thinks there should be recognition that children do not learn this way.

Some teachers still use the three part lesson structure, but it is more paying lip service to it than a formal structure in the lesson plan. The need for a plan is still emphasised by some teachers, but so is the need to be flexible and adapt any plan in response to pupils' reactions, and to be able to pick up from the previous lesson. Teachers, generally, found RME lessons to be multi-phase, with a variety of activities including whole class plenary sessions, but some still did review with pupils what had been achieved at the end of a lesson. One teacher commented that the senior management at her school are pleased to see problem solving and collaborative learning taking place in mathematics lessons, and another that an Ofsted inspector observed a MiC

lesson and liked the questioning and the way the contexts were used. There was a general feeling that lessons should aim for a variety of activities and to engage pupils and this need not necessarily be captured in a lesson plan with objectives.

- *Have there been any problems with classroom management due to the RME approach. Has there been any change or problems with pupil behaviour?*

Most teachers felt that RME lessons didn't cause any more behaviour problems than those that might be seen in any lesson. Indeed, if the pupils had appropriate work that kept them interested and engaged, any behaviour problems tended to be minimal. It was noted that it was down to the teacher to create a lesson in which pupils would engage and that teachers needed strategies to bring this about. Most teachers mentioned that the RME-type activities created noise in pupils talking and arguing with each other, but that was OK because they were learning. Some noted that the classroom may appear somewhat chaotic but contrasted the learning activities of an RME lesson with a more traditional approach, of "here's a worksheet now get on with it". It was noted that pupils given routine practice exercises were easy to "cover" if there was staff absence, but this wasn't the case with a RME lesson.

One teacher noted that getting pupils to think and discuss requires management and the teacher needs to feel in control, even if the teacher has moved from pupil-to-teacher interaction to pupil-to-pupil interaction in groups. She talked of the need to "let go" while making sure crucial points come out. Another teacher noted that some pupils experience reading difficulties so she avoids dependence on textbooks and often starts a lesson with a visually based activity. She highlighted the "need to know your pupils" and that the way the lesson is introduced will determine how they respond. Another teacher emphasised the need for teachers to have good behaviour management skills, and that group membership needs to be chosen carefully, but it was generally agreed that suitably interesting problems will engage the pupils and avoid behavioural problems. The need to keep discussion focused on the problem in hand was also noted. Another teacher noted that some pupils reacted disruptively to her MSM way of working, but, over time, they came to accept it as a way of working from which they can learn useful skills as well as some maths.

- *To what extent do you find the RME approach compatible with the new (2010) GCSE specifications?*

The teachers are generally agreed that pupils who have followed an RME approach will be well prepared for the applications and functional skills aspects of GCSE. Through RME, they will have developed problem solving skills and the ability to think around a problem and will find it quite natural to get started on a new problem. There was some concern, though, about adequate preparation for the more abstract questions, with some saying they revert to traditional methods to prepare pupils to answer such questions. No teacher thought they were disadvantaging their pupils by teaching them using

the RME approach, indeed, the development of problem solving ability and thinking skills gave them an advantage and pupils went into the examination feeling confident. They will find it quite natural to tackle a new problem and to make use of the toolbox that RME has given them. It was felt that the impact was greatest on the foundation pupils, although higher level pupils would still benefit by being able to apply the models they had acquired through RME. RME pupils also have the added advantage of a deeper understanding of mathematics, compared to the “rote” taught pupils. However, this was qualified by saying the GCSE needs to be end of course linear assessment and not modular. One teacher who uses MSM did say she found it difficult to get through all the material required for GCSE in the time available.

From a parents’ perspective, particularly with the younger KS3 pupils, there was some concern that there was little in the pupils’ exercise books and that suggests that they do little in mathematics lessons. One teacher mentioned a parent saying to her child “this is how you do it”. There may be conflict here with parents who were taught by traditional methods themselves. In one school this problem has been addressed by inviting the parents of Year 7 pupils to a meeting when they join the school. The rationale of RME is explained to them and they can have a go at solving problems RME style, using models. This is supported by a booklet of problems they can take away with them.

- *To what extent has RME been implemented in the mathematics department at your school?*

Implementation varies from whole department use to a lone teacher. In some schools, RME is being used by all the teachers across all the year groups, but in some schools there is a mix of those who use RME and traditionalists. In most of these schools the teachers are hoping for a gradual development to where all the staff are using the RME approach. In one school, new members of staff are encouraged to try RME based activities with their classes. The extreme is a school in which there is one teacher working alone who doesn’t see others wanting to teach this way. There is a view that traditional teachers don’t see the need to change: “it ain’t broke so don’t fix it”. One teacher noted how his scheme of work allows for both approaches, side by side. Not all teachers are following the MiC or MSM schemes, as such, but dip in and out and use the resources flexibly in their lessons. One teacher noted that, although all staff in her school use RME, they do it in their own style. Another teacher noted how, when a keen member of staff left the school, the impetus was lost, and although there are still two teachers using it, the influence of RME is now limited. She thinks the more traditional teachers are concerned about the time demands of RME so keep to their trusted methods. One teacher noted they are to get a new Head of Department and the way the department develops in terms of RME will be up to him or her.

4. Interviews with teachers from MIC Project 2004-06

In the first year of the Project, 2004-05, twelve teachers from six secondary schools in the greater Manchester area participated. They were trained in the use of MiC materials with pupils from Year 7. These teachers were interviewed by the Project team throughout their year of training. In the second year of the Project, 2005-06, a further twelve teachers joined the Project, and they were interviewed twice a term. The teachers involved ranged from newly qualified teachers (NQTs) to experienced Heads of Department.

Teachers who joined the Project were interested in a new approach to mathematics teaching. Many had previous experience of projects, with CAME (Cognitive acceleration in Mathematics) and WCIT (Whole Class Interactive Teaching) being two of the more recent ones mentioned.

Not all teachers who joined the project stayed with it, some seeing no advantage over the National Numeracy Strategy (NNS) type lessons they were familiar with.

Transcripts from the interviews by the Project team at the time were made available to the current evaluation, so that the views, issues and any concerns of the teachers involved then could be contrasted with those of the teachers interviewed for the current evaluation. The results from these two series of interviews are reported in abstract form below

First cohort 2004-05

Transcripts were available from interviews with ten of the participating teachers in the first cohort. Only one of these teachers was one of the thirteen interviewed in the current evaluation, but the teachers generally came across as enthusiastic for MiC, and showed a deep understanding of the philosophy behind it. They were also aware of the problems of implementation of MiC where teachers are traditionalists and see no need for change. Apart from the one interviewed by the evaluator, what these teachers are doing now in respect of RME is not known, but they were certainly enthusiastic advocates then.

The abstracts of these interviews are summarised under three headings below; “teachers”; “pupils’ development in mathematics” and “discussion”. The indentation in the paragraphs indicates that these are summaries taken from the original transcripts.

Teachers

Teachers need to believe in MiC; they need to understand the philosophy behind it and not let it become “this is how you do it”. Teachers need to work through the MiC materials themselves to understand what the pupils are to get from it. Teachers need to listen to what pupils are saying about solving a problem; not all teachers are good at doing that. There is a conflict between developing understanding in pupils and preparing them to pass examinations.

There is a fundamental question of what is mathematics and how do we want our pupils to perceive it. But perspectives on mathematics change for both teacher and pupil, and it is important to let pupils experience that change in perspective. Mathematics should be about how the answers are obtained rather than the answers themselves. The end point is less important than the process of getting there.

The MiC books need teacher input; pupils cannot just pick them up and use them; teachers need familiarity with the material so that they can respond appropriately to how the pupils respond to the material. Some of the contexts are found odd by some pupils so teachers need to be able to respond to that, either by not using the context or by giving the context a suitable introduction. Teachers need to judge what they feel can be left out, but there is a feeling that within MiC you have to do it all so there is an issue there. Pupils can misunderstand what they read in the books so the teacher needs to be able to respond to that.

Teachers need to be able to make the material come alive so that it captures their pupils' interest and they become engaged with it. Teachers also need to be good mathematicians so they can respond to pupils' questions and encourage them to think about problems. Managing this with pupils of differing abilities is a problem. Teachers need to be positive and enthusiastic and encourage all pupils to have a go and engender for pupils a view that they can do the maths any way they want to.

Teachers should make lessons fun and interesting for the pupils. Teachers need to get pupils to explain their ideas. Teachers shouldn't be concerned about pace; they should provide the time so that pupils have time to think, and encourage pupils into a mind-set that there isn't a right way to solve this problem and there isn't necessarily one right answer so all can have a go, which contrasts starkly with conventional exercises.

The maths should come from the pupils not the teacher. They should feel part of the process of developing mathematics rather than being told results. The teacher needs to be well organised, to be the facilitator, but also the director of the classroom and know what is going on to respond appropriately to pupils.

It is difficult to share teaching in MiC. Teachers know where they have got to one lesson and where to pick it up the next. It is difficult to convey this to a colleague.

Pupils can be assessed through the contributions they make in class. Happy for MiC classes to be mixed ability.

Pupils' development of maths

Pupils cannot understand mathematics through being told it; they need to think. Working in the contexts that MiC offers enables that thinking through coming at an idea from several different angles.

Teachers have seen schemes like this before. Why is this any different and likely to have impact? It takes a long time to get anywhere; other classes are getting ahead in the scheme of work.

Pupils should have freedom to explore mathematics. MiC provides fun activities through which they can do this. Pupils have stopped asking what this has to do with life.

Pupils have a natural interest in the problems in context, there is much less need to justify what they are being asked to do. The NNS goes too quickly into abstract ideas and MiC is, fundamentally, a different way for children to learn. In NNS you might do area in a week, in MiC it might take 5 weeks, but the children will have a far better understanding than those who were taught the NNS way. All the pupils are willing to have a go at solving a problem. The pupils can develop their own links in mathematics and not rely on memory. MiC allows more time to be spent on problems without a feeling of a need to move on. However, bright pupils might find the pace too slow and want to move on.

If retaining the three part lesson, it is important not to give the pupils the results, in terms of objectives, beforehand. The objectives should emerge from the lesson, when pupils have had the opportunity to explore around a result through suitable problems before it might be brought into focus by the teacher towards the end of the lesson. There is conflict here with the traditional view, of "give them the formula and then let them practise using it", but some won't understand where it comes from or even what it really means. The three part lesson is very structured, and involves algorithmic skills and drill, whereas MiC involves the pupils and they are making the decisions about how to approach a problem. Teachers need to be flexible, use time appropriately and not be constrained by a lesson plan. MiC allows pupils to use different strategies, to do it "their way" and is fluid so that any plan can be changed in response to the pupils' response.

What would be the MiC approach to something like Pythagoras' Theorem?

Discussions

Discussions need to be short and pacy, not long discussions - so teachers need to intervene when they feel it is appropriate. Discussion is important; pupils need to talk to each other about their strategies and justify them and respond to criticism of them. The whole class needs to be involved but how to manage it is problematic

for teachers. Should it be whole class, or in groups or in pairs and for how long? Teachers need to develop a skill to judge what is appropriate to the current situation and try to avoid any pupils “switching off”.

Pupils enjoy discussing the problems with each other. They learn it is OK to start out wrong and then change their point of view. A pupil might propose a strategy and the teacher doesn't know if it is right or wrong, so getting the pupil to justify it to everyone is important and the strategy might be amended as a result. Teachers need to judge when it is appropriate to go into a discussion, but it is important to follow up what pupils are saying and getting them to engage; teachers need to mix the discussion up between whole class, groups and pairs.

Second Cohort

Transcripts from interviews with sixteen participants from the second cohort of teachers who joined the project were found in the files supplied by MMU. Of these, four seemed to have lost interest in the Project, preferring a more traditional approach to their teaching and weren't pursued further. One of these teachers did raise the question of what is wrong with showing pupils a technique and then letting them practise it; he noted many actually enjoy doing that! He thought MiC was frustratingly slow, particularly for the bright pupils. The views, issues and concerns raised by these teachers are summarised below. Three of these participants were in the current cohort interviewed for this evaluation.

Teachers

Teachers need to be open to new ideas and ways of thinking about how children learn mathematics; MiC provides an opportunity to explore that. But is it just another scheme that will soon be forgotten?

Teachers need to organise the classroom and its furniture so that group work and whole class discussion is facilitated. Pupils should enjoy the lesson so we need short activities that the pupils can understand. There should be a few minutes' discussion and then pupils should write their own version of what has been found out. Then some can share that with the class using the IWB.

The pupils may be interested in this problem solving approach but there is concern over whether it is “proper” maths; what view will the parents take of it? Not all of the contexts interest the pupils so the teacher needs to be aware of that. Teachers also need to be aware that pupils are not used to reading maths books so may need support in understanding a context and the problems they are being asked to solve. Some teachers find some of the contexts to be artificial and fear pupils will find them silly; is it OK to write your own? Some teachers find that weaker pupils do need more support than brighter ones and lesson organisation needs to take this into account.

Teachers need to facilitate interaction. Get pupils both working together and presenting their solutions to each other through using the IWB. Teachers need to go with the pupils' discussion rather than trying to follow a lesson plan. Teachers need to be aware that some pupils may find repeated use of the same model(s) counter productive, despite them being met in different contexts. "are we going to do arrow strings all year"? Teachers should make their own decisions re use of the materials.

Teachers need to find a balance between developing understanding of mathematics and preparing pupils to pass an examination.

Pupils' development of Mathematics

Group work is important. Pupils must be able to find things out for themselves.

The pupils need to explain to each other their strategies and solutions; this helps them develop their ideas of how to solve a problem, rather than being told how to by the teacher. MiC alleviates the concern of too much text book dependency of the more traditional classroom.

It is important that pupils are allowed to have a go at a problem as group work, but then to discuss the outcomes and talk it through with the whole class. Teachers need to help the pupils make sense of what they have been finding before moving onto another problem.

There is concern that there is little written work. There is little evidence in pupils' exercise books that they are doing any mathematics. How do you assess the pupils? How do you assess problem solving ability as compared to mastery of a technique, which traditionally is much easier to assess.

The bright ones finish too quickly; how do we manage this problem? Is it a problem? MiC seems to suit the lower ability pupils more. They see maths as being useful and it is important that this is brought out for them in lessons. For pupils, MiC is interesting through stimulating an investigative exploratory approach, as opposed to the, rather boring, traditional approach of learning and repeating rules.

Discussion

Interactive discussion is preferable to talking to children but there is anxiety over managing a discussion and losing control.

Pupils seem to prefer discussing with the teacher, rather than with each other. How do we overcome that?

5. Analysis of pupil data from the initial MiC project

Pupils from Year 7 who were taught using the MiC materials by teachers involved in the 2004/05 Project, were assessed on a range of questions to test their ability to solve a problem and explain their strategy in a finding a solution.² The same assessment problems were also given to a control group of Year 7 pupils who had not experienced the RME approach nor used the MiC materials. The pupils were matched on the level they had achieved in the Key Stage 2 mathematics standard attainment test (SAT) taken in Year 6. The results of these assessments have been reanalysed in the present evaluation, using quantitative methods rather than the qualitative methods used at the time, to compare pupil understanding and ability to communicate their problem solving strategies.

Data for 100 students was available (50 in the project group, and 50 in the control group).

In analysing the data, the answer to each question item was coded in two different ways. Firstly, the actual answer was coded as Correct (1) or Incorrect (0). In addition the types of explanations provided by the pupils for each answer were also coded as No explanation (1), Incorrect explanation/diagram (2), Reasonable diagram (3), Correct explanation (4), and Correct explanation and diagram (5).

Table 1 shows the percentages of the Project pupils and the control group pupils getting particular items correct. As can be seen, the Project group were more likely to get each item correct except for Q4c.³

Table 1: Proportions of correct answers

Question	Group	
	Control	Project
Q1a	4.2%	17.0%
Q1b	2.0%	20.8%
Q2a	8.2%	32.7%
Q2b	34.7%	55.1%
Q4a	39.5%	40.8%
Q4b	16.3%	32.7%
Q4c	2.3%	0.0%
Q5a	39.5%	63.3%
Q5b	37.2%	44.9%

We can also look at how the quality of explanations have been categorised for the students in the different groups (Table 2).

² The RME test for Year 7 pupils is appended

³ There was no Question 3 in the test.

Table 2: Quality of explanations

Question	Group	Quality of explanation				
		1	2	3	4	5
		No explanation	Incorrect explanation or diagram	Reasonable diagram	Correct explanation	Correct explanation and diagram
Q1a	Control	6.3%	79.2%	6.3%	4.2%	4.2%
	Project	6.4%	57.4%	23.4%	2.1%	10.6%
Q1b	Control	20.4%	69.4%	10.2%		
	Project	8.3%	52.1%	31.3%	8.3%	
Q2a	Control	38.8%	49.0%	12.2%		
	Project	18.4%	44.9%	16.3%	4.1%	16.3%
Q2b	Control	6.1%	63.3%	6.1%	18.4%	6.1%
	Project	6.1%	38.8%	14.3%	10.2%	30.6%
Q4a	Control	30.2%	53.5%	4.7%	11.6%	
	Project	34.7%	38.8%	2.0%	24.5%	
Q4b	Control	55.8%	37.2%	2.3%	4.7%	
	Project	46.9%	30.6%		20.4%	2.0%
Q4c	Control	55.8%	44.2%			
	Project	44.9%	44.9%		10.2%	
Q5a	Control	27.9%	44.2%	2.3%	20.9%	4.7%
	Project	12.2%	26.5%	4.1%	38.8%	18.4%
Q5b	Control	41.9%	32.6%	16.3%	7.0%	2.3%
	Project	34.7%	20.4%	12.2%	12.2%	20.4%

In each case, Table 2 indicates that the Project pupils were more likely to provide higher quality explanations.

To further quantify the positive differences between the two groups, partial credit Rasch analysis was carried out on the above data. Rasch analysis expresses the probability of a person being successful on a given item in terms of a mathematical function of the difficulty of the item and the ability of the person, where the difficulty of the item and the ability of the person are measured on the same scale. (Bond & Fox, 2007). Rasch analysis is commonly used to analyse dichotomous items (questions which have only two answers, right or wrong), but can also be used to analyse items with a greater number of possible responses, and also allowing for differing numbers of responses on different items. This, so called, partial credit analysis estimates not only the person's ability and the overall question item difficulty, but also provides estimates for the difficulty thresholds between scoring categories. These thresholds should increase in an ordered manner, in line with the ordering of the scoring categories (Bond & Fox, 2007). Otherwise, adjacent categories should be combined and reanalysed. Therefore, Rasch analysis was also used to confirm the ordering of the categories for the explanation. It was found that category 3 appeared problematic. As the difficulty of a question item and the ability of the person are measured on the same scale, it

is possible to calculate a numerical difference between them. Figure 1 below shows the output from Rasch analysis, where the probability of someone giving that response (in this case the type of explanation) is plotted against the difference between difficulty measure for choosing that response and the ability of the person answering the question. For example, for large differences between person ability and response difficulty, it is much more likely that the person will provide a high quality explanation. As the difference between person ability and response difficulty decreases, we would expect pupils to provide less advanced explanations. What we look for in Rasch analysis is that there are distinct probability 'peaks' – i.e. for a given difference between person ability and difficulty of response, there is an expected probable response associated with that. If the peaks are not distinct, that calls into question whether the responses are ordered correctly, and whether response categories should be combined. In Figure 1 below, we can see that there are distinct peaks for responses 1, 2 and 5. There are no distinct probability peaks for 3 and 4 as there should be for well-ordered categories.

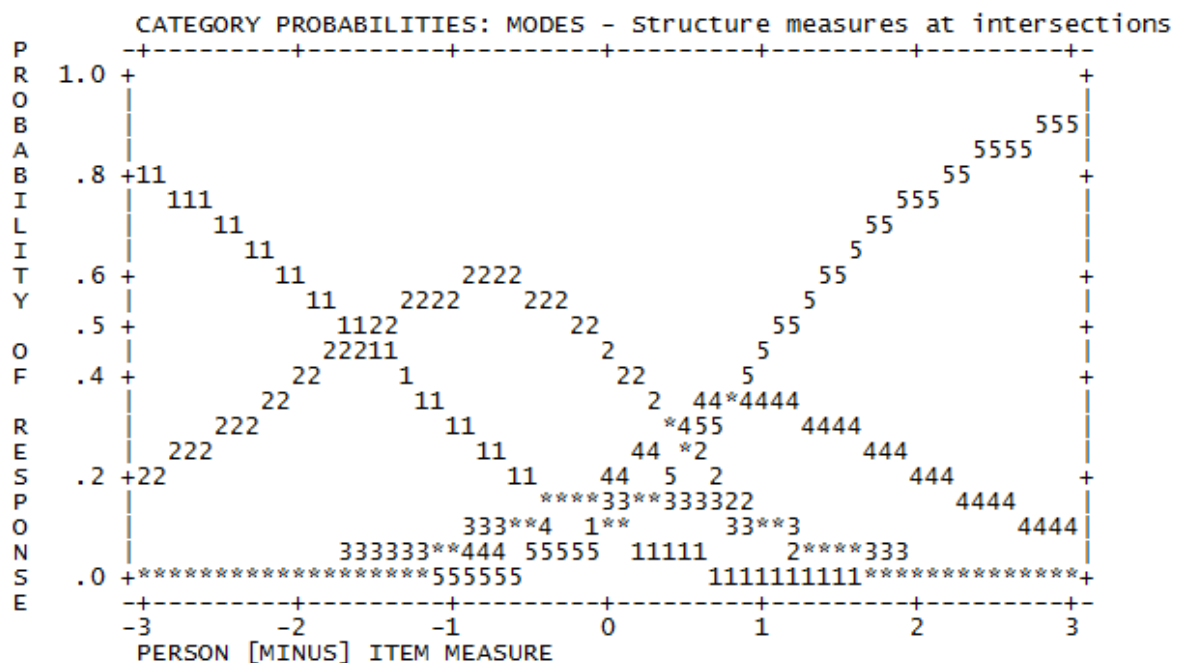


Figure 1: Category probabilities

As a result, categories 3 (reasonable diagram) and 4 (correct explanation) were collapsed together with 3 collapsed into 4. This ensured that the categories appeared to be well ordered (see Figure 2).

Categories 3 and 4 each indicate some partial degree of correctness, but not as much as both together.

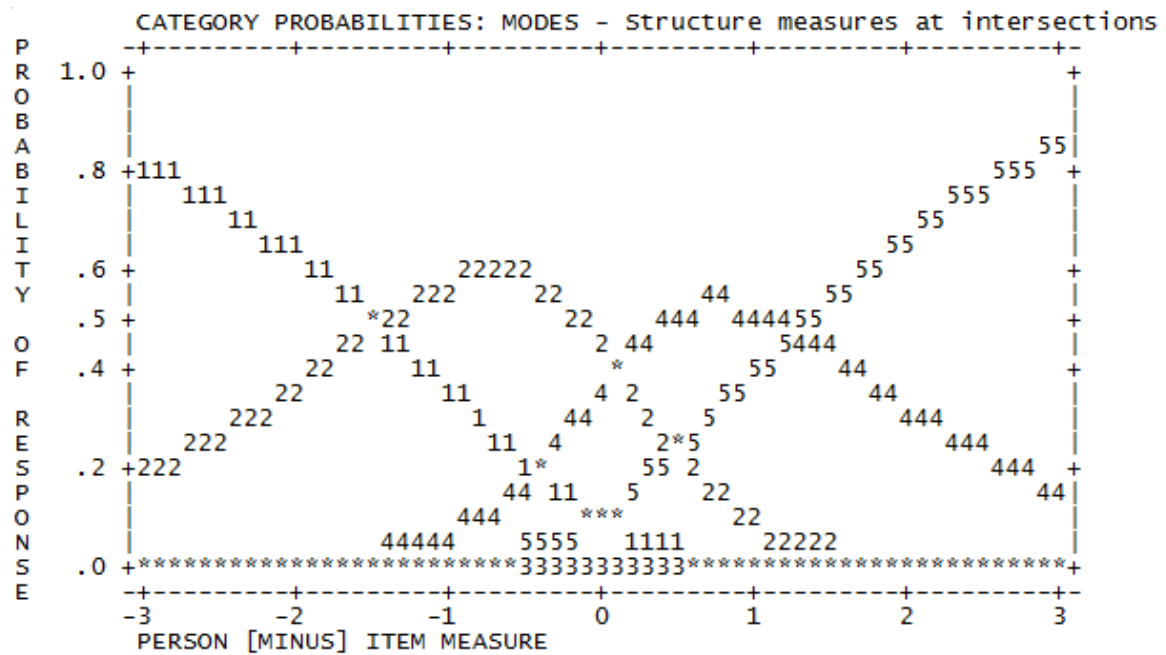


Figure 2: Category probabilities after collapse of 3 into 4

With the collapsed categories, the estimated reliability of the measure of student ability using all of the above questions was Cronbach $\alpha = 0.79$, which is above the conventional value for reliable measures of 0.7. The measure of pupil ability using these items, with the explanations accounted for, was, therefore, considered to be a reliable measure.

A measure of the pupil's abilities can be calculated using the Rasch Analysis. The average values for the abilities of the Project and control group pupils are given in Table 3.

Table 3: Results of Rasch Analysis

Group	Mean	Std. Deviation
Control	-1.37	.66
Project	-.69	.65

Using an independent samples t-test, the difference in means between the two groups was found to be significant at the 1% level ($p < 0.001$). The result of the t test indicates that the Project group pupils showed a higher average ability in solving these types of problem and explaining the strategies they used to solve them, than the matched Control group pupils. In terms of effect size, the difference between the two groups corresponded to an effect size of 1.05, $\{(-0.69 - -1.37)/0.65 = 1.05\}$, or a difference of over one standard deviation in favour of the Project pupils. Cohen (1969) categorises effect sizes of 0.3, 0.5 and 0.7 standard deviations as 'small', 'medium' and 'large' respectively. The difference between the two groups could, therefore, be considered to be very large.

Bond, T. G., & Fox, C. M. (2007). Applying the Rasch model (2nd Edition). Mahwah, NJ: Lawrence Erlbaum Associates.

Cohen, J. (1969). Statistical power analysis for the behavioural sciences. New York: Academic Press.

The Rasch analysis, and the statistics that are derived from it, indicate that the pupils who experienced the RME approach and the MiC materials during Year 7, show considerably more ability in solving this set of problem items than the pupils from the control group. Not only were the Project pupils more likely to get the correct answer for a particular item they were also better able to explain and communicate their strategies.

6. Case studies: observation of RME classes

In June and July 2011 the evaluator visited three schools in the Greater Manchester Area where at least some of the teachers are using the RME approach in their mathematics lessons. Four lessons were observed, three with Year 8 classes and one with a Year 10 class.

Lesson Observation 1

Year 8, 11-16 school; lower ability set; 20 pupils in class

There was no apparent written lesson plan, but the teacher clearly knew what he was going to do, and had the required resources readily to hand.

The desks were arranged as islands with groups of pupils at each set of desks.

The lesson was about triangles, a new topic for this class this year. The objective, which was deliberately not shared with the pupils until the conclusion of the lesson, was to discern whether, or not, three given lengths would form a triangle.

The teacher started by telling the class the topic area and then the pupils were organised into pairs with a mini white board, one to act as scribe, and given the task of writing down facts about triangles. They were given two minutes to do this before sharing with other pairs, asking 'what have you got that we haven't?' All pupils were actively engaged and moving round the class getting more ideas before going back to their desks. From their findings, pupils then decided a league table of facts: which were the most common? The rapid pace was continued with pupils being encouraged by the teacher to make up their minds quickly and be ready to report back; this was done as a class plenary.

The teacher challenged some of the pupils' responses, such as "180 degrees", and asked "what does it mean?" He also asked "how many different types of triangle are there?" The ensuing discussion involved the whole class in deciding the answer and what the important features of a triangle are. The

teacher used the term vertices rather than corners, but without emphasising it, just saying it was agreed that it was clearly an important feature of a triangle that it has three vertices.

The teacher moved the class onto a practical activity. He had come prepared with spaghetti, which would be broken up to form the sides of a triangle. The pupils were breaking off various lengths of spaghetti and measuring them, the teacher noting it only needed to be approximate. The pupils decided whether or not their three lengths formed a triangle and recorded the result in their exercise books. The activity then moved on, again at a pace, to a worksheet, which involved deciding whether a given set of three lengths would form a triangle. The results were tabulated and the pupils encouraged to say why, or why not, a triangle can, or cannot, be formed and to record the results on their worksheets. The pupils had four different worksheets between them so there should have been some repetition of results. The teacher encouraged discussion of the results, inviting pupils to use the IWB. He emphasised it doesn't matter if you don't agree but asked why there might not be agreement.

The teacher then challenged the class; "do lengths of 3, 3 and 7 make a triangle", making skilful use of the IWB to illustrate the problem. The pupils having concluded they didn't, the teacher moved the discussion on. He asked "what about 3, 4 and 7?" Many pupils contributed a view, until one pupil said with authority, "because 3 and 4 is 7, it will make a straight line." The teacher simply asked the class if she was right, immediately saying "what about 3, 3 and 6?"

The question was left unanswered, ready to move on next time, leaving the pupils with a homework task of finding pictures of triangles from magazines and the internet, to bring to the next lesson.

The teacher explained to the evaluator that he would use the spaghetti as the link by which the pupils would recollect what they had done in this lesson, when starting the next.

The pace of this lesson was rapid with little respite for the teacher or the pupils, all of whom seemed to be actively engaged in what they had been asked to do.

There was no opportunity to interview any of these pupils outside the lesson, but the evaluator did circulate and ask some of them two questions.

- (1) "Can you explain to me what you are doing?"
- (2) "Can you explain to me what a ratio table is?"

To the first question, pupils gave the somewhat predictable answer of finding out about triangles; they struggled to explain what a ratio table is until the evaluator suggested they give an example. Contexts were then recollected and the pupils asked were able to give a fair description of what a ratio table is and how they had used one in their problem, ably assisted by their

colleagues. They were aware of the link between a ratio table and finding percentages.

Lesson Observation 2

Year 8, 11-16 school; lower ability set (set 6 of 7); 14 pupils in class

The teacher had a detailed written lesson plan in the format of a three part lesson.

The desks were arranged in rows facing the IWB

The lesson plan had as objective: to identify and discuss different ways of sharing out sandwiches; to describe the amount of sandwiches that each person can get.

The lesson was really about fractions and equivalent fractions although the terms were hardly used during the lesson.

The starter to the lesson simply introduced the idea of sandwiches, using a sandwich shop the pupils might have been familiar with. Using information on the IWB, the class discussed how big is a sandwich and what is a good deal for the cost. This was basically arithmetic with the pupils adding up costs on their mini-whiteboards (no calculators), and sharing and discussing their results. The teacher invited some pupils to share their answers with the class, and, more importantly, how they had obtained them. There was some discussion over the “right answer”, as there was disagreement amongst the pupils. It emerged that one group had made a mistake, which they accepted.

The main body of the lesson was a MiC based activity, *Some of the Parts*, using worksheets, about sharing out sandwiches amongst a group of friends, only with the number of sandwiches and the size of the group varying. The pupils were asked to put an appropriate title in their exercise books and they would record their results there.

The pupils were given only a minute to discuss with each other, in pairs or small groups, which people in the groups of friends would get the most or least sandwiches if they were shared out fairly. The pupils clearly understood the problem, and most were engaged with it. The pupils were then asked to give their answers and share them in discussion with the class; the word fraction wasn't mentioned. The activity moved on to the pupils colouring in or shading parts of the sandwich to show where it would be cut up to allow the sharing out. The teacher kept the pace moving and encouraged all pupils to participate by circulating and prompting questions or responding to pupils' queries. She emphasised the need for them to make decisions.

The lesson then moved to a plenary sharing of results. One pupil was asked, in one case, how much each friend would get. He called it “half” and the teacher asked how it might be written and the usual notation was offered by a pupil. This developed into cut the half in half and what have we got now; the pupils understood it was a quarter and could write it in the conventional

notation. One pupil explained that, if the sandwich was cut into four and each friend got two parts then they would have a half. So this was establishing the equivalent fractions of two quarters and a half, and how it might be written in the usual notation. The teacher continued the discussion, asking why it might be better to cut a sandwich into quarters rather than just in half, eliciting some sensible suggestions from the pupils. Another pupil, who had worked with a different worksheet, was invited to share her results with the class, using the IWB. The teacher then led a discussion on whether she was right. She asked “how do we know if she is right and whether the parts of the sandwich will be shared out fairly”? Another pupil was able to explain why it was fair.

The teacher then asked the class to write down three quarters and invited a pupil to explain what it meant. Pupils did find this difficult but the teacher illustrated how one half plus one quarter became three quarters, and asked the pupils to explain how the picture showed this, which some were able to do.

The lesson ended here with questions similar to those on the worksheet set as homework. However, each pupil was asked in turn what he or she had got from the lesson today and had to answer before being allowed to leave the room. Most of the pupils were able to successfully verbalise a summary of what they had done. All the pupils had contributed to this lesson, many of them showing confidence when explaining to others, and others accepting when they were wrong and another’s strategy led to the right answer.

Interview with a group of Year 8 pupils

A group of six of these pupils had been made available for a short interview before the lesson started. The evaluator firstly asked them to describe some of the things they had done in maths lessons recently. They did find it difficult to articulate (no doubt somewhat nervous), but talked about circles, which they had investigated through considering ferris wheels, and also patterns and how they could relate to various sequences. They had also used the ratio tables in a problem on witches’ potions which had clearly appealed to them.

The pupils were asked how they felt about the problem solving activities they had been given. They said they found it fun, it wasn’t boring. They often used worksheets but they sometimes played games. The problems were sometimes challenging but the teacher helped them. They said they talked with each other about solving problems in different ways. They thought that working together had raised their confidence in doing maths.

They talked about a recent activity they had done on number patterns related to shapes. They had found lots of ways of thinking about it, and felt it had helped their understanding; they could see maths related to real life problems. They looked forward to their maths lessons because they were both fun and sometimes challenging.

These pupils thought they were getting better at maths. The way of working was new to them when they arrived at the school in Year 7, and it was quite a contrast to their primary school experiences, but they were much more

receptive to it, now in their second year at the school. They wanted their lessons to continue in a similar way with physical activities and related worksheets on various problems, and would like to use computers occasionally. In summary, they like their maths lessons and the way they are being taught.

Interview with the Teacher

An in depth interview was conducted face to face with the class teacher before the lesson. A full transcript of this interview is at the end of this section.

Lesson Observation 3

Year 10, 11-16 school; top set; about 30 pupils in class

There was no apparent written lesson plan, but the teacher clearly knew what she was going to do, and had the required resources readily to hand.

The desks were arranged in rows facing the IWB.

The teacher started by reviewing the last lesson. The pupils had been using the higher level draft MSM book *Seeing the Solution* and had been working on problems involving combination tables (which traditionally would have been called in context simultaneous equations). The pupils recollected the problem when asked; it had been about the cost of playing pitch and putt for various combinations of adults and children. The teacher asked some of the class members to recollect the strategies they had used in investigating the problem, which essentially was what else can you find out from the information you have been given? (Not “what is the cost for one adult and one child?”)

A new problem was introduced from the book, about the cost of buying various combinations of items from a shop and comparing the costs with those same items sold from a van. The teacher set the class a 5 minute challenge to see what other results they could come up with, using the information given in the book. Some pupils worked alone, but most were discussing the problem in pairs and all were engaged in some way. The pupils were then encouraged to discuss their findings with other pupils sitting nearby, explaining their strategies and how they had got their results. The strategies involved ways of adding and subtracting multiples of the given combinations and derived combinations, but in an open exploratory way, rather than looking for the cost of each item, which would be the more traditional algebraic approach to solving the problem.

The teacher moved the class to a plenary session and invited one pupil to come to the IWB to explain his strategy to the class. He clearly articulated what he had done. Another teacher present asked the pupil what assumptions he was making in the context of the problem and whether this limited his results, the basic assumption being that the prices hadn't changed. The teacher opened the plenary to the class asking if they agreed, which most seemed to, and then the teacher asked “can you find the cost of each item?” Most pupils could do this and agreed the answers between them.

The teacher moved the pupils onto a similar problem, but in this problem the pupils were introduced to an algebraic notation to represent the information they had been given. The teacher invited another pupil to come to the board to explain a result. He started to do this but another pupil questioned whether his explanation made sense asking “what if the prices were different in different shops?” This picked up on the previous point raised by the teacher about assumptions. The pupil was still at the IWB trying to sort out his thoughts, and being offered help from other members of the class. The pupil explained he felt uncomfortable with the “algebra” and wanted to go back to the more familiar combination tables, which sparked discussion on going from pictures, to a combination table to an algebraic representation.

The teacher then challenged the class with the question; there are two things we are trying to find; how many rows in the combination table do we need to set up? She didn't invite answers but asked the pupils to explore the question using one of the problems from the book. The pupils did their written work on the associated worksheet. She gave them three minutes to explore the problem, but there was some unrest. This problem had an impossible answer in the context, (deliberately so it appeared) leading to a lot of discussion. However, the teacher returned the focus to the combination table she had put on the IWB and invited explanations on how the values had been obtained and were they valid? This led to an in context suggestion that it is valid if the prices are fixed but what if one shop has an offer on? There was further discussion before general agreement that the tables only made sense if the prices stayed fixed. So what of the apparent price of -90p? Pupils decided that perhaps the original information was wrong.

The teacher then moved on to a related problem, posed in pictures and asked a pupil how it might be represented as an equation. Another pupil questioned his choice of notation which led to discussion about the appropriate notation to use. Having got an equation, the teacher wrote up some multiples of it, and invited stories from the class to describe what she had done; what could the new equations represent? She got several suggestions.

The lesson was coming to an end, and the teacher invited someone to explain how the combination tables could be used to find the cost of each item. A pupil offered a clear explanation which others agreed was a good strategy. All the pupils in the class had been generally involved with these problems for an hour. They had learnt a great deal about setting up and solving simultaneous equations, although that term was never used in the lesson. It had all been about using combination tables to represent information given pictorially and in text, and what could then be derived from the information.

Interview with a group of Year 10 pupils

A group of three of these pupils was made available for a short interview after the lesson. The evaluator asked firstly, how the pupils were finding the mathematics now they were in Year 10. They agreed it was different to the KS3 years, and that it is harder now. They find it quite challenging; they said

you need to think in depth about the actual maths and why it happens rather than just doing it and why certain results emerge from the investigations.

When asked about what maths they had recently been working with, the pupils were able to talk about algebra and using letters to represent things. This had apparently not been in any context and with no pictures; they just had "to figure it out".

They also talked about investigating shapes and they had come across the circle theorems. The work with circles had introduced them to the idea of proof and how you convince yourself or others that the result found is definitely true. They had found the results working in groups and then discussed them as a whole class. They said this had been based in geometrical diagrams rather than a real life problem, but they were still asked by the teacher to explain their strategies and the results to the rest of the class which then led to the discussion about proof.

They described another shapes problem about how many pyramids will fit inside a cuboid. They noted how this had led to conflicting ideas. They had done some related practical work using nets, but they couldn't see any real-life use for that were doing, except, perhaps, in building-design work. However, they did describe how a formula had emerged from the investigations, but agreed that "the journey", or how they had got to the formula was important; they needed the journey to understand the formula.

When asked about any other skills they thought they were gaining from the way they worked with mathematics, the pupils talked about presentation skills when coming to the front of the class and using the IWB, and speaking with confidence when presenting their strategies. They could also listen to others and agree or put an alternative point of view. These pupils said they liked solving problems and discussing their solutions. One offered a perspective of mathematics as riddles that can largely be resolved through common sense, but it was good to discuss things. They worked in a variety of ways, including on their own, in groups and as a whole class.. They liked sharing ideas or letting issues arise and then trying to resolve them. They noted the teacher doesn't always tell them who is right; they believed they remember results better if they are discussed and they can agree what is right. They found much of what they did to be fun, and thought this, with the interactive and practical nature of many of the lessons was helping them to understand, and thus remember things when they needed to.

The evaluator asked them to comment on the most recent lessons about combination tables. They thought that its introduction through pictures had been helpful, but one pupil in particular had clearly abstracted for himself what was going on. He said he could see how to solve the problem by what would be called traditional simultaneous equations algebraic methods. The pupils were in general agreement that pictures helped the lower ability pupils, but they were moving on from needing them.

When asked how they felt about mathematics in general and did they see themselves as wanting to study it at advanced level, these three, perhaps hand picked, all “loved maths”. One liked the logical way you can get to an answer, but also liked that there were often several ways to the same answer. He thought the best way was your own way. He liked being challenged and definitely wanted to continue his study of mathematics. He had heard of calculus and asked what that was. All three pupils agreed it took a while to understand things, but coming to an understanding was part of the challenge. They accepted that mathematics was important, as it is used in many ways in life, mentioning engineers and statisticians. One pupil noted that some of the work they had done on equations was useful in physics, where similar equations had arisen. They concluded that they enjoy the way they are taught mathematics and looked forward to the lessons.

Lesson Observation 4

Year 8, 11-16 school; mixed ability (levels 3 to 7); about 25 pupils in class
There was no apparent written lesson plan, but the teacher clearly knew what she was going to do, and had the required resources readily to hand.
The desks were arranged in traditional classroom arrangement facing the board.

The teacher noted to the evaluator that she was part time and only saw this class once a week, so there was sometimes a continuity problem. The lesson today was about proportions and the pupils would be using ratio tables. She started with a recipe for “fish pie for four people”, and asked the class “what can we find out from this?” She elicited various ideas such as doubling it and the teacher asked the pupil to explain what that meant. She then posed the question “how can we find out what is needed to make the fish pie for just one person?” She set up part of a ratio table on the board, and asked the pupils to copy it into their exercise books and asked “how can we start to fill it in?” In the discussion, pupils noted it is easy to do even numbers of people but not odd numbers. She asked pupils to describe their strategies for getting to the recipe for six people. The pupils who were asked to explain their strategy were able to do so, explaining “you halve to get to two then times by three.” She reminded the class they had used similar strategies in their last lesson with her, a week ago. She then asked the pupils to fill it in the table and continue it as much as they could. The pupils all seemed to be engaged in this task and were willing to help each other, in their pairs at the desks, and with near neighbours. She invited a pupil to come to the board and write up his table and then to explain how he had worked out the numbers. This pupil, in trying to explain how to get to one person, said you divide 4 by 240, rather than vice-versa, which led to an aside discussion on what was meant by division and how we should describe it.

The pace of this lesson seemed slow, but all the pupils appeared to be working, but with some contributing more than others. They were generally well behaved.

The teacher continued with the theme of division but now bringing it back to the problem and invited the pupil to do the division by four, and to talk about

what he was thinking, which was he would “halve it and halve it again”. Having got to an answer, the teacher asked how it might be checked, with the pupil offering that you could “times by three and see if you get half of the recipe for six”. He was clearly showing some understanding and further discussion with the class suggested that they all were.

The teacher then moved the pupils on to a worksheet with more recipes, one of which was an extension of the fish pie recipe they had already had a look at. Although the teacher did clarify the task, some pupils were soon “stuck” and started to become inattentive. The teacher readily made calculators available to those who wanted to use them, and encouraged the pupils to help each other, which got the pupils all back on task. The teacher encouraged the pupils to finish their tables as she wanted to move on, but a somewhat heated discussion had arisen between two pupils about fractions and what was a half of a half. The teacher intervened taking the opportunity to discuss what it meant, with most satisfied that the answer was a quarter, which could be verified on the calculator.

The lesson was coming towards its end, and the teacher brought the class back together to focus on the strategies they had used with the recipes. She asked them each to write down in their books three strategies they had used today which most seemed able to do, although just what they were writing couldn't be discerned! The pupils ended the lesson by reviewing what they had done over the last four weeks (four lessons) and the various contexts in which they had used ratio tables. Some pupils were clearly having problems recollecting, illustrating the continuity problem, although when probed...“what about the ribbons?...what about the cheese?...what about the percentages?” most pupils seemed to remember. She asked what other contexts a ratio table might be useful in, giving the example of speed, and “if we are going at 60 mph how far will we go in two hours?” The pupils offered a range of ideas, before the teacher brought the lesson to a close.

It was not possible to interview any of these pupils and so get any assessment of what they had learnt on ratio tables, but it was clear, when watching them at work, that at least most of them understood and could use the idea.

Good practice in the RME approach

It is a limitation that it was only possible to observe four teachers using the RME approach. It should also be noted that these four teachers were all quite willing to be observed and were advocates for the RME approach. However, there were some commonalities in the lessons from which some principles of good practice can be discerned.

Preparation

Teachers need to be well prepared; they need to know what they want the pupils to get out of the lesson and to have suitable activities planned and the required resources readily to hand. They need to have planned the time to be spent on each activity.

Delivery

If appropriate, teachers should relate the work they will be doing in the current lesson to pupils' previous experience. They should have a variety of activities planned which might include pupils working on a problem as individuals, in pairs, and in larger groups. Pupils should be encouraged to keep a record of their results and how they got them.

The teacher needs to keep the pace moving swiftly, with planned time allowances on each activity, but also to allow this to be flexible, depending on the pupils' response. However, teachers do need to judge when to move on, so that all pupils stay engaged with the lesson.

Teachers should allow plenty of time for reporting back, both within groups and as a whole class. This should involve as many pupils as possible in explaining their problem solving strategies to the class, making use of the IWB.

It is important for the teacher to bring out the key points emerging from class discussion, and then to relate this to the next task or activity set to the class. Towards the end of the lesson, the teacher should review with the pupils what they have done in the lesson and relate it to a homework task, if appropriate, and to what they will be doing in the next lesson.

Interview with the Teacher of Lesson Observation 2

The transcript from this interview is reproduced here, more or less in full. The teacher, who is Head of Department, is clearly highly committed to the RME approach, believes in the learning theories behind it and wants to teach this way. The interview highlights many of the positive points of the RME approach and how she has adapted it for use in her department. However, the interview also highlights many of the issues and barriers to its full implementation within one school, let alone amongst a group of schools; this will need to be addressed if there is to be successful wider use of the RME approach in schools across the country.

Do all the staff in the department use RME methods?

You can't insist on it because people... you need to be with it to be able to make it successful, if that makes sense, you need to be able to embrace it to work and... you can't force it. We've done lots of department training on it together, but still I can't then say, 'You need to use the books,' and so on.

How many staff do you have here?

Permanent full-time maths staff... we have six.

And how many of you would you say are using it?

I would say I use it the most, out of everybody. Other people dip in and out of it. Nobody really starts at the beginning of the book and works through the book. I don't even do that. But with everybody - most people dip in and out of it. Our scheme of work is kind of

objective-based really, there's no text book or anything like that, so people get resources from all different areas and this is one of the resources that they use. I'd say, because of the training that we've done as a department together, with this and with the Making Sense of Maths project, the KS4 one, that people use the ideas behind it, maybe, more than they do the resources, or equally as much as they do the resources.

So what would you say are the ideas behind it? What makes RME different?

I'd say that there's no sort of push or need to formalise things as much. That's maybe not an idea behind it, but that's one of the outcomes of it. I would say, working with what pupils already know, in that establishing at the beginning of each lesson or the beginning of two lessons, a common ground if you like, not necessarily finding out what they've already done about a topic but establishing some sort of common starting point, like using the concepts, basically. Like today we're doing some work on fractions, and our common ground is going to be *Subway sandwiches*, and that's our starting point. So establishing that and then working from everybody being in the same position I think is the thing that I would say I think is the most significant.

Yes, that is interesting, because in the lesson objective here the word fractions isn't mentioned.

Yes, I mean that's one of the battles that we have really with this and with school objectives and lesson observations and so on, is that you have to compromise. School procedure is that pupils need to know what they're going to do in the lesson exactly, they need to know this and that but it doesn't always fit with the RME approach, and so there is a bit of a tension there sometimes. But I think if I was being observed, in the beginning I would have worried about that. I think now if I was being observed by the head teacher or whoever, I wouldn't hesitate to have an objective like the one for this lesson, although my initial thoughts were, we're doing a lesson on fractions as that is what is on my scheme of work. I don't necessarily think now that the pupils do need to know that.

That's interesting, because... you'd really rather not tell the pupils what they're learning, just let them learn it!

Yes, I find rather than it just being unnecessary, I actually find it's counterproductive. I feel like it's... I don't know how to describe it without sounding quite flowery. It feels like it's sort of forcing the maths upon them if you do it that way, whereas, with this, it feels a bit more like it's a bit more organic, it kind of comes from a common ground and works out, maybe not at the same rate for everybody, and maybe not everybody ends up at the same position. That's why it's hard to say, 'By the end of today's lesson everybody will have...' And the 'We are doing fractions today' kind of phrasing forces a sort of compartment on things that is unnatural, I think.

So do you have a scheme of work planned out week by week?

No, we have a two-year KS3 so these pupils have already taken their options to do GCSEs, and start from next year. We have a two-year plan and we have objective targets – you know, you will spend - a guideline is three weeks on this, and two weeks on this - and that's it, just twenty headings. That's really it. We have a more detailed KS4 one, but it's exam board based, related to that, so it's not restrictive in that you have to do things in a certain way, by a certain time.

Do you find your workload has gone up because of RME?

No. Well, in some respects I do. I think planning a lesson using RME is not... because there's a booklet there doesn't mean it's ready-planned, it's certainly not – but it gives you a starting point. So often I find that maybe I get an idea, I don't have to think of the ideas quite so independently, and I can get a starting point from here, but it's just as much work planning the lessons using these. I actually find in the lessons it's probably harder work. They're quite demanding lessons to teach, and teaching them for five hours, five days a week is really quite hard work. They're so discussion based, and so they're quite tiring.

I have been hearing in telephone interviews that the children seem to like that.
Yes, I know.

I just think of the contrast from when I started teaching, 1970s, would you believe, the ideal maths lesson was everybody was paying attention to teacher, and then I'd say, 'Do exercise whatever, on your own, in silence.' It just seems quite a contrast.

Well it is, and I think the whole department, whether they use these books or not, would prioritise discussion as one of the key elements – you know lessons have to be discussion based. There's a real kind of expectation now, certainly in this department, that you can't learn maths without discussing with other people and certainly you can't bring pupils on unless they discuss maths with other people. It's hard to bring pupils on unless they're discussing things, I think.

Do you find you get all the children involved, or are there any wallflower problems, as it were?

No. I mean, there are still some pupils who don't, but there are no confidence issues in this Year 8 group, and there are no confidence issues in my Year 9 group; although they're GCSE, they still follow the same scheme, and they are a group who have had me all the way through. There are no confidence issues in there; nobody's frightened to come up to the board, nobody's frightened to explain things, feeling that they're going to get things wrong. But there still are some pupils in my Year 10 and 11 groups that still suffer from confidence issues. I think, at the beginning, pupils were a bit reticent, but it seems so long

ago... very few children now that I teach are too frightened to come up to the board.

You mentioned Years 10 and 11, would they not have had this all the way through?

No. They won't have. If they've had me, then they will have had an awful lot more of it all the way through; if they've had other members of staff they will have had bits but not consistently. And I hate to say it, and it's a real problem, but by the time they reach Year 9, because of Year 9 doing GCSE and also in Year 10 and Year 11, it's so exam-focused that we really struggle. I wholeheartedly agree with the philosophy behind RME, but even I can't sustain it in lessons. I've tried my hardest to teach completely using the MSM programme, and I can't do it to fit in with the GCSEs, so I have to dip in and out. The exam focus kind of damages the confidence that they already built up, if you like; they get less and less confident the more and more exams they do. And because of tracking and so on, and targets – we start them with that from Year 9 now - so a lot of damage is done with GCSE exams unfortunately, so trying to do both the RME approach and prepare pupils for exams is really difficult.

So, how do you view the new GCSEs in that light?

Well, our Year 9s are doing the twin pilot and they've got their exam on Monday, and actually, I feel that the content suits this. And I feel that really just working on their confidence is enough to make them perform as well as they would do in the exam if they'd just focused on more traditional ways. Does that make sense? So confidence boosting is enough, in a way, to carry them a quarter of the way through the exam with the twin pilot type of questions. But again, the exam is on Monday and so I feel like we've still, for the last three weeks we've been focusing on the exam and saying, 'You're working towards it,' and so there's a very small pocket of time in a year where you're not actually preparing for an exam, it feels. So although I do, I feel that the material lends itself to it, the fear of them not performing in the exam still is there, and takes over for too much of the year, if you like. So it's doing a bit of both, really.

Would you say that it's a barrier to the development of RME?

Yes. I would say that the national exam structure and, more than that, the need for schools to continually develop in maths and English, the more damage it does to the freedom to learn in interesting ways and at the pace that the pupils need, and so on, and I feel it's so target, so exam-driven that it does a lot of damage. And it prevents us from being able to use Making Sense of Maths as intended, as it's difficult to pick in and out of it. It's very difficult to make actual proper use of Making Sense of Maths as intended within the RME philosophy. It's difficult to do when you dip in and out of, unless you're confident enough as a teacher to be able to create your own materials based around it, which I think I have now, and I think I've been doing this for a long time, and I think my natural way of teaching now ties in very

well with this. So I don't think many of my lessons are traditional any more, even exam-focused lessons. But for the rest of the department, they've not been quite as in touch with it, so they haven't had so long to marry it with their natural way of planning lessons and so on. I don't know if that makes sense?

It does, yes.

When I plan my lessons now, even if it's nothing to do with MSM, the philosophy behind it will still play a part in how I plan the lesson. So I still will try and create some common starting point and it'll still be very discussion-based, and it'll still be pupils sharing ideas, and it'll still be as much not leaping into the abstract as possible, and so on. It's hard to get to that point without spending years.

I find it interesting, in the evaluation I've found that certainly in schools where at least some teachers are using it, then there are sort of positive things being said about it. How do you feel in the Greater Manchester area – do you feel isolated?

Because of this, do you mean? No, I feel ...I feel that I wish other people would do it, I feel that other people are missing out from not doing it. I feel that this is something that really everybody should be doing, but to do it on your own is harder. I don't mean it's isolated in that I wish I wasn't doing it, and it doesn't make me want to do what everybody else is doing, but... I don't even think it is the Greater Manchester area, I think it's the school-driven targets and it's the government-driven targets or the, whatever, that really is holding us up.

No, by that I meant do you feel you've got support in the area?

Oh, yes, from other schools that are doing this, or from just generally?

Well, from other schools or wherever.

Yes, oh, generally. Yes, I get a lot of support from MMU, and if we needed any support they would probably be one of the first people I'd turn to. More than the local authority, because in the local authority there isn't somebody anymore really who unites schools. Any support we would need, I think I would probably turn to MMU first.

So no sort of maths inspector, or strategist or whatever they call them these days?

No, they've been fired. The government have stopped funding for that, so there isn't anybody. There's very little; there is the local authority maths collective but it's often too difficult to get to.

Sort of heads of department meeting?

There used to be a monthly, or a termly, head of department meeting, hosted by the strategy person, but that's stopped because the strategy person no longer exists. There's something that still goes on but it's too difficult to get to, to be honest, so I never could get a day off school for it, or a half a day, and so it's too difficult to get time out,

really. Yes. I feel that really our development as a department with this is all down to us, really. The school is very supportive, and the school would wholeheartedly be behind anything that they thought enhanced learning, and teaching and learning, even if it was different to what the rest of the school was doing. They can't help it, but targets are so over-arching that they hold us back a little bit. Is that what you mean in terms of support?

Yes.

There isn't much, but MMU are very good at supporting ...

At which point the children arrived.

7. Conclusions and Recommendations

There are many teachers across the Greater Manchester Area who have embraced RME; they understand how it is intended to work, believe in it and are generally successful in putting it into practice. There may be other teachers from the initial 2004/06 project who have left the area but are still using a RME approach but this isn't known. It was difficult to discern any difference in the views and experiences and concerns of the teachers interviewed in this evaluation and those from 2005-06, despite the current interviewees being more experienced in using the RME approach. What they have been able to do is adapt the approach to the circumstances in the schools in which they are teaching. However, it is also clear that there is a need for ongoing support and for teachers to be able to meet with each other and supporting trainers and researchers (MMU) to share and discuss their experiences of the RME approach. A local support network that may bring in other teachers new to RME would seem essential to the successful development of RME.

In many schools in the area there is a mix of RME teachers and more traditional teachers who follow the National Numeracy Strategy and use the three part lesson structure, with an explicit objective to be met and a lesson plan to follow. This might create conflict in some schools, although the two do seem to be able to exist side by side. It may, though, create confusion for pupils, who experience both types of teacher, particularly if a class is shared. For RME teachers, there is also a "cover" problem, of providing suitable work if they are to be absent from their class. How to get a whole school using the approach in an integrated manner remains a problem. It appears it may take several years to achieve in some places, and unless there is an RME "champion" in a school, it will probably never happen, unless there is a change in government policy. Some teachers hope the move to functional skills and the applications paper in the twin pilot GCSE will help to bring this about. However, teachers need to be clear that functional skills is about solving problems using mathematics that pupils have been taught, whereas RME is about using problems to discover and explore mathematics and to develop a deep understanding of it.

It is quite clear from the evaluation that no teacher can just pick up a RME book and use it with pupils effectively. They must be trained in how to use these materials and how the pupils are expected to respond in an RME lesson. The conflict with the NNS based ideas of lesson plans and time limited schemes of work against the need for RME to be fluid and flexible and unconstrained in terms of time demands was noted by many teachers. Members of senior management teams, and school inspectors, need to have an understanding of this, so maybe there should be a RME guide aimed at them. School senior managers and inspectors may also need guidance on evidence that RME “works”; they may ask where is the evidence it is preferable to the traditional NNS methods? Evidence does need to be gathered when it comes to formal examinations and progress as to how RME taught pupils fare and how many go on to study mathematics at advanced level. There is an issue that why should traditional teachers, or senior managers or inspectors not dismiss RME as just another innovative scheme whose influence will pass? There would appear to be a case for a much larger study along the lines of that reported in Section 5 of this evaluation on comparative pupil achievement, as long as what constitutes achievement in mathematics can be agreed. An item bank of suitable items, building on those used in the 2004/06 project, would form a suitable basis for gathering such evidence.

RME needs to be viewed as a long term project, with pupils being introduced to this approach in Year 7, and, possibly, earlier in the primary school, and then ideally developing over the five years of mathematics education through RME to GCSE. However, such ideal situations may not readily occur. There are many factors that affect the outcome at GCSE and it may prove to be very difficult, to say whether any significant difference in achievement at GCSE by pupils taught through RME methods compared to those taught by other methods was due to the teaching methods. The nature of the assessment itself would be an important factor in discerning any difference. The problem is confounded further in that some pupils may experience a variety of teaching methods throughout their school years, one of which could be the RME approach.

Teachers who are willing to use RME methods may face the criticism that it is not proper mathematics, which may come from colleagues, parents or the pupils themselves. Teachers need to be suitably trained and prepared to respond to such criticism. There are the associated issues of there being less day-to-day written work by pupils and of assessing their progress. Pupils may appear to be doing little in mathematics lessons because there is little written in their exercise books. How, then, are teachers to have objective evidence of a pupil’s progress; are regular tests appropriate or how should it done? The conflict intensifies in KS4 as the need to be prepared to respond to examination questions comes closer. Those supporting RME (MMU) need to offer guidance on this and to offer appropriate preparatory material.

There is a clearly a problem for some teachers and some pupils with some of the contexts in the books. The American nature of the MiC books has been a problem for many. Most of the teachers interviewed for this evaluation are

using the materials flexibly, but it will be an issue for teachers who come fresh to the scheme as to what, if anything, they can leave out. The training and accompanying teacher's guide to the materials will need to offer clear guidelines on this.

Recommendations

It has become clear, through this evaluation, that initial training in the philosophy of RME and the theory of learning that lies behind it is essential if teachers are to use it effectively. Equally essential is the availability of on-going support.

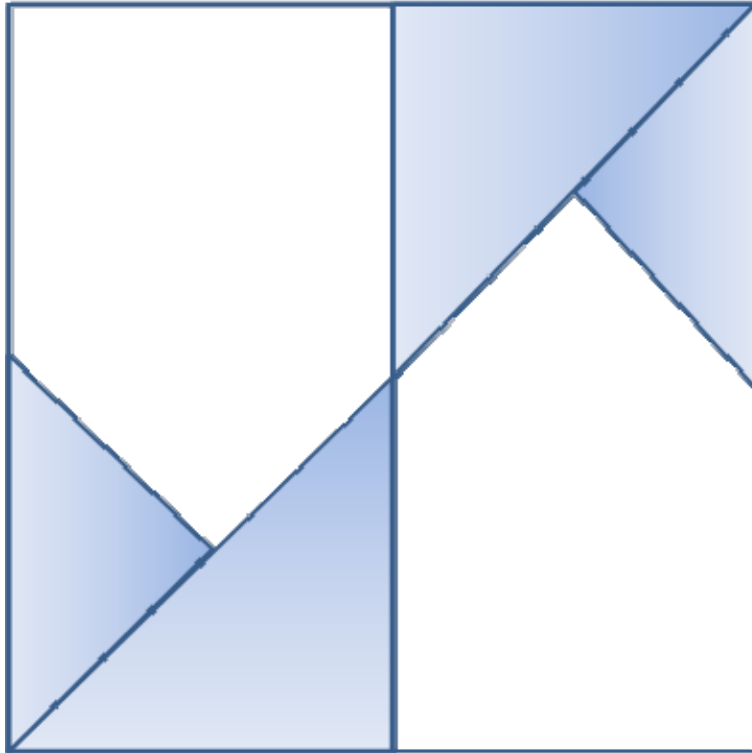
For a wider take up of the RME approach across England, the system that has evolved at Manchester, with MMU being the principal trainer and support provider, needs to be replicated in other cities. There needs to be a university department of mathematics education at the hub, with committed tutors, who themselves understand the RME philosophy. They then need to attract teachers into a project, perhaps through the carrot of a possible masters degree, much in the way that MEI's professional development programme, *Teaching Advanced Mathematics* (TAM), did. A publication similar to the TAM Gateway, which highlights the success of this project from the perspective of many teachers involved, with quotations of their views and experiences of RME, might attract teachers from elsewhere to become involved.

The MMU team should also take the opportunity to present the RME philosophy and approach and achievements at appropriate conferences and similar events, ideally supported by teachers, such as those from this evaluation, who have successfully put it into practice and thus can share this positive experience with other teachers and mathematics education professionals who are considering adopting or supporting the RME approach.

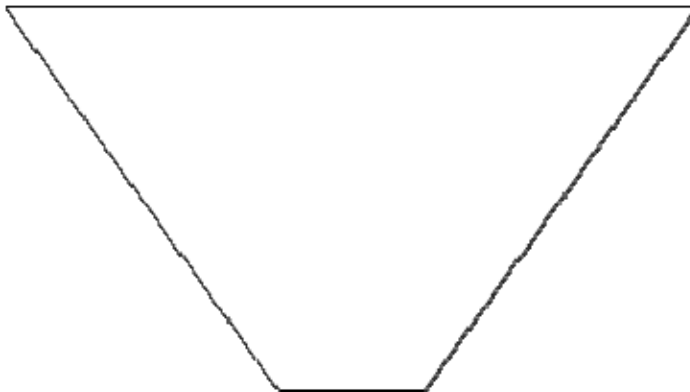
Appendix

RME test for Year 7 pupils

1. (a) Estimate what fraction of this square is shaded.
Explain carefully how you found your answer

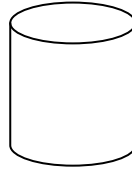


- (b) Find the area of the shape shown below.
Show carefully how you worked it out.

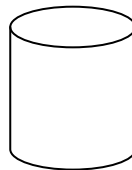


2. (a) Tape is sold in pieces $\frac{1}{3}$ of a metre long. Show how many pieces you can cut from a piece 4 metres long.

- (b) $\frac{3}{4}$ of this glass is full of orange.



- $\frac{1}{3}$ of this glass is full of orange.



Explain whether you can pour the second glass into the first without it overflowing.

**Onion soup Recipe for
8 people**

8 onions
2 pints of water
3 chicken stock cubes
2 dessertspoons of butter
 $\frac{1}{2}$ pint cream
1 teaspoon of parsley

4. The recipe shown is for 8 people.

If you were cooking for 6 people, explain how you would work out:

(a) How much water you would need?

(b) How much parsley you would need?

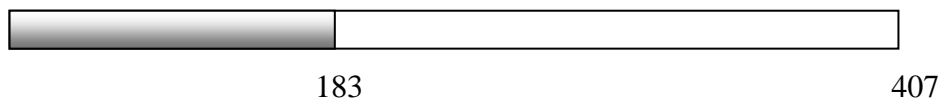
(c) How much cream you would need?

5. 407 people were asked to list their 3 favourite TV chefs. The following graphs show how many people had Delia Smith and Jamie Oliver on their lists.

People with Delia on their list



People with Jamie on their list



(a) Is it reasonable to say that roughly 45% of the people asked had put Jamie on their list? Explain why or why not.

(b) Show how to work out an estimate for what percentage had put Delia on their list.