Research Report DFE-RR207

The independent evaluation of the pilot of the linked pair of GCSEs in mathematics (MLP): Second Interim Report

Alpha*Plus* Consultancy Ltd

Department for Education

Table of contents

Table of tables

Executive summary

Introduction

This is the third of seven formative evaluation reports on the pilot of the linked pair of GCSEs in mathematics (MLP). A final summative evaluation report will be presented in December 2013.

The response to some of the criticisms of mathematics outlined in Adrian Smith's report, *Making Mathematics Count* (2004), was the development of a new programme of study (PoS) for mathematics that placed the emphasis on problem solving, functionality and mathematical thinking. New subject criteria and a new-specification single GCSE in mathematics were developed for first teaching from September 2010 alongside the pilot of the linked pair of GCSEs in mathematics.

The aims of the pilot qualifications, over and above those of the single GCSE in mathematics, were to:

- increase student commitment to, and engagement with, mathematics
- develop greater breadth and depth of subject skills and knowledge by providing two GCSEs, including additional content, to prepare students for progression to further study
- develop students' recognition of, and capacity to use, the different methods of enquiry encouraged by having two distinctive GCSEs.

Each qualification in the MLP is intended to have a distinctive quality, so that students are explicitly aware of the skills they are developing and the topics covered – and of their relationship to problem solving in everyday life, to mathematical conceptualisation, and to critical thinking.

The applications of mathematics GCSE is intended to:

> *assess skills relating to how mathematics is used to interpret, analyse and solve problems relating to a range of realistic contexts, including financial and statistical applications; place an additional emphasis on the interpretation of graphical information and the use of approximate methods.*

The methods in mathematics GCSE is intended to:

> *assess powers of reasoning and logical deduction; assess fluent use of symbolisation and exact methods of solution; assess understanding of probability.*

The focus for this report

Data collection and analysis for this report focused on the appropriateness of the MLP for different student groups and whether or not it provided value over and above the new-specification single GCSE in mathematics. The report addresses the following evaluation questions:

- To what extent are the wider aims of the MLP recognised by stakeholders and perceived to offer value over and above what is offered by the single GCSE?
- What is the perceived impact of the MLP on students' engagement with, and learning and understanding of, mathematics? The areas to be covered include: student engagement with, and commitment to, mathematics; the different methods of enquiry encouraged by teachers and developed by students working towards two distinctive qualifications in mathematics; the extent to which this promotes depth and breadth of understanding.
- To what extent are the MLP qualifications appropriate for different cohort groups and centre types?
- To what extent are wider policy changes – specifically the change in emphasis to 'core' curriculum subjects e.g. English Baccalaureate (EBacc) and the introduction of new performance measures (e.g. the 50% floor target for schools) – likely to affect the behaviour of centres and their attitude towards offering a pair of GCSEs?

Methodology

This report is based on the analysis of a range of sources and types of data collected (qualitative and quantitative): in-depth interviews and observations at case-study pilot centres; an online survey of pilot centres; interviews with wider stakeholder organisations, interviews with heads of mathematics at further pilot centres not included as case studies and at centres offering the single GCSE only;[1] a focus group with representatives from the four awarding organisations, and an analysis of statistical attainment data from the first two examination series. More information on these sources and data-types are given below.

The analysis in this report uses the number and profile of pilot centres participating at 31 August 2011. There were 267 pilot centres across the four awarding organisations: 97

[1] It was recognised that centres offering the single GCSE only may have little or no knowledge of the MLP. However, it was necessary to gain the wider perspective of single-GCSE-only centre views in order to address research questions on the appropriateness of the MLP in a range of contexts and for different cohorts. Single-GCSE-only centres were sent information about the MLP prior to the interview.

with AQA, 94 with Edexcel, 64 with OCR and 13 with WJEC (one centre was recorded as being registered with both Edexcel and OCR).

The MLP is only at the beginning of the second year of a three-year pilot, with the majority of centres only in the second year of a two-year programme of study. Findings must therefore be treated with caution.

In-depth interviews and observations at 10 case-study centres in autumn 2011 – further details on the case-study pilot centres can be found in Appendix 1 of the main report. A total of 17 lesson observations were undertaken across the 10 centres. A framework for the observations was developed, based on the work of Malcolm Swan.[2]

The online survey of pilot centres (September 2011): 105 (39%) of the 267 pilot centres completed the questionnaire; 75 (71%) of responding centres had also responded to the March 2011 survey, so 30 (29%) were new respondents. New centres were evenly split between those teaching only the MLP and those teaching both the MLP and the new single GCSE. Analysis of the centre characteristics shows the survey to be broadly representative of schools in the pilot, other than in relation to awarding organisations for the MLP, where OCR is under-represented and WJEC is a little over-represented.[3]

Statistical attainment data was received from each awarding organisation (AQA, Edexcel, OCR).[4] Data was received for the applications of mathematics GCSE (Applications), the methods in mathematics GCSE (Methods) and the mainstream GCSE. The data was combined to give a single dataset, which included data from the National Pupil Database (NPD) on prior attainment and census information.

Wider stakeholder interviews – representatives from 10 wider stakeholder organisations were invited to take part in a semi-structured interview during October 2011. The sample included subject associations,[5] professional bodies, and workforce development organisations. Data from six wider stakeholder organisation interviews has been used for this report.

Awarding organisation focus group – a focus group was held with representatives from the four awarding organisations involved in the pilot.

---

[2] The pedagogical framework has eight descriptors: high-order questioning, stretching and challenging, creating connections, encouraging reasoning, supporting development of strategies for investigation and problem solving, the value of mathematics, making learning explicit, and developing 'mathematical' language. The descriptors are useful, as they can be used to identify the aims of the MLP in classroom practice.

[3] There are only 13 WJEC centres in the pilot, so the figure of 62% equates to only 8 centres responding to the online survey.

[4] WJEC data was not included in the analysis, as first awards will not be made until 2012.

[5] This includes professional subject associations and other expert and advisory organisations.

Joint-offer and single-GCSE-only centre telephone interviews – the heads of mathematics from 33 centres were interviewed to complement the in-depth interviews at the 10 case-study pilot centres. The final sample generated was intended to get the views of centres with a good working knowledge of both the MLP and the new single GCSE, and those that offer only the single GCSE. Of these heads of mathematics, 11 represented centres that offered both the new single GCSE in mathematics and the MLP, 21 represented centres that offered the new single-GCSE-only and one only the iGCSE. The first 11 centres will be referred to as 'joint-offer centres' and the remaining 22 as 'single-GCSE-only' centres. The centre offering only the iGCSE has been included in the latter group to ensure that the anonymity of the centre is guaranteed. Further details on the joint-offer and single-GCSE-only centres can be found in Appendix 2 of the main report.

Summary of findings

When interpreting this round of data collection and analysis, it has been important to recognise that the MLP is still in an early stage of the pilot process. Impact can therefore be assessed only in terms of outcomes to date.

Representativeness of pilot centres and cohorts

Initial analysis of centre and student representativeness and participation suggests that the pilot cohort is not representative in terms of centre performance (Ofsted grade) or candidates' prior attainment at Key Stage 3 (KS3). There is a higher proportion than would be expected of centres that received an Ofsted grade of 'outstanding' in the MLP pilot and a lower proportion of centres that received a grade of 'satisfactory'. Although this may not indicate under- or over-representation in the types of school asking to participate in the pilot, it represents a small degree of un-representativeness in terms of actual participation – i.e. the pilot centres that have entered candidates for examinations so far. Based on examination entries, the MLP candidates to date comprise a higher proportion than would be expected of stronger candidates and fewer students eligible for free school meals (FSM), fewer ethnic minority students, fewer students whose first language is not English, and fewer students with a registered special educational need.

Problem solving and functionality in GCSE mathematics

Problem solving and functionality are central to mathematics at Key Stage 4 (KS4). The previous reports on the MLP have identified the lack of a shared understanding by centres of what problem solving and functionality mean in relation to mathematics teaching and learning generally and in particular in relation to the revised assessment objectives (AOs) for GCSE mathematics. The fact that stakeholders have no common definition for these terms across the range of instances and contexts in which they use them, such as the two MLP qualifications, is problematic. An absence of clear definitions might lead stakeholders to fail

to recognise and understand the different types of problem solving which the structure of the MLP promotes. The two previous MLP reports indicated that both effective teaching and assessment of problem solving and functionality are still in relatively early stages of their development. This is not an issue specific to the MLP: centres offering the MLP together with the single GCSE, awarding organisations and wider stakeholders all suggest that the issues regarding the teaching of problem solving are also evident for the single GCSE in mathematics.

Recognition and value of the wider aims of the MLP

The findings for this report have to be considered in the wider context of the high-stakes nature of mathematics in school performance targets (floor targets), which often results in schools narrowly focusing on preparing students for the examinations.[6] There is evidence across the range of primary and secondary data analysed for this study that schools focus strongly on C/D borderline students, monitoring them closely and providing additional intervention. The data shows that as a gate-keeper qualification, grade C at GCSE is important to students and centres. However, the emphasis on teaching to the test reported in the secondary data suggests the quality of teaching and learning for GCSE mathematics is often skewed by the focus on threshold attainment data. The importance of the C (and the A/A*) grade in mathematics at GCSE is evident in pilot centres' perceptions of 'value' of the MLP as well as in the extent to which centres have (or have not) changed their approaches to teaching and learning.

Most stakeholders from pilot centres and the wider stakeholder organisations interviewed recognise the value in the wider aims of the MLP, but there is currently no widespread recognition of how the structure and additional content of the two GCSEs are intended to work together to meet these aims. The 'value' of the MLP is interpreted differently across the pilot centres. Many pilot centres cited as their main reasons for taking part in the pilot the opportunity for students to gain two GCSEs in mathematics, together with the opportunity to stretch and challenge their students – but centres also reported that the opportunity for some students to have two chances to gain a C grade at GCSE influenced their decision to participate.

[6] Ofsted (2008) reported the use of 'booster' lessons, revision classes and extensive intervention, coupled with a heavy emphasis on 'teaching to the test'. While these strategies were successful in preparing students to gain the qualifications the narrow emphasis on 'disparate' skills did not necessarily support mathematical understanding. Ofsted (2008) *Mathematics: understanding the score*. London: Ofsted.

Heads of mathematics at pilot centres, joint-offer centres and even some single-GCSE-only centres[7] express enthusiasm for the qualifications. Wider stakeholders, too, refer to, and welcome, the 'potential' of the MLP – but this potential is still some way off being fulfilled. From the evidence of the case-study pilot centres, there appear to be two reasons for this: centres have not fully recognised the 'difference' promoted by the MLP; they are also nervous about embracing the full possibilities of the MLP because of perceived restrictions of time, lack of guidance on the range of pedagogies required, and uncertainty of the short-term impact of new teaching approaches on examination grades – especially for the traditionally higher-attaining students chasing A* grades or for the C/D borderline students.

In some of the pilot centres enthusiasm for the MLP was tempered, to some extent, by the fact that students did not do as well in the assessment as expected. Two of the case-study centres, however, despite the examination results, recognised and liked the challenge of the MLP but felt that they might need to consider whether the pilot was going to prevent their students getting the grade they wanted. Where early unit or examination results had been better than expected, some centres had also included additional cohorts of students (mainly C/D borderline students) in the pilot.

Perceived impact of the MLP on student engagement and students' learning and understanding of mathematics

The consensus was that for many students it was not a love of mathematics that promoted engagement and commitment but the extrinsic value of gaining the required grade at GCSE or the perceived relevance and usefulness of mathematics for further study or life. A minority of (higher-tier) students mentioned how they liked the way in which connections between different topics were now being made explicit to them.

A majority of the heads of mathematics from the case-study centres felt that their higher-attaining students were highly motivated and committed to their mathematics. Some accredited this to the MLP, but others felt that by Year 11 the higher-tier students were usually very focused on their mathematics and, in particular, on achieving their target grade (A*/A). Centres offering both the MLP and the new single GCSE found MLP students to be more engaged with and committed to mathematics than those doing the single GCSE. The applications of mathematics, and financial applications in particular, was cited as the main reason for enhanced student engagement with, commitment to and understanding of mathematics.

[7] Based on their current knowledge, some single-GCSE-only centres had the impression that the MLP would prepare students better for level 3 mathematics and related qualifications, because it introduces some A level materials and contains more added stretch and challenge than the new single GCSE.

Overall, students reported that enjoyment of, and to some extent engagement with, mathematics related directly to their levels of confidence and sense of achievement in the subject. There was often a stark contrast within the same case-study centre between how higher-tier and foundation-tier students felt about mathematics, which seemed to relate to prior as well as current experiences of success in mathematics as well as to how individual teachers related to and engaged students. Some stakeholders saw the MLP as providing a better foundation for studying mathematics at A level than the new single GCSE.

Breadth and depth of students' learning and understanding

There was broad support for the view that the MLP is encouraging a greater breadth and, to some extent, more in-depth understanding of mathematics than the new single GCSE in mathematics, by virtue of either the extra content or the structure of the linked pair. Of those centres participating in the online survey that offered the MLP and the new single-specification GCSE, most felt that the MLP was more successful than the new single GCSE in promoting the pedagogical approaches associated with effective mathematics teaching and learning and the wider aims of the MLP.

Many of the issues reported in terms of teaching and of students' learning and understanding of mathematics relate equally to the wider context of mathematics teaching at GCSE. Most centres remained enthusiastic about the opportunities the MLP offered, but there was still a tension between the pressure to 'teach to the test' and the exploration of new ways of teaching – which may be more effective in developing students' mathematical proficiency but are considered to be more time consuming.

Recognising the structure of the MLP in pedagogy

What is taught and how it is taught influence the type of knowledge students develop. The main focus of the problem solving that was seen in the majority of the MLP observations, or described by teachers, was applying mathematics in everyday contexts or scenarios: horizontal mathematisation – 'moving understanding from, or between, the everyday and the academic' – rather than vertical mathematisation – problem solving within the domain of academic mathematics (e.g. conceptualisation and theorising).[8] A minority of case-study centres recognised and/or promoted vertical mathematisation, and then only with higher-attaining students. The problem solving described by the case-study centres can generally be defined[9] in terms of word problems with arithmetical steps or worded contexts which

[8] Treffers, A (1987) *Three Dimensions: A Model of Goal and Theory Description in Mathematics Instruction – The Wiskobas Project.* Dordrecht: Reidel.

[9] For the analysis, Watson's (2009) typology of problem solving has been used see: Watson, A (2009) 'Key Understandings in Mathematics Learning – Paper 7: Modelling, problem-solving and integrating concepts', London: Nuffield Foundation.

require the learner to decide to use standard techniques. Relatively basic mathematics was generally required to reach a solution.

In a minority of case-study centres, problem solving either involved worded contexts in which there was no standard relationship to apply, or algorithm to use, but a solution was expected – or it entailed exploratory situations in which there was an ill-defined problem. With these exceptions, the problem solving observed or discussed related to a 'realistic' context rather than a mathematical context. The two latter types of problem solving offer opportunities for student-led peer or group working activities, but there was no evidence that this sort of interaction was regularly used in practice in the case-study centres.

Problem solving was not described by case-study teachers in terms of abstract, mathematical problems that require methods of enquiry and thinking specific to mathematics. Nevertheless, many of the case-study teachers interviewed welcomed and valued the additional emphasis on proof in the MLP.

In a few centres depth was recognised in terms of creating connections across mathematics topics and developing conceptual knowledge and understanding. The lack of problem-solving activity within classrooms that provides opportunities for vertical mathematisation – i.e. creating connections by building on conceptual understanding and theorising – may explain why many case-study centres felt that the MLP promoted breadth rather than depth. Most of the problem solving observed or discussed at case-study centres involved applying known mathematics rather than using problem solving as a means of introducing new learning.

Several case-study centres reported being unsure about how much 'depth' was required and wanted more guidance from the awarding organisations. There was still nervousness in many of the case-study centres about teaching problem solving. Student-led, investigative approaches to learning mathematics were still an aspiration for many of the centres – although the value of introducing such approaches to student learning was acknowledged. Many of the case-study centres felt that these approaches would support students to become more-independent thinkers and learners, and the centres either had introduced these ideas with younger students in the school, or were planning to do so. However, centres continued to express concern that more student-led group and peer problem-solving activities would reduce the time available to cover the content, especially in foundation-tier classes. The majority of teachers nevertheless recognised the need to change their teaching approaches and were looking for resources to do this. At present centres continue to be overly reliant on textbooks and resources generated by the awarding organisations.

There is some evidence to suggest that knowledge of mathematical methods is often tacit for mathematics teachers, which leads to them assuming such understanding in their own teaching rather than making the different methods explicit to their students.

Perceptions of time for effective teaching and learning

Many of the case-study centres still believe that there is insufficient time to teach the content for the MLP. This belief may be due, in part, to their use of early entry, re-sits and early certification to ensure students achieve at least a grade C in one mathematics GCSE by the end of Year 10. Centres are using assessment opportunities to optimise performance in respect of government targets, without necessarily optimising attainment for all students.

However, there is evidence to suggest that the MLP is helping to ensure a minimum of two years' study, with students continuing into Year 11 in many cases. Two of the case-study centres felt that a two-year GCSE course meant that there was time to do more than 'teach to the test'. Both of these centres had minimised re-sits, using the second GCSE as an opportunity to improve grades rather than re-sitting units.

The statistical data for results from the first year of the pilot also suggests that most MLP candidates taking qualifications in the first year of the pilot will continue to take mathematics in their second year. Almost all of the candidates who have completed one but not both of the MLP qualifications are in Year 10 or below, and 84% of those who have completed both MLP qualifications are in Year 11. Of the candidates with one or more unit entries but no completions, 95% are in Year 10 or below. Taken together, and also noting the requirements that (a) MLP candidates must attempt both qualifications, (b) candidates cannot take mainstream GCSE mathematics if they are participating in the pilot and (c) attempting GCSE mathematics is mandatory for most students at KS4, this suggests that most of the MLP candidates taking qualifications during Year 10 will go on to take further MLP units in Year 11.

MLP candidates are more likely to complete a mathematics qualification earlier than their mainstream equivalents (of those who have completed a mathematics qualification). This suggests that many MLP pilot centres are aiming to complete the MLP qualifications sequentially (mostly taking the methods in mathematics GCSE first, during the first year of teaching).

The KS3 mathematics level of attainment tends to be higher and the age slightly lower for candidates for MLP Methods, which may offer an explanation for relatively poor grades achieved for the methods in mathematics GCSE: the strongest candidates are being entered for MLP Methods, but at a slightly younger age, and are therefore performing less well (in comparison with Applications and mainstream mathematics). Awarding organisations

expressed the opinion that centres may be experimenting with entry patterns for MLP with different cohorts, using opportunities for early entry and re-sits.

Appropriateness of MLP for different cohort groups and centre contexts

There are mixed views on the appropriateness of the MLP for different cohort groups and centre contexts. Half of the centres taking part in the online survey felt that some groups of students were benefiting from the MLP while others were not – with the common (although not universal) view that higher-attaining students were benefiting but lower-attainers were not. This view is, however, tempered by indications from other centres that borderline C/D students are benefiting from either the increased opportunity to gain a grade C or the nature of the GCSEs.

The application of mathematics to everyday or realistic contexts was frequently cited as offering more relevance to students. Applications was considered to offer more and better opportunities for students to develop problem-solving skills than the single GCSE did. However, the more 'wordy' problem-solving tasks generated were thought to create barriers for some students whose low literacy levels meant that they found it hard to understand mathematical language and even some everyday language. There were, however, a few examples in the observations of foundation-tier lessons where mathematical language was being successfully introduced and understood by students.

There was no consensus across the range of centres interviewed as to which of the MLP qualifications was likely to be more challenging for lower-attaining students. There was some pattern emerging to suggest that single-GCSE-only centres with no experience of the MLP thought that Applications would be most accessible for lower-attaining students, whereas centres offering both the MLP and the single qualification considered Applications more challenging for this student group.

There was concern from many centres that the MLP had too much content for lower-attaining students, so two GCSEs would be challenging for students who already struggled with one GCSE. Conversely, there were some centres that felt that the MLP was not challenging enough for their higher-attaining students.

Impact of wider policy changes on centre behaviour and attitudes towards offering a pair of GCSEs in mathematics

In response to questions in the online survey about the possible effect that changes in government policy may have on their decision to offer the MLP in mathematics, pilot centres largely indicated that the changes would have no effect on their decision. Where an effect is foreseen, it seems set to make centres more likely to offer the MLP, by a factor of approximately three to one. It should, however, be recognised that at this stage the responses can be based only on early perceptions.

The value of a move to linear-only assessment was recognised by many of the centres, although there was concern that this was likely to affect the results of lower-attaining students who benefited from the ability to 'chunk' their learning and revision for unitised assessment. Several case-study centres reported a flexible use of the unitised approach, using the assessment in a linear form as appropriate for their groups of students. Feedback from centres suggested that many would, if possible, enter students for one MLP GCSE one year and the other at the end of the following year, to ease the pressure on students.

Generally, students were concerned that taking examinations for two mathematics GCSEs at the end of Year 11 would be very stressful.

1 Introduction to the second interim report

This is the third of seven formative evaluation reports on the pilot of the linked pair of GCSEs in mathematics (MLP). A final summative evaluation report will be presented in December 2013.

The government is reviewing the National Curriculum requirements for mathematics and will take decisions on the number and content of mathematics GCSEs in the light of the review. Evidence from the pilot will also inform decisions. The government expects new GCSEs to be introduced for first teaching in 2015, subject to decisions on phasing in of the new curriculum at KS4.

1.1 Background to the pilot and the evaluation

The impetus for change to the assessment of mathematics at GCSE level began with Adrian Smith's report, *Making Mathematics Count* (2004). Smith concluded that GCSE mathematics:

- was content-heavy – the 'complexity, process skills, rigour and amount of work required' were too much for a single GCSE when compared with the double award then available for science or two GCSEs in English
- lacked stretch and challenge for the top 10% of students
- was inadequate preparation for progression beyond level 2
- was perceived by many students as irrelevant and boring.

The response to some of these criticisms was the development of a new programme of study (PoS) for mathematics that placed the emphasis on problem solving, functionality and mathematical thinking. New subject criteria and a new-specification single GCSE in

mathematics were developed for first teaching in September 2010, alongside the pilot of the linked pair of GCSEs in mathematics.

Before the government announced the linked pair of GCSEs in 2008, earlier qualifications, developed as a response to Smith, had been piloted but not launched in the wake of the pilot.[10] The single-specification GCSE and the pilot qualifications[11] were both developed with the three aims of increasing engagement and participation in mathematics at GCSE and beyond, enabling understanding of the relevance of mathematics, and offering opportunities to stretch and challenge all students. There were also specific additional aims for the linked pair of GCSEs.

The philosophy behind the linked pair of GCSEs was to provide learners with a 'rich experience' of mathematics, enabling them to recognise its importance in solving problems relating to both mathematics and everyday life, to understand how mathematics works in the real world (applications of mathematics), and to engage in more-conceptual thinking (methods in mathematics).

In April 2009 Ofqual approved the criteria for the linked pair of GCSEs in mathematics:

> *The linked pair of GCSEs will cover the rigorous core national curriculum programme of study, which is also assessed by the single GCSE. The pair will, in addition, give a broader grounding in both methods in mathematics and applications of mathematics. One of the GCSEs will focus primarily on applications of mathematics in contexts that are relevant to the real world (including financial and statistical applications), and the other will focus on mathematical reasoning and analysis. This will give more opportunities for students to see how mathematics works in the real world (applications of mathematics) and to engage in more conceptual thinking (methods in mathematics).*[12]

Each qualification in the MLP is intended to have a distinctive quality, so that students are explicitly aware of the skills they are developing, the topics covered – and of the relationship to problem solving in everyday life, to mathematical conceptualisation, and to critical thinking.

The applications of mathematics GCSE is intended to:

---

[10] The Mathematics Pathways project developed and piloted a possible model for two GCSEs in mathematics on the same PoS, but with different emphases. The pathways model was found to be inconsistent with the 2008 regulatory requirements and therefore could not be launched in the wake of the pilot (Alpha*Plus*, MLP pre-pilot report, December 2010).

[11] The linked pair of GCSEs together cover the national curriculum PoS (KS4); each includes additional content intended to give a broader grounding in both methods in mathematics and applications of mathematics. As neither of the qualifications on its own covers the KS4 PoS, students must be entered for both qualifications to ensure assessment of the entire KS4 PoS. The new single GCSE covers the full PoS and is 'nested' within the linked pair (AlphaPlus, MLP pre-pilot report, December 2010).

[12] QCDA (2009) http://webarchive.nationalarchives.gov.uk/20100314125737/qcda.gov.uk/24956.aspx

assess skills relating to how mathematics is used to interpret, analyse and solve problems relating to a range of realistic contexts, including financial and statistical applications; place an additional emphasis on the interpretation of graphical information and the use of approximate methods.

The methods in mathematics GCSE is intended to:

assess powers of reasoning and logical deduction; assess fluent use of symbolisation and exact methods of solution; assess understanding of probability.

Since summer 2009 assessment has been wholly through timed written examination following the removal of coursework and, since September 2010, the AOs for both the MLP and the new single GCSE are no longer set out largely in terms of subject content. Instead, they are set out as mathematical skills[13] which use the subject content; in the MLP these are weighted differently across the two GCSEs.[14] Unlike the legacy modular GCSEs, where mathematics is split by topic, each of the linked pair of GCSEs is unitised, with the subject content distributed across units. Assessment was unitised to allow pilot centres a greater degree of flexibility than a linear-only regime.

To summarise, the aims of the pilot qualifications, over and above those of the single GCSE in mathematics, were to:

- increase student commitment to mathematics, with increased engagement with the subject
- develop greater breadth and depth of subject skills and knowledge by undertaking two GCSEs, including additional content, to prepare students for progression to further study
- develop students' recognition of, and capacity to use, the different methods of enquiry encouraged by having two distinctive GCSEs

[13] AO1: recall and use knowledge of prescribed content; AO2: select and apply mathematical methods in a range of contexts; AO3: interpret and analyse problems and generate strategies to solve them. For the MLP, AO3 is different for methods in mathematics: interpret and analyse problems and use mathematical reasoning to solve them (methods in mathematics). AOs for the single GCSE are the same as applications of mathematics.

[14]

	AO1	AO2	AO3
Methods in mathematics	50–60%	15–25%	20–30%
Applications of mathematics	40–50%	30–40%	15–25%
Single GCSE mathematics	45–55%	25–35%	15–25%

1.1.1 Aims of the evaluation

The overall aim of the evaluation is to consider the extent to which the MLP offers a different experience of learning mathematics from the new-specification single GCSE. This is addressed by looking at:

- attitudes to mathematics – in particular, possible changes in:
    - students' engagement and participation in mathematics, within and beyond GCSE
    - stakeholders' attitudes towards, and understanding of, mathematics
- comparability of demand of the pilot qualifications both with each other and with other GCSEs in mathematics
    - the demand of each of the qualifications within the MLP and their comparability with the new-specification single GCSE in mathematics
    - challenges in the development of assessment for the MLP when compared with the new-specification single GCSE
    - possible changes to post-16 participation in mathematics, particularly progression to level 3
    - the extent to which two GCSEs in mathematics give appropriate recognition to the amount of content in KS4 mathematics and to perceptions of its value
- the views of centres (both pilot and non-pilot) on the pilot
    - the impact of the pilot on the nature of teaching and on learners' achievements in mathematics compared with the single GCSE in mathematics, and whether the additional aims for the MLP in mathematics pilot qualifications are being met
    - the impact of the pilot in the context of wider reforms, including issues of manageability for centres and learners
- the support offered to pilot centres by the awarding organisations
    - the nature and extent of the support offered
    - other identified support needs
    - the support that non-pilot centres will be likely to need if the qualifications become mainstream.

1.1.2 Summary of the main findings from the first interim report

The first interim report (December 2011) used the following data sources:

- In-depth interviews and observations at case-study centres – 13 case-study pilot centres and 3 non-pilot or single-GCSE-only case-study centres

- Pilot centre online survey – 112 responses (46%)
- Analysis of examination papers – November and/or January examination series for the new-specification single GCSE and the MLP.

1.1.2.1 Centre and student representation and participation in the pilot

- 244 centres were participating in the pilot (as at March 2011)
- There was under-representation of particular centre types in the pilot cohort – special schools, independent schools and further education institutions – and an over-representation of academies (compared with what would be expected by chance); there was the potential for under-representation of some student groups reported, particularly those eligible for FSM or with special educational needs (SEN) but not within mainstream education.
- Centres gave a range of reasons for participation in the pilot: the opportunity to stretch higher-attaining students, the opportunity for students to gain two GCSEs, enthusiasm about the pilot qualifications, the feeling that two GCSEs represent the level of effort and content in mathematics at GCSE, the belief that the MLP provides students with two opportunities to gain a GCSE at grade A*–C in mathematics, and that it provides better preparation for A level and life.
- Pilot centres were entering either whole-year cohorts or high attainers/gifted and talented students, with strong evidence of the current Year 11s and large numbers of Year 9 students being entered for examinations.

1.1.2.2 Teaching and learning

Where pilot centres reported that the MLP had necessitated design changes in the curriculum, or changes to their teaching, many also reported that the new single GCSE had had the same effect.

Centres were enthusiastic about the opportunities the MLP offered, but many of them would need to make considerable changes to teaching and learning if these opportunities were to be realised. How far centres were able to do this was reported as depending primarily on the extent to which they embraced a more student-led, challenging and open approach in their teaching. Centres recognised the need for some teacher input and modelling at this early stage but, in the majority of the lessons observed, reasoning and conceptualisation were mainly teacher-led and structured.

Observations in lessons in only in a minority of centres revealed high levels of effective questioning and the use of opportunities for the development of reasoning, problem-solving skills and making connections with other aspects of mathematics. These centres, however,

reported that this had been their approach to teaching before the changes in September 2010.

Centres expressed concern that more student-led group and peer problem-solving activities would reduce the time available to cover the content, especially in foundation-tier classes. There was a stark difference between foundation-tier and higher-tier lessons in the level of higher-order questioning and reasoning observed, with little evidence of this at all in the foundation-tier classes. The majority of teachers nevertheless recognised the need to change their teaching approaches and were looking for resources to do this.

Centres were working hard to incorporate more functional elements into their teaching and learning and to apply mathematics to everyday scenarios. In general, they understood the need to teach students how to approach less-structured problem-solving tasks, but there was still little evidence at this stage of students experiencing the entire problem-solving cycle.

Many of the case-study pilot centres were continuing to relate topics to GCSE grades and seemed unaware of the implications of the change to AOs and grade descriptions that require different mathematical behaviour from candidates.

1.1.2.3 The support offered to pilot centres by the awarding organisations

The pilot centres said they had received good support from awarding organisations, but they appear to be over-reliant on resources generated by these organisations. The early findings for the first interim report suggested that three levels of support may be required if all centres are to realise the full potential of the MLP. A minority of centres require a minimal level of input; most centres, however, although they recognise the need for change, will require support to implement planned changes to their teaching in terms of developing more skills-based, interactive approaches, and fully effecting the move from topic-based to process-skills assessment in their practice. A significant minority, however, require support to enable them to recognise that changes to their teaching and learning are needed.

Some teachers will also need to undertake continuing professional development (CPD) specifically to address the new content. The extent of the support they will require is likely to depend on where the centre in which they teach sits in the different levels of support identified above. The rate of change needed in teaching styles and approaches for the linked pair of GCSEs and the new single GCSE may affect lower-attaining students more, as they tend to find investigative approaches challenging.

1.1.2.4 Assessment

An initial scrutiny of the assessments, following the January 2011 examination series undertaken to give a benchmark for future analysis, suggested that:

- the weighting of marks for AO1, AO2 and AO3 are in line with the weightings required by the subject criteria[15]
- examination papers contain some questions that are unstructured and require longer chains of reasoning
- there was a relatively high level of analysing–procedural questions in the papers scrutinised.

Full suites of live papers were not available, so drawing any conclusions from the analysis and scrutiny would have been premature. Awarding organisations confirmed that the development of examination questions that assess problem-solving skills is on-going, and changes are being made that will be reflected in the questions in future papers. But, as examination questions are being written already for 2013, there may be insufficient time in the piloting phase for these to be evaluated fully. The report suggested that the speed and direction of change should be monitored, given the pilot timescales and the extent to which the changes will allow and encourage candidates to use higher-level mathematical skills, such as generalising and constructing arguments.

1.1.3 Focus for this report

Fieldwork for this report will build on what was learned from the case-study visits, classroom observations and the pilot centre online survey in the last round of data collection, with an emphasis on student attitude to and engagement with mathematics, evidence of classroom practice that makes explicit the different methods of enquiry the MLP encourages, the changes centres have made to their approaches to delivery (and reasons for the changes), teaching and learning, and the profile of students included in the pilot.

While recognising that the full range of cohort groups and contexts are not currently represented in the pilot, the report also considers data from wider stakeholders and single-GCSE-only centres on the extent to which the MLP qualifications may be appropriate for all cohort groups and centre contexts.

[15] AO1: recall and use knowledge of prescribed content; AO2: select and apply mathematical methods in a range of contexts; AO3: interpret and analyse problems and generate strategies to solve them (applications of mathematics) and interpret and analyse problems and use mathematical reasoning to solve them (methods in mathematics).

	AO1	AO2	AO3
Methods in mathematics	50–60%	15–25%	20–30%
Applications of mathematics	40–50%	30–40%	15–25%

The report also offers initial findings on the extent to which wider policy changes are likely to affect how centres behave and their attitudes towards offering a pair of GCSEs in mathematics in terms of:

- change in emphasis to 'core' curriculum subjects (e.g. EBacc)
- performance measures (e.g. the 50% floor target for schools)
- models of delivery and assessment (e.g. linear assessment).

The third interim report will extend and build on the findings reported here and will focus more on comparing the expected or actual progression to further study from the MLP with that from the single GCSE. Fieldwork will include visits to further case-study centres, follow-up telephone interviews with case-study centres visited in autumn 2011 for this report, and further wider stakeholder interviews.

1.1.4 The scope and limitations for this report

The MLP is only in the first months of the second year of a three-year pilot, with the majority of centres only in the second year of a two-year programme of study. Findings must therefore be treated with considerable caution. When interpreting this round of data collection and analysis, it is important to recognise that this is still a very early stage of the pilot process. Impact can therefore be assessed only in terms of outcomes to date.

2 Methodology

2.1 Sources of data collection

This report is based on the analysis of a range of sources and types of data collected (both qualitative and quantitative): in-depth interviews and observations at case-study centres; an online survey of pilot centres; interviews with wider stakeholder organisations, further, joint-offer pilot centres not included as case studies and single-GCSE-only centres; a focus group with representatives from the four awarding organisations; and an analysis of statistical attainment data from the first two examination series. More information on these sources and data-types are given below.

The analysis in this report uses the number and profile of pilot centres participating as at 31 August 2011. There were 267 pilot centres across the four awarding organisations: 97 with AQA, 94 with Edexcel, 64 with OCR and 13 with WJEC (one centre was recorded as being registered with Edexcel and OCR).

2.1.1 In-depth interviews and observations at case-study centres

There were in-depth interviews and observations at ten case-study pilot centres. Of these ten centres, eight were also visited in spring 2011 and two were new case studies. Further

details on the case-study centres can be found in Appendix 1. Case-study centres were originally identified for the first round of visits conducted in autumn 2010 – they were selected to ensure coverage of: awarding organisation representation in the pilot, centre type and region, phase of education (i.e. 11–16 and 11–18), and urban and rural contexts. Some of the case-study centres offer the MLP and the single GCSE. As far as possible, the same case-study centres are visited for each phase of fieldwork to offer a qualitative longitudinal study of change over time as a result of the MLP.

The case-study pilot centre visits focused on establishing the perceived key differences between the MLP and the new single GCSE in mathematics, including any added value of the MLP over and above the single GCSE. The observation of MLP lessons in case-study centres was central to the focus of this report. A total of 17 lesson observations were undertaken across the 10 centres.

The interviews conducted with centre staff and in the focus groups with students covered the following topics:

- the benefits and challenges of the MLP, particularly in terms of ways in which students are engaging with, and are committed to, mathematics
- the different methods of enquiry they use and that are developed by students working towards two distinctive GCSEs in mathematics, and the extent to which this promotes depth and breadth of understanding of mathematics
- comparisons between the MLP and the new single GCSE in mathematics depending on centres' knowledge and/or experience of the single GCSE in mathematics.

2.1.2 The online survey of pilot centres

The survey focused on centres' participation in and management of the pilot qualifications, and the planning and implementation of any changes to teaching and learning. Where pilot centres also offered the new-single specification GCSE, they were asked about the extent to which their responses to the questions would be the same or different for the single qualification. Of the 267 pilot centres, 105 (39%) completed the questionnaire: 75 (71%) of these responding centres had also responded to the March 2011 survey, so 30 (29%) were new respondents. New centres were evenly split between those teaching only the MLP and those teaching both the MLP and the new single GCSE. Heads of mathematics made up 72% of respondents, and 28% were teachers/managers responsible for the MLP in that centre. The three most common types of centre were comprehensive maintained schools (50%), academies/city technology colleges (CTCs)/free schools/university technical colleges (UTCs) (29%), and selective maintained schools (8%). The awarding organisations forwarded the invitation to take part in the survey to their pilot centre contacts. Response

rates across the awarding organisation varied, with 48% of both AQA and Edexcel pilot centres responding, 8% of OCR centres,[16] and 62% of WJEC.

This analysis of the centre characteristics shows the survey to be broadly representative of schools in the pilot, other than in relation to awarding organisations for the MLP, where OCR is under-represented and WJEC is a little over-represented.[17]

2.1.3 Attainment data: statistical analysis

From each awarding body (AQA, Edexcel, OCR[18]), data was received for the applications of mathematics GCSE (Applications), the methods in mathematics GCSE (Methods) and the mainstream mathematics GCSE (including the various specifications of legacy GCSE mathematics awards only, as no awards of the new single GCSE were made by the three awarding organisations in 2011). This data was provided as three separate sets of data for each of the three awarding organisations: one for Applications candidates, one for Methods candidates and one for candidates of the various mainstream GCSEs.

The data was combined to give a single dataset which was then matched to incorporate census information and data from the National Pupil Database (NPD) on prior attainment at individual candidate level. This was used for the analyses reported in section 3 of this report.

2.1.4 Wider stakeholder interviews

Ten representatives from wider stakeholder organisations were invited to take part in semi-structured interviews during October 2011. As data collected for this report focused on changes seen in teaching and learning, stakeholders were identified on the basis of their likely knowledge of current classroom practice relating to the MLP. The sample included subject associations,[19] professional bodies and workforce development organisations. Of these, one organisation was unable to take part as a result of other work commitments, and two organisations' representatives felt unable to comment on the MLP. Data from six wider stakeholder organisation interviews has been used for this report.

2.1.5 Awarding organisation focus group

A focus group was held with representatives from the four awarding organisations involved in the pilot in October 2011, following the initial analysis of attainment data and the online centre survey. The focus group covered four main themes: centre and awarding organisation perceptions of the pilot, centre participation, analysis of attainment data, and operational

[16] OCR's pilot project manager was on leave when awarding organisations were requested to send reminders to their centres, which may explain why there is a lower response rate from OCR centres for this survey.

[17] There are only 13 WJEC centres in the pilot, so the figure of 62% equates to only 8 centres responding to the online survey.

[18] WJEC made no qualification awards in the first year of the MLP pilot.

[19] This includes professional subject associations and other expert and advisory organisations.

issues relating to the pilot qualifications. For the second and third themes, initial findings from the analysis of the statistical data and the online survey were discussed.

2.1.6 Joint-offer and single-GCSE-only centre interviews

A total of 252 centres were initially invited to take part in the telephone interviews during October and November 2011. The sampling strategy involved contacting the centres that had responded to the MLP online survey in spring 2011 (and had agreed to be contacted), identifying suitable centres through awarding organisations and some random sampling. The sample generated was intended to get the views of centres with a good working knowledge of both the MLP and the new single GCSE. The heads of mathematics from 33 centres were interviewed. Of these centres, 11 offered both the new single GCSE in mathematics and the MLP, 21 offered the new single GCSE only and one centre offered only the iGCSE. The 11 centres offering both qualifications are referred to as 'joint-offer centres' and the other 22 centres as 'single-GCSE-only centres'. It was recognised that centres offering the single GCSE only may have little or no knowledge of the MLP. However, it was necessary to gain the wider perspective of single-GCSE-only centre views in order to address research questions on the appropriateness of the MLP in a range of contexts and for different cohorts. Single-GCSE-only centres were sent information about the MLP prior to the interview. Further details on these centres can be found in Appendix 2.

2.2 Theoretical framework developed for the evaluation

2.2.1 Development of a pedagogical framework

The framework developed for the classroom observations undertaken for the first interim report in spring 2011, based on the work of Malcolm Swan, has also been used for data collection and analysis for this report. The pedagogical framework has been used more widely this time; it has been used to support a comparison of the pedagogy promoted by the new-specification GCSE with that promoted by the MLP by pilot centres taking part in the online survey offering all three qualifications. It has also been used for further observations of MLP teaching and learning.

The pedagogical framework has eight descriptors:[20]

- high-order questioning – opportunities for higher-order questions requiring explanation, application and synthesis rather than just recall

[20] Swan, M (nd) *Mathematics Matters: Final Report*, London: NCETM. https://www.ncetm.org.uk/public/files/309231/Mathematics+Matters+Final+Report.pdf

- stretching and challenging – opportunities for resolving through discussion, and opportunities to struggle and learn through perseverance, rather than just repeating previous success
- creating connections – encouraging identification of related concepts, and supporting generalisation, transfer and recontextualisation, rather than teaching and learning topics or skills in isolation
- encouraging reasoning – supporting and encouraging reasoning to get to the answer, rather than just getting the answer
- supporting development of strategies for investigation and problem solving – there is a range of skills described as problem solving, including understanding the mathematics required and application within a particular context (AO2) and higher-level theorising (AO3)
- encouraging a recognition of the role of mathematics in everyday life, both as a discipline and also in terms of its historical/philosophical roots – the value of mathematics
- making learning explicit – supporting reflection on how and what is learned
- developing 'mathematical' language – supporting development of mathematical language for description, modelling, framing and argument.

The pedagogical framework reflects the teaching strategies encouraged by the aims and nature of the pilot qualifications. The descriptors are 'level-free': for example, higher-order questioning and creating connections are not approaches specific to teaching for either higher-tier or foundation-tier students but can be differentiated according to the starting point of the students involved.

2.2.2 Horizontal and vertical knowledge structures

The previous reports on the MLP have identified the lack of a shared understanding by the stakeholders interviewed of what is meant by problem solving and functionality in relation to mathematics teaching and learning generally, and in particular in relation to the revised AOs for GCSE mathematics. As solving problems and functionality are central to mathematics at KS4, this lack of a common definition across the range of instances and contexts for which the terms are used by stakeholders becomes problematic. The lack of clarity may, in part, result from teachers not recognising or making explicit the different knowledge structures present within school mathematics at KS4. Problem solving in the schools interviewed for the previous reports predominantly focused on 'unpicking' a scenario to identify the mathematics to apply to reach a 'solution'.

The literature suggests there are difficulties when moving teaching and learning between different knowledge structures – for example, everyday practical knowledge and mathematical knowledge. Dowling (1998)[21] provides a starting point for discussing the issues mathematics teachers and their students face when presented with 'realistic' problem solving in the applications of mathematics GCSE. Using a scenario involving a realistic problem that needs to be resolved as an introduction to mathematics supposes that everyday practical knowledge is part of mathematical knowledge. The everyday knowledge is likely to be insufficient to solve the contextualised problem, as the knowledge structure will be different from that of the mathematical solution. In addition, when mathematically constructed problems have some limited practical reference, though the student is aware that they should approach the problem mathematically, the 'mathematical' solution cannot be evaluated from a practical perspective.

Teaching and learning that remains contextualised and practical may help students to gain meaning but does not offer entry to the academic domain of mathematic knowledge. Mathematics learned in isolation from its practical application may not, however, support the individual development of understanding and meaning for students (Adler, 2001).[22]

Bernstein's (2000)[23] work distinguishes between vertical and horizontal discourses of knowledge acquisition. Horizontal discourses are segmented, local and context bound and relate to everyday and work-based knowledge; horizontal discourse is acquired experientially without the need for explicit pedagogic interventions and is not easily transferred across contexts. Conversely, vertical discourse is organised into hierarchical knowledge structures (as with the natural sciences) or horizontal knowledge structures, organised into specialised languages (as with mathematics and the social sciences). Moving understanding from, or between, the everyday and the specialist/academic has been termed by Treffers (1987) as 'horizontal mathematisation'. Once teaching and learning is in the specialist domain of academic mathematics (e.g. conceptualisation and theorising), students engage in vertical discourse, or what Treffers calls 'vertical mathematisation'.

The 'usefulness' of mathematics, through its applications to economic or domestic practice, has historically been seen as more relevant to young people than the specialist/academic perspective of mathematics as a purely intellectual practice. The KS4 PoS identifies a dual role for school mathematics: the utility of mathematics and its application, and the

---

[21] Dowling, P (1998) T*he Sociology of Mathematics Education: Mathematical Myths/Pedagogic Texts*, London: The Falmer Press.

[22] Adler, J (2001) *Teaching Mathematics in Multilingual Classrooms*, Dordrecht: Kluwer.

[23] Bernstein, B (2000) *Pedagogy, Symbolic Control and Identity: Theory, Research, Critique* (revised edition), London: Rowman and Littlefield.

introduction and initial development of the higher-level thinking skills of conceptualising and theorising required for further study of mathematics and related subjects. The analysis of data collected during classroom observations, interviews and focus groups with heads of department, teachers and students used the descriptors 'horizontal mathematisation' and 'vertical mathematisation' to consider the type of knowledge used and/or developed. These types of knowledge were also identified in observed or discussed pedagogical approaches to problem solving and methods of enquiry promoted in the classroom.

2.2.3 A typology of problem solving

Describing the knowledge structure and using the descriptors from the pedagogical framework supports the identification of the 'type' of problem solving seen. To overcome the absence of a shared understanding and language of problem solving, a typology of problem solving was required for the purpose of description and analysis during the evaluation. Watson (2009) identified:[24]

> *The phrase 'problem solving' has many meanings and the research literature often fails to make distinctions. In much research solving word problems is seen as an end in itself and it is not clear whether the problem introduces a mathematical idea, formalises an informal idea, or is about translation of words into mathematical instructions. There are several interpretations, and the ways students learn, and can learn, differ accordingly. (p 12)*

Watson identified the following main uses of the phrase:

- word problems with arithmetical steps
- worded contexts which require the learner to decide to use standard techniques
- worded contexts in which there is no standard relationship to apply, or algorithm to use, but an answer is expected
- exploratory situations in which there is an ill-defined problem
- mathematical problems.

2.2.4 The 'what' and 'how' of mathematics teaching and learning

'What' students learn and 'how' they learn lead to different types of knowledge. Issues are identified in the literature with both routine learning of mathematical procedures and investigative, problem-solving approaches, with neither approach necessarily supporting conceptual understanding and application of mathematics. Watson (2009) reported that the literature identifies that students who have the 'habit of complex exploration' often

[24] Watson, A (2009) 'Key Understandings in Mathematics Learning – Paper 7: Modelling, problem-solving and integrating concepts', London: Nuffield Foundation.

subsequently learn procedures quickly. For the purpose of the evaluation, the 'how' of teaching and learning was analysed in terms of the variety and frequency of activity in the classroom, and also to give instances and examples of where the pedagogy observed corresponded to the wider aims of the MLP. Data collection from the case-study centres included recording examples of:

- interactions – whether work is teacher-led, student-led or independent
- groupings – pair work, group work, individual work[25]
- exposition – how the teacher sets the scene and explains ideas or theories
- use of resources and artefacts
- language – what was said and how it was said, recording direct quotations where possible.

2.2.5 The theoretical framework

The notion of vertical and horizontal mathematisation is of particular relevance and is used here to consider the type of knowledge promoted in the structure (and content) of the MLP and whether this was observed in practice in the case-study pilot centres. It also offers a framework to consider the different knowledge types implicit or explicit across the range of problem-solving types identified by Watson (2009).

3 Research findings

3.1 Wider context of mathematics education

The evaluation of the impact of the MLP has to take into account the wider, systemic environment of GCSE mathematics and how this influences and shapes the starting point and rate of change promoted by the pilot qualifications.

3.1.1 GCSE mathematics

Mathematics: Understanding the Score (Ofsted, September 2008) found that, on the basis of data from national tests and public examinations, there had been a significant rise in standards in mathematics for students of all ages over the last decade.[26] At KS3, test results were improving and a greater percentage of students were reaching the threshold of grade C in mathematics at GCSE level.

---

[25] Ideas developed from work by the University of Sheffield – Brooks, G *et al* (2007) *Effective Teaching and Learning: Reading*. London: NRDC.

[26] Ofsted (2008) *Mathematics: understanding the score*. London: Ofsted.

The report included one major caveat, however. Given the gains being made at KS3, more students would have been expected to reach the higher grades at GCSE than actually had. The reason for this, the report suggested, was the nature of the strategies that schools were using to improve test and examination performance. These included 'booster' lessons, revision classes and extensive intervention, coupled with a heavy emphasis on teaching to the test. While these strategies were successful in preparing students for the examinations, they were not necessarily supporting the development of mathematical understanding.

Many schools focus strongly on C/D borderline students, monitoring them closely and providing additional intervention. The emphasis on teaching to the test, however, may mean that the quality of learning that leads to GCSE mathematics is in practice skewed by the emphasis on threshold attainment data. This may not just result in a narrower range of skills being developed but may also affect students' progression. Ofsted's *Annual Report of Her Majesty's Chief Inspector of Education: Children's Services and Skills* (2009/10) reported an increase in the number of schools starting GCSE mathematics in Year 9 and commented that in a few schools this resulted in students stopping mathematics early (once grade C achieved). Such practice raised concerns about 'the possible negative impact on uptake and success in higher level studies of mathematics'.[27] The Department for Education (2011) also reported an increase in early entry for GCSE mathematics and the use of re-sits to ensure a grade C at GCSE, resulting in lower-than-expected attainment levels for some students based on their prior attainment.[28]

In 2008 Ofsted reported the standard of the application of mathematics to a variety of open-ended, novel or complex tasks remained lower than in other areas of the mathematics curriculum. Classes typically concentrated on the acquisition of skills, solutions to procedural exercises and preparations for assessments. The report concluded that the fundamental issue for teachers was how to develop students' mathematical understanding and to ensure their ability to use and apply it.

The report of the Advisory Committee on Mathematics Education (ACME) on the mathematical needs of learners (2011)[29] recommended that the assessment regime should be revised to include all aspects of mathematical knowledge, to encourage mathematical proficiency rather than short-term teaching to the test. Teaching to the test was felt to 'hinder' understanding. Based on international comparisons, the report identified curriculum coherence (reflecting the connections and relationships between key mathematical ideas in

---

[27] Paragraph 93.

[28] DfE (2011) *Early entry to GCSE examinations* https://www.education.gov.uk/publications

[29] ACME (2011) *Mathematical Needs: The Mathematical Needs of Learners*, London: The Royal Society and the Joint Mathematical Council.

a non-linear way) and the need for teaching resources to focus on conceptual development rather than assessment as important factors for the successful development of mathematical proficiency and understanding.

The final report of the Evaluating Mathematics Pathways project (EMP) (2010) highlighted that obtaining a grade A at GCSE in summer 2009 was not necessarily an indicator of a student 'demonstrating algebraic fluency' (Ofqual, GCSE grade A descriptor, 2009). The EMP report recommended that:

> *High-attaining students need to develop greater facility with algebra by age 16 and assessments should incentivise high-quality teaching and learning in this critical area. (p. 7)*

The development of algebraic fluency was considered 'imperative' if high-attaining students were to translate mathematical understanding at GCSE level into successful engagement with A level teaching and learning.

The previous reports on the evaluation of the MLP have looked at the extent to which teachers were planning to introduce, or were already introducing, different approaches to teaching as a result of the MLP. The recent round of classroom observation has focused on the pedagogical approaches seen in MLP lessons and how these may be changing as a result of the qualifications.

3.2 Centre participation in the pilot

3.2.1 Rationale for centre participation in the pilot

The two main reasons centres taking part in the online survey (n=105) gave for participating in the pilot are the opportunity for their students to get two GCSEs (mentioned by 45 respondents) and the opportunity to stretch and/or challenge their students (mentioned by 23 respondents). Numbers for the most common reasons mentioned are listed in Table 1. Please note that respondents could give more than one reason, and that the table summarises only the most frequent responses.

Table 1: Reasons for centre participation in the MLP

Reason	Number
The opportunity to get two GCSEs/parity with English and science in getting two GCSEs	45
Opportunity to stretch or challenge (possibly groups of) their students	23
Two opportunities for lower-attaining students to get a C	6
Better preparation for A level	6
To be 'ahead of the game', ready if the MLP is rolled out nationally	6
Less reading in the 'methods' qualification, better for autistic/EAL/poor readers	4

The reasons for participating given by centres in the online survey may not represent the full picture. Awarding organisations felt that the two opportunities for students to gain a C is probably a stronger and more prevalent driver for participation than the survey data suggests. Awarding organisations confirmed that a few centres had joined the pilot because the 'methods' qualification was thought to be more accessible for autistic and EAL students (students who have English as an additional language) and students with weaker literacy skills.

Pilot schools are self-selecting and choose to take part for different reasons and are therefore more likely to have a strong mathematics department and qualified mathematics teachers, which would tend to make them unrepresentative of KS4 mathematics generally. Only three centres responding to the online survey had one or more teachers delivering the pilot qualifications who were not qualified to teach mathematics. This does not reflect the national picture for mathematics teaching.[30]

The awarding organisations suggested that centres will tend to be risk-averse and cautious because of the high-stakes nature of mathematics within school performance measures (increasingly so, with recent policy changes such as changes to floor targets). Schools are getting used to understanding unit results: getting information earlier, and deciding which students to target, particularly for C/D outcome boundaries. Several strategies were observed within the MLP by the awarding organisations: putting students in early to get an early look at examination papers; putting in specific cohorts first to see how they perform; entering students for single *and* MLP examinations. It is not possible to say how this differs (or not) from behaviour in relation to the single GCSE. Awarding organisations concluded that indications in the online survey in terms of whole-cohort participation in the pilot are likely to reflect intention rather than the pattern of entry seen for the initial assessments. There is a potential mismatch between stated intention (full cohort entry) and actual entry levels observed from the awarding organisation data, but this cannot be said with certainty because the entry data from only the first year of the pilot is available at present.

3.2.2 Representativeness of pilot cohort (statistical data analysis)

This section of the report considers data provided by the awarding organisations in the pilot for the winter and summer assessment windows in the academic year 2010–11. Data is included for AQA, Edexcel and OCR, all of which awarded MLP qualifications in summer 2011.[31] As part of the data collection undertaken in September 2011, all mainstream GCSE

[30] The national picture of teachers who do not hold a post-A level qualification in a subject relevant to maths is 26% (School Workforce In England Statistical First Release, November 2010, DfE).

[31] Data was not requested from WJEC, which, although also in the MLP pilot, has not awarded qualifications in summer 2011 – their first awards will be in the academic year 2011–12.

mathematics data from the three awarding organisations was also collected so that comparisons could be made between MLP and mainstream GCSE mathematics candidates. While MLP data was collected at unit level (i.e. including those candidates who had completed units but not yet completed the qualifications), mainstream data was collected at qualification level only and so included only those candidates who had completed a mainstream GCSE mathematics qualification.[32]

In the analysis that follows, it should be noted that this is 'early data' as far as the pilot goes – with the candidature having completed only one year of what is for most a two-year programme. This has some important implications:

1. The candidature seen in the second year of the pilot in June 2012 (when the majority of MLP candidates who started in September 2010 reach the end of their two-year GCSE mathematics programme) may differ substantially from that seen in the first. For example, candidates who have started on MLP programmes in 2010–11 but have not taken any units during that year are not represented in the MLP statistical data (approximately 90 of the 252 centres registered with the three awarding organisations that supplied data have not yet entered any candidates).
2. Some of the candidates entered in 2010–11 may have been entered earlier than would otherwise have been the case to help the school learn about MLP examination content and style. If candidates did not achieve to their full potential, then centres would have plenty of opportunities for unit re-sitting, particularly for younger candidates, e.g. those in Year 9.
3. Comparisons between MLP and mainstream candidates need to be treated with a degree of caution. Although in this section MLP completers are generally compared with mainstream completers, it is likely that MLP completers to date (those completing one or both of the MLP qualifications within one year) will be unrepresentative, to an extent, of the whole MLP cohort. Comparing them with the entirety of mainstream GCSE completers (including those on one- and two-year programmes) may not therefore be a completely like-for-like comparison.[33] It should also be noted that the mainstream GCSE results will be for the legacy GCSE mathematics qualifications. No

[32] It would not have been possible to collect and process the vast quantity of unit data for GCSE mathematics in the time and resources available for the project.

[33] The report does draw a number of comparisons between MLP and mainstream qualification outcomes, despite this caveat. This has been reported because of the need for early information about how the pilot is progressing, but it should be noted throughout that the findings must be treated with caution, and that a more complete comparison will be possible only once a full two-year programme of MLP is complete (i.e. from Summer 2012).

students will have yet been awarded the new single GCSE, as first awards will not be awarded until summer 2012.

Following receipt and processing of the awarding organisation data, additional data about each mainstream and MLP candidate from the NPD datasets was appended, including demographic information (ethnicity, eligibility for free school meals, SEN status, etc) and prior attainment (levels attained at KS3 in English, mathematics and science). Ofsted inspection data about the schools in the pilot (and all secondary schools) was also obtained.

This combined dataset was used to provide participation and attainment information about the students and schools in the MLP pilot, and then to consider the extent to which the profile of these participants is similar to the profile of all schools and students.

3.2.2.1 Participation in the MLP pilot

Table 2 shows the number of entries and completions for each qualification for each of the participating awarding organisations. It shows that around 24,000 entries have been made for MLP examinations, and around 5,000 completions have been achieved. There are substantially more entries and completions for GCSE methods in mathematics (Methods) than for GCSE applications of mathematics (Applications) (15,000 Methods entries compared with 9,000 for Applications). Male candidates make up 57% of the completions and 52% of the entries, which is significantly higher than the candidature for mainstream GCSE mathematics (for which 49.8% of completions are male). There are 573 candidates who have completed both Applications and Methods. Of these, 348 completed both with AQA, 200 with Edexcel and 25 with OCR. Also of note is that, proportionately, the completion rate for OCR is lower than for the other two awarding organisations; in particular, completions for OCR's Applications are very low (1.1% of entries compared with 15.8% for AQA and 30.2% for Edexcel – see Table 3).

Table 2: MLP entries and completions for English awarding organisations in the academic year 2010–11

	MLP GCSE	Candidate entries			Completions		
		Male	Female	Total	Male	Female	Total
AQA	**Applications**	2848	2649	5497	486	381	867
	Methods	3706	3233	6939	1163	888	2051
Edexcel	**Applications**	700	587	1287	246	143	389
	Methods	2461	2396	4857	624	400	1024
OCR	**Applications**	1205	1217	2422	11	15	26
	Methods	1655	1516	3171	346	319	665
Total	**Applications**	4753	4453	9206	743	539	1282
	Methods	7822	7145	14967	2133	1607	3740

Table 3: Percentage of MLP candidates with a completion

		Number of candidates entering at least one unit but not completing	Number of candidates entering and completing	Proportion of candidates entering and completing (%)
AQA	**Applications**	4630	867	15.8
	Methods	4888	2051	29.6
Edexcel	**Applications**	898	389	30.2
	Methods	3833	1024	21.1
OCR	**Applications**	2396	26	1.1
	Methods	2506	665	21.0
Total	**Applications**	7924	1282	13.9
	Methods	11227	3740	25.0

Table 4 shows the proportion of completions by awarding organisation for the mainstream and MLP GCSE mathematics qualifications in summer 2011. It shows that AQA is over-represented in terms of candidates in the pilot, compared with mainstream GCSE mathematics candidates, and that, conversely, Edexcel is under-represented.

Table 4: Proportion of completions by awarding organisation – 'market share' (summer 2011 completions)

	Mainstream	MLP
AQA	24%	58%
Edexcel	63%	28%
OCR	14%	14%
Total	100%	100%
Base: Mainstream 786,332 MLP 5,022		

Table 5 shows the MLP entries by tier. It shows that there are slightly more unit entries at higher tier than at foundation tier; 18% of all entries were made in the winter 2011 series, the remainder being made in the summer series.

Table 5: MLP entries by tier

	Entries (units) (%)		Completions (units) (%)	
	Foundation	**Higher**	**Foundation**	**Higher**
AQA	43	57	51	49
Edexcel	35	65	52	48
OCR	43	57	49	51
Totals	41	59	49	51

Table 6 shows the number of candidates in summer 2011 re-sitting units that they had taken in winter 2011 (and whether the re-sit involved a change of tier). Edexcel offered no winter 2011 series, so is excluded from the table. Around 30% of AQA's units sat in winter 2011 were re-sat in the summer (mostly at the same tier). OCR's proportion of re-sits was much lower, with no re-sits at the same tier. This may suggest a difference in guidance given, and the fact that centres may be experimenting with entry decisions (further supported in later sections of the report). No information was available about re-sit rates for mainstream GCSE mathematics qualification.

Table 6: Re-sits in summer series 2011 of paper 1 (P1) units taken in winter 2011

		Number of P1 entries in Jan 2011	Number of P1 re-sits in June 2011	Proportion of Jan 2011 P1 entries re-sat in June 2011 (%)	Combination of tiers			
					Both attempts sat at foundation level	Both attempts sat at higher level	Foundation in Jan 2011, higher in June 2011	Higher in Jan 2011, foundation in June 2011
AQA	A[1]	1862	591	32	213	363	0	15
	M[2]	3234	994	31	639	270	48	37
OCR	A	177	7	4	0	0	0	7
	M	556	17	3	0	0	1	16
Totals	A	2039	598	29	213	363	0	22
	M	3790	1011	27	639	270	49	53

[1] Applications

[2] Methods

Table 7 shows the school years of candidates entering for and completing MLP GCSEs, and of those completing mainstream GCSE mathematics qualifications. It shows that (of those candidates completing) proportionately more MLP candidates are completing at least one MLP GCSE earlier than their mainstream equivalents. It suggests that many MLP pilot centres may be aiming to complete the MLP GCSEs sequentially, mostly taking Methods first, in the first year of teaching. As noted later in the report, however, around a third of MLP pilot centres in England have as yet made no entries at all. The figures here therefore relate only to those centres making entries in the first year.

It is worth noting that 30 candidates were entered for an MLP unit in Year 8, and almost 20% of the overall unit entries were from Years 8 and 9 (mostly Year 9). The profile of candidate ages varies a little between awarding organisations: 26% of AQA's entries are from candidates in Year 9 or below, whereas only 19% of Edexcel's and OCR's are. Most students still entered their exams in Year 10.

Table 7: MLP and mainstream candidate completions by school year

	MLP entries		MLP completions		Mainstream completions	
	n	%	n	%	n	%
Year 7	0	0	0	0	132	0
Year 8	30	0	0	0	861	0.1
Year 9	3142	19	754	18	10181	1
Year 10	12253	75	2731	65	105678	14
Year 11	850	5	707	17	567973	76
Year 12	5	0	1	0	41598	6
Year 13	0	0	0	0	17282	2
All	16280	100	4193	100	743705	100

Figure 1 shows the proportion of candidate entries by school year for both MLP GCSEs. Methods candidates tend to be a little younger than Applications candidates, confirming the view from the number of entries that centres are tending to start teaching and assessment for Methods ahead of Applications (20.2% of Methods unit entries were from Year 9 candidates, while 11.2% of Applications unit entries were from Year 9 candidates).

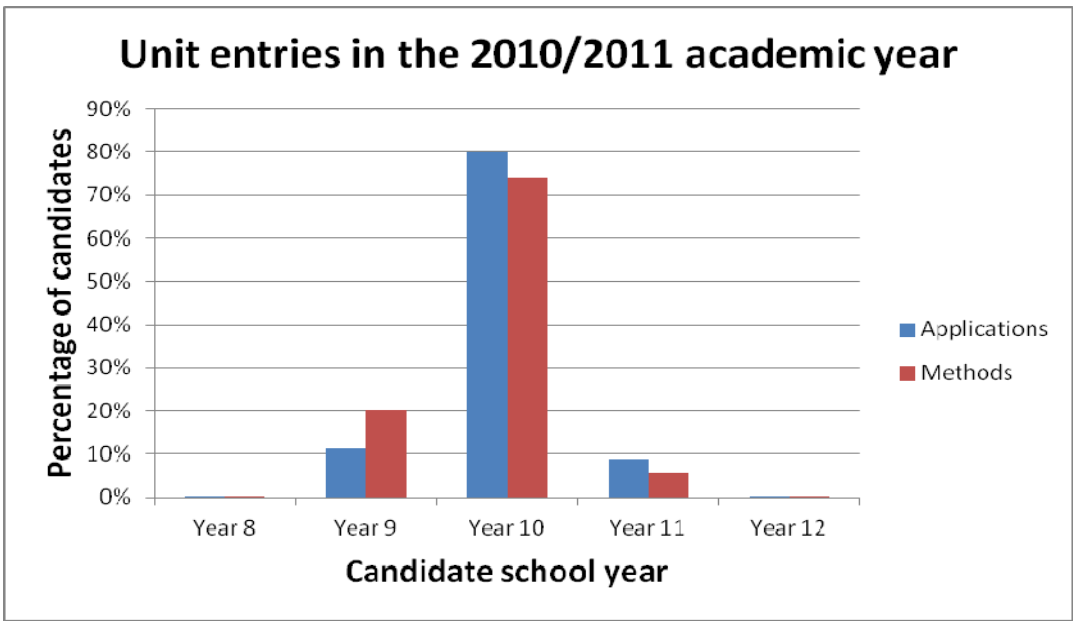

Figure 1: MLP entries and completions by candidates' school year

The statistical data for results from the first year of the pilot also suggests that most MLP candidates taking qualifications in the first year of the pilot will continue to take mathematics in their second year. Almost all of the candidates who have completed one but not both of the MLP qualifications are in Year 10 or below, and 84% of those who have completed both MLP qualifications are in Year 11; 95% of candidates with one or more unit entries but no completions are in Year 10 or below. Taken together, and also noting the requirements that (a) MLP candidates must attempt both qualifications, (b) candidates cannot take mainstream GCSE mathematics if they are participating in the pilot and (c) attempting GCSE mathematics is mandatory for most students at KS4, this suggests that most of the MLP candidates taking qualifications during Year 10 will go on to take further MLP units in Year 11.

Table 8 shows the completions for each awarding organisation that offered assessments in winter and summer 2011. It shows, for each qualification, the proportion of completions where both units were completed in the summer series.[34] It shows that around 20% of

[34] Edexcel is excluded because it offered no assessments in winter 2011, so all its completions are effectively 'linear'. It was not possible for AQA and OCR candidates to complete either MLP qualification in winter 2011, as neither awarding organisation offered, in that session, both of the units that would be required.

completions were for candidates taking both units in the summer session (and with no entry in the winter session) – that is, in the form of a linear qualification with all assessment at the end of the programme of study. Linear completions were proportionately higher for OCR. As for all data in this section, but particularly for this table, it should be noted that this is early data, and that most of the completers will be going on to complete the second qualification in 2011–12, so this should not be considered strictly linear.

Table 8: Comparison of unitised and 'linear' completions by awarding organisation

		Total completions	'Linear' completions	Proportion of 'linear' completions (%)
AQA	**Applications**	867	192	22
	Methods	2051	209	10
OCR	**Applications**	26	8	31
	Methods	665	303	46
Total	**Applications**	893	200	22
	Methods	2716	512	19

Candidates at academies and comprehensive schools are over-represented in the pilot, and those at secondary modern and independent schools are under-represented, suggesting that a school's type may have a bearing on whether it is more or less likely to choose to join the pilot. However, in mathematics, awarding organisations tend to have different profiles of centres, with some awarding organisations tending to attract particular types of centre. Given that AQA is over-represented in the pilot compared with its mainstream GCSE mathematics candidature, the balance of centres may also be affected by differences in the numbers of centres that each awarding organisation has recruited to the pilot.

Table 9 considers the centres registered at each of the awarding organisations, and whether they have entered candidates in either of the assessment series. An active centre is one where one or more unit entries have been made in either session; an inactive centre is one where no unit entries have been made in either session. It shows that 82% of AQA's centres have entered one or more candidates to date, whereas around 50% of Edexcel and OCR's centres have not made any entries as yet. There were 250 centres in the pilot with these

three awarding organisations – two centres are registered with both for MLP, giving the total of 252 in the table.[35]

Table 9: Pilot participation in the 2010–11 academic year by centres registered with each of the awarding organisations

	Number of active centres	Number of inactive centres	Proportion of centres in pilot that are inactive (%)
AQA	79	17	18
Edexcel	51	44	46
OCR	30	31	51
Total	160	92	36

3.2.2.2 Ofsted inspection grades

Of the MLP centres in the pilot, Ofsted Section 5 inspection grades were identified for 195 centres in the pilot. The approximately 60 centres for which this information was missing comprise pupil referral units (PRUs) and special schools excluded from the data (as not comparable), independent schools (which are inspected under a different regime and are therefore also not comparable) and recent UTC/academy converters (new schools that do not yet have an inspection grade). Similarly, inspection grades for around 3,000 maintained secondary schools were obtained.

Figure 2 shows the profile of all centres in the MLP pilot compared with all secondary schools. It shows that a slightly higher proportion of 'outstanding' schools are involved in the MLP pilot than would be expected and a slightly lower proportion of 'satisfactory' schools. This difference is not, however, statistically significant and could be down to chance.

[35] Please note that there were four centres listed on the awarding organisations' lists of pilot centres that did not appear to have entered candidates for either mainstream or the MLP examinations – this may be due to a change of school name or status, which had not been recorded. Two centres appeared to have registered with two awarding organisations, but only one centre was recorded on the awarding organisations' list at this time.

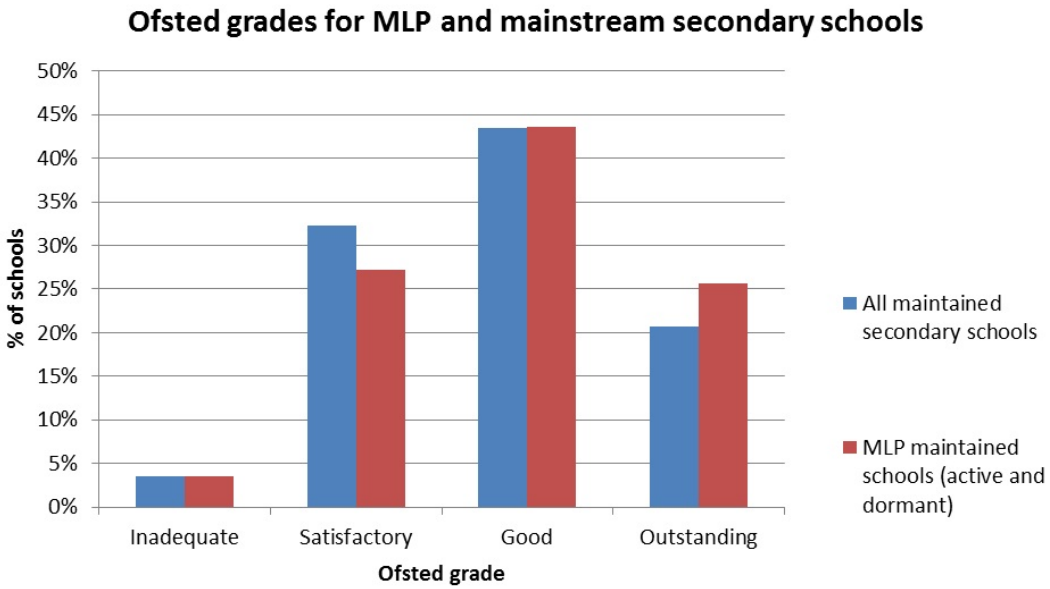

Figure 2: Ofsted Section 5 inspection grades for MLP schools and all maintained secondary schools

3.2.2.3 Candidate demographics

NPD data was matched to candidates in the MLP and mainstream datasets (i.e. to candidates who had entered at least one MLP unit or completed a mainstream GCSE),[36] and analyses for each of the following demographics were undertaken:

- whether candidates were eligible for free school meals (FSM)
- whether candidates had SEN registration (whether these registrations were statement, school action, or school action plus is considered separately)
- whether candidates do not speak English as their first language (EAL)
- candidates' ethnicity (the report comments on White British and Black and minority ethnic – BME)
- candidates' government region
- whether candidates were registered as gifted and talented (G&T)
- candidates' teacher assessment KS3 results in English and mathematics.

The range of results is presented in Appendixes 4 and 5. The results show an element of under-representation, for some student characteristics, among the MLP candidate cohort, when compared with the mainstream cohort:

[36] Data problems meant that most of Edexcel's data for candidates who had entered but not completed was not matched to the NPD, and so they are not considered in the demographic analyses (data for Edexcel completers was matched).

- The mean KS3 English level[37] of candidates in the MLP is 0.2 of a level higher than that of mainstream GCSE mathematics candidates.
- The mean KS3 mathematics level of candidates in the MLP is 0.39 of a level higher than that of mainstream GCSE mathematics candidates.
- Proportionately fewer FSM candidates are in the MLP pilot (11% compared with 15%).
- Proportionately fewer SEN candidates are in the MLP pilot (18% compared with 23%):
    - proportionately slightly fewer candidates with SEN statements are in the MLP pilot (1.9% compared with 2.2%)
    - proportionately fewer candidates with SEN action plus are in the MLP pilot (5% compared with 6%)
    - proportionately fewer candidates with SEN action are in the MLP pilot (11% compared with 14%).
- Proportionately fewer EAL candidates are in the MLP pilot (9% compared with 12%).
- Proportionately fewer BME candidates are in the MLP pilot (15% compared with 19%).
- Proportionately more G&T candidates are in the MLP pilot (18% compared with 15%).
- Regions in the pilot are not represented in the same proportions as in the mainstream data:
    - the proportion of candidates from London in the MLP is less than half of what would be expected
    - there are fewer candidates from the North West, the West Midlands and the North East in the MLP pilot than would be expected (by 20–30%)
    - there are 50% more candidates from the East Midlands, the South West and the South East than would be expected.

All the results above are statistically significant: in other words, they are unlikely to be due to chance variations in the candidature. It should be noted that EAL and ethnic bias may be due to the under-representation of candidates from London (where BME and EAL people make up a much higher proportion of the population than elsewhere in England). It is also possible that such biases are due to interactions between awarding organisation participation trends and the regional distribution of awarding organisation entries.

[37] Mean grade score is calculated by assigning a score to each candidate based on their grade (3 points for a KS3 level 3 result, 4 for a 4, etc through to 8 for an 8) and then taking the average for all candidates.

The results show that the profile of MLP candidates to date differs from that of mainstream candidates: there are fewer poor and ethnic minority students, fewer students whose first language is not English, and fewer students with a registered special educational need. However, it should be noted that within individual awarding organisation's candidatures there are variations in candidature demographics, showing that the demographic and prior attainment profiles of candidatures vary from one awarding organisation to the next: as more Edexcel and OCR centres become active in the pilot (or if proportions of the MLP cohort for each awarding organisation change for other reasons), the proportions of candidates will change significantly.

The demographic and prior attainment measures are also different for MLP candidates according to whether they have completed the qualification or only 'started' with one or more unit entries. The results above are for all MLP candidates. If, instead of considering all MLP candidates, only MLP completers are considered, the difference between the profiles of MLP and mainstream candidates increases: the under-representation of FSM, SEN, EAL and BME candidates in the MLP increases, while the over-representation of G&T candidates and candidates with higher prior attainment also increases.[38]

3.3 Attainment

Findings presented here consider attainment in the broadest sense. There is an overview of the statistical attainment data, but attainment is also considered in the wider context of centre perceptions of the attainment data and student development of mathematical skills, knowledge and understanding in practice.

3.3.1 Overview of the statistical attainment data

Attainment data was provided by the awarding organisations in the pilot for the winter and summer assessment windows in the academic year 2010–11. Data is included for AQA, Edexcel and OCR,[39] all of which awarded MLP GCSEs in summer 2011. As noted previously, this is 'early data', as far as the pilot goes – with the candidature having completed only one year of what is normally a two-year programme – and so it is not reasonable to expect that the results seen in summer 2012 will correspond to those presented here. Figure 3 shows the proportions of grades achieved for the two MLP GCSEs

[38] The MLP NPD-matched candidature is 9,697, of which 'entry only' candidates make up 6,577. The likely impact of adding a proportion of the 3,000 missing Edexcel 'entry only' candidates who match to NPD (typically 80% of them) to the dataset would serve to increase the differences observed between mainstream and MLP cohorts.

[39] Data was not requested from WJEC, which has not awarded qualifications in summer 2011 – its first awards will be in the academic year 2011–12.

(for those that completed in summer 2011) and for all mainstream GCSE mathematics candidates;

Table 10 shows the mean grade scores[40] for candidates taking these three qualifications in summer 2011. They show that candidates generally achieved the highest grades on MLP Applications (5.5) and slightly lower on MLP Methods (4.6) compared with grades on the mainstream GCSE mathematics (4.7). It is not possible from this to disaggregate the effects of:

- stronger candidates (based on KS3 performance) taking MLP GCSEs
- younger candidates taking MLP GCSEs, and candidates having only one year of GCSE mathematics teaching rather than two
- the possibility that the MLP assessments present a different level of challenge to students (which itself would combine factors associated with quality of teaching, teachers' familiarity with the pilot specifications, difficulty of assessment content and marking and grading processes).

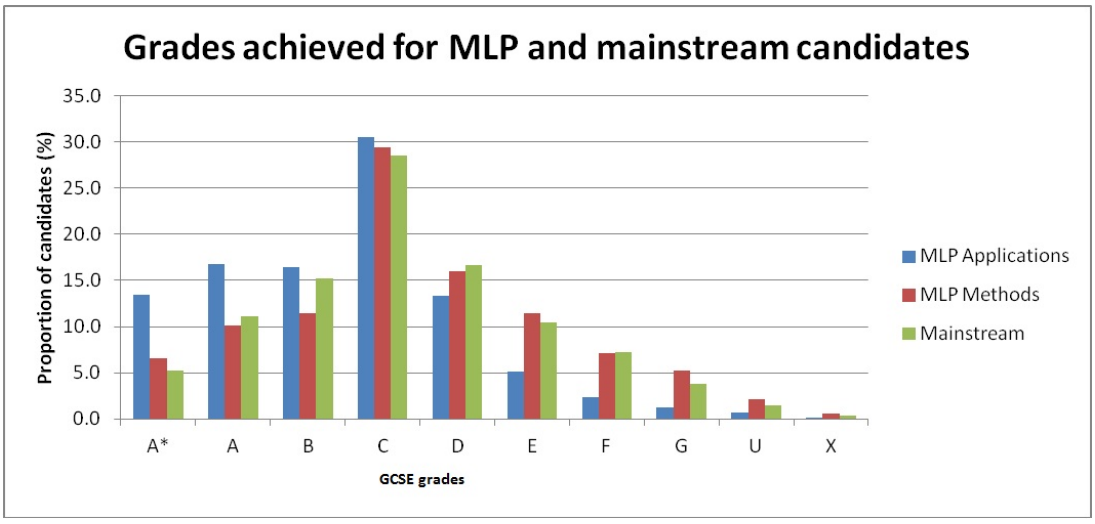

Figure 3: MLP and mainstream grades (all awarding organisations)

[40] Mean grade score is calculated by assigning a score to each candidate based on their grade (8 points for a GCSE A* grade, 7 for an A, etc. through to 1 for a G) and then taking the average for all candidates.

Table 10: Mean grade score for MLP and mainstream grades

	MLP Applications		MLP Methods		Mainstream outcomes	
	n	Mean grade score	n	Mean grade score	n	Mean grade score
AQA	867	5.2	2051	4.7	193222	4.6
Edexcel	389	6.2	1024	4.4	497695	4.8
OCR	26	5.0	665	4.3	105141	4.7
All	1282	5.5	3740	4.6	796058	4.7

Table 11 shows the average age (at the end of the school year in which the qualification was obtained) and the average KS3 mathematics score[41] for candidates taking the MLP and mainstream mathematics qualifications. It can be seen that, on average, MLP candidates (at all grades and for both Methods and Applications) are taking the GCSE at a younger age and have a higher KS3 mathematics score than their mainstream counterparts. It also shows that for all the GCSEs KS3 mathematics score is a good predictor of grade, as might be expected.

The KS3 mathematics score tends to be higher and the age lower for candidates for MLP Methods, which perhaps offers an explanation for the poorer grades achieved for Methods: the strongest candidates are being entered for MLP Methods, but at a slightly younger age, and hence are performing less well (in comparison with Applications and mainstream GCSE mathematics). This supports the view expressed previously that centres may be experimenting with entry patterns for MLP with different cohorts.

[41] Average KS3 mathematics score is based on candidates' teacher-assessed KS3 mathematics level. It is calculated by assigning a score to each candidate based on their teacher assessment KS3 mathematics level (3 for level 3, 4 for level 4, etc. through to 8 for level 8) and taking the average for all candidates.

Table 11: Prior attainment and average age (at year end) for MLP and mainstream candidates

		Methods	Applications	Mainstream
A*	Average KS3 maths level	7.9	7.9	7.7
	Average age (at year end)	15.3	15.7	15.9
A	Average KS3 maths level	7.5	7.4	7.2
	Average age (at year end)	15.3	15.6	15.9
B	Average KS3 maths level	7.0	6.8	6.6
	Average age (at year end)	15.1	15.4	15.9
C	Average KS3 maths level	6.1	6.0	5.8
	Average age (at year end)	15.0	15.5	15.9
D	Average KS3 maths level	5.5	5.5	5.1
	Average age (at year end)	14.9	15.5	16.0
E	Average KS3 maths level	4.9	4.9	4.6
	Average age (at year end)	14.8	15.4	15.9
F	Average KS3 maths level	4.6	4.5	4.0
	Average age (at year end)	14.8	15.4	15.8
G	Average KS3 maths level	3.9	4.3	3.7
	Average age (at year end)	14.8	15.4	15.8
U	Average KS3 maths level	3.5	3.3	3.9
	Average age (at year end)	14.8	15.6	15.8
X	Average KS3 maths level	4.7	5.0	4.6
	Average age (at year end)	14.8	15.5	16.1

3.3.2 Centre perceptions of student attainment (examination results) and the assessments

Approximately one centre in ten responding to the online survey has reduced the number of students entered for the MLP pilot, some reporting either that their lower attainers had struggled or that students were not achieving the grades expected at the end of Year 10. A small number of centres reported that they had decided to involve more students in the pilot as a result either of positive results or of a positive reaction from students.

The reduction in numbers of students participating in the pilot reported by some survey participants does not mirror what centres are saying to awarding organisations. In particular, the awarding organisations questioned whether comments about lower attainers involved comparisons with the new-single specification qualifications or, as was thought more likely, with the legacy qualifications.

Awarding organisations reported that centres overall were happy with the examination results, although there were a few exceptions where centres were disappointed that students had not gained the results they had hoped for. The awarding organisations felt that early entry may be an explanation for lower results – centres are comparing Year 10 entries in the MLP with the single GCSE and making judgements too early in terms of the candidates' time

on the programme, and their maturity in mathematics knowledge and skills. Some centres were putting students in for examinations after only a few months of teaching.

There was a range of responses from the case-study centres to the question about how they felt their students had done in the examinations to date (not all case-study centres had entered students). One centre was particularly pleased with the results that its foundation-tier students had achieved, and this has led it both to increase the number of foundation-tier students taking the MLP and to reconsider the tier of entry for other students. The success of the students on the foundation tier at this centre is attributed to good examination preparation and the fact that students can differentiate more easily between the questions posed in the two GCSE examinations. One further centre was also satisfied with the results its foundation-tier students had achieved to date. (Both centres had entered their foundation-tier students for the first Methods and Applications papers only.)

There were several other centres that were concerned that their foundation-tier students were finding the MLP too challenging. One foundation-tier teacher thought, as a mathematician, that the Methods June 2011 foundation paper was excellent, but probably too challenging – students the teacher expected to get a C received lower grades. By comparison, the teacher considered that grade boundaries in the new single GCSE seemed lower and thought that students would as a result find it harder to feel that they had achieved.

Another case-study centre was concerned that results were lower than expected, especially for the Methods paper. Despite these misgivings, the centre did feel that the MLP would develop better mathematicians. Another foundation teacher was disappointed that students had gained low grades in the first units taken – but these students had originally not been expected to gain a GCSE at all. It should be noted that the lesson observed evidenced a higher-than-average use of the full range of pedagogic approaches. However, another centre, which had entered only higher-attaining students, stated that their results were much better than expected. This centre – and one other entering the whole cohort – was using a linear approach and not encouraging re-sits. The centre felt that taking the second GCSE offered the opportunity to improve a grade, rather than re-sitting units from the first GCSE.

There are some early indications from case-study and centre online survey data that, where students are reported to have attained better grades than expected, these centres are mainly with one particular awarding organisation.

Awarding organisation representatives felt strongly that commercial factors were not leading to a ‘lowest common denominator’ approach to examination question writing. They felt that in practice boundaries were being pushed – examination questions perceived to be ‘hard’

would not be dismissed unless the questions themselves were felt to perform badly in terms of what is being assessed. Awarding organisations are nevertheless aware that teachers and students need time to adjust to new assessments and current students should not be penalised in this process of adjustment. The awarding organisations assert that they will not set easier questions in response to students struggling in previous sessions.

Awarding organisations are aware that many teachers will mirror teaching to meet the needs of the assessments. Centres now receive enhanced results (data for AOs 1, 2 and 3), so they can focus on areas that need further/different teaching. There is also feedback to teachers in the chief examiner's report. Algebra and fractions remain an issue in terms of student knowledge and understanding, as does the new topic of linear programming. Awarding organisations reported huge gaps in knowledge evidenced and felt that responses to problem-solving questions (AO3) were getting better, that teaching is improving but that it should be recognised that change takes time. As problem solving is also part of the new single GCSE, issues are also likely to apply to that qualification.

3.3.3 Depth and breadth of teaching, learning and student development

Respondents in the online survey were asked to what extent they think the MLP is encouraging a deeper and broader understanding of mathematics. Of the 82 respondents who answered, only 5 felt that it had not; 11 felt that a deeper and broader understanding of mathematics was encouraged simply by virtue of the additional content of the MLP; but most respondents felt that the structure of the MLP was beneficial. Thirty-seven respondents referred to applications of mathematics/putting mathematics into context as having a positive effect (one respondent commented, 'The Applications papers in particular have been a revelation for the students'), with 15 specifically mentioning the finance topic as engaging students ('We especially like the financial topics'). Thirteen respondents specifically mentioned the linking of methods and applications as being beneficial.

The question asked for a free-text response. The results are summarised in Table 12. The question was asked of all centres, and respondents were free to give more than one reason. The table shows the results from all centres responding to the survey, extracting from these figures the results for only those centres teaching both the MLP and the new single GCSE in mathematics. The numbers are too small to allow any firm conclusions to be drawn, but it is noticeable that 10 of the 12 centres that felt the extra content of the MLP to be beneficial are also teaching the new single GCSE in mathematics.

Table 12: Reasons given by centres to support the view that the MLP is encouraging a deeper and broader understanding of mathematics

Reason	All centres	Centres teaching both
Positive effect from applications of mathematics/putting mathematics into context	37	15
Specific mention of positive effect of finance topic	15	7
Extra content is beneficial	12	10
The opportunity to link methods and applications is beneficial	9	2

Those centres also offering the new single GCSE in mathematics were then asked the extent to which the qualification is encouraging a deeper and broader understanding of mathematics, and how this is different from the MLP. Of the 37 respondents who answered this question and who teach both GCSEs, 15 felt that the new single GCSE was not encouraging a deeper and broader understanding of mathematics, or was not doing so to the same extent as the MLP; 12 gave an answer indicating that the new single GCSE was encouraging a deeper and broader understanding of mathematics, with the functional content of the new GCSE mentioned by 5 respondents; 6 respondents mentioned the extra content of the MLP as a reason why the MLP encourages a deeper and broader understanding of mathematics than the new single GCSE. Only one respondent reported that the new single GCSE was superior: 'MLP feels rushed and not as structured as the single GCSE.'

3.3.3.1 Pedagogic approaches promoted by the MLP

Figure 4 shows the extent to which respondents believed that the linked pair of GCSEs in mathematics and the new single GCSE in mathematics promoted particular pedagogic approaches. Centres offering both the MLP and the new single GCSE were asked to indicate the extent to which the MLP and the single GCSE promoted the eight approaches in the pedagogic framework, using a scaled response. Circling a point at the lower end of the scale meant there was little or no evidence of the pedagogic approach being promoted; circling at the higher end of the scale meant there was a high level of promotion of the pedagogic approach. The points on the scale have been interpreted as a 'score' between 1

and 5, with 1 representing no promotion and 5 representing a high level of promotion.[42] The scores plotted are the 'average' score for each pedagogic approach for both qualifications. Scores for the linked pair of GCSEs in mathematics are higher in each category.

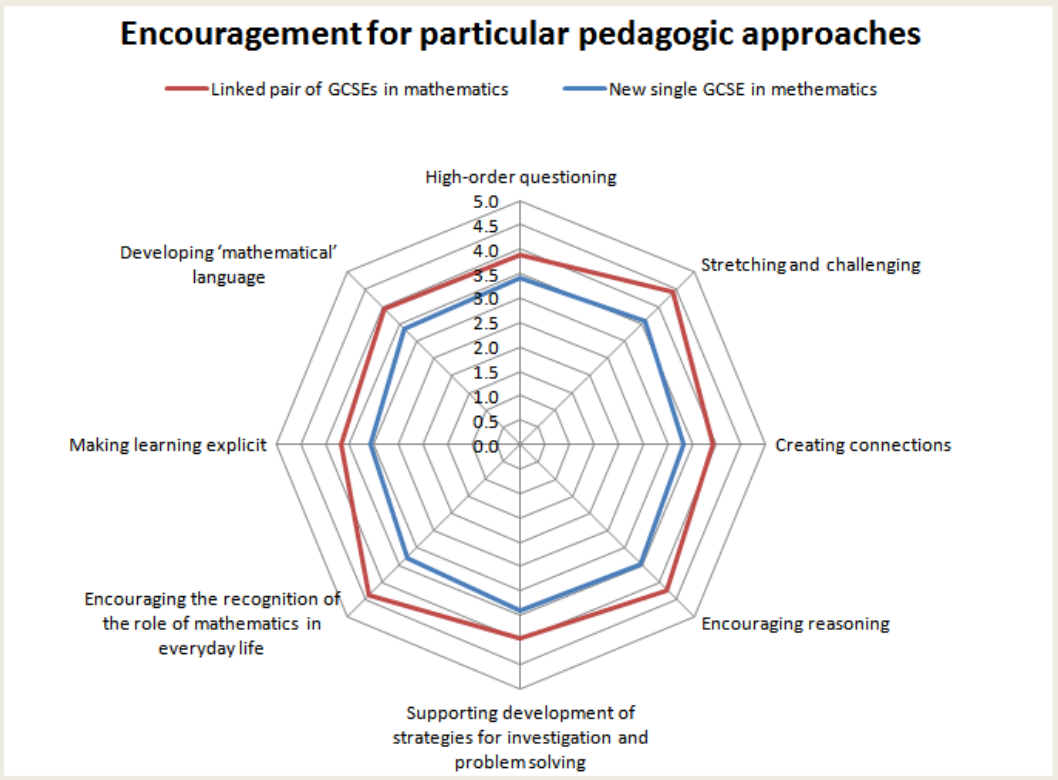

Figure 4: Radar chart showing the encouragement for particular pedagogic approaches

Centres reported positively on how the MLP and overall, if to a lesser extent, the new single GCSE were promoting the areas of pedagogy in the framework; examples of this continue, however, to be less obvious in many of the case-study lesson observations. As recorded in the first interim report, the observation of the case-study pilot centre lessons showed a wide range of approaches. Although lesson content and learning outcomes varied, it was still possible to use the pedagogic approaches based on Swan to frame the observations and the analysis of the data. In addition to the observation record, the researchers also completed a summary table to record overall impressions of the lesson against the eight aspects of pedagogy, by circling a point on a scale of 1–5 that was most representative of what they had observed, in a way similar to that used for Figure 4. Circling a point at the lower end of the scale (1 or 2) meant there was little or no evidence of the pedagogic

[42] Generating an 'average' using this type of data is not strictly statistically accurate but is fit for the purpose of the evaluation and is useful for this comparison.

approach being attempted effectively and/or that opportunities had been missed in the opinion of the observers; circling at the higher end of the scale (4 or 5) meant there was a high level of evidence of its effective use observed overall.

The points on the scale have been interpreted as a 'score'. The majority of observations in spring 2011 were scored at a point between 1 and 3. There were some exceptions, with a minority of classes evidencing the effective use of many of the pedagogical approaches. The range of classes observed and the score for each pedagogic approach used can be seen clearly in the diagrams in Appendix 3. The diagrams from the spring 2011 observations showed a stark difference between the teaching for students working towards the foundation-tier GCSE and that for those working towards the higher-tier GCSE: there was a higher level of higher-order questioning and reasoning observed in the higher-tier lessons. The 'average score' for the autumn 2011 observations showed little difference between the teaching approaches for higher tier and foundation tier – this is due not just to an increase in the range of pedagogical approaches being used in the foundation tier but also to less evidence of the approaches being used in some higher-tier lessons. The difference may be in part due to the time of year, with several of the higher-tier sessions revisiting topics, following the summer break. Often students had different teachers, and in some cases teachers were new to the school and were getting to know the students.

The difference in the classroom observations is summarised in Figures 5 and 6. The scale used for presenting the data starts at '0' for ease of reading. It should, however, be noted that '0' was not an available point on the summary table.

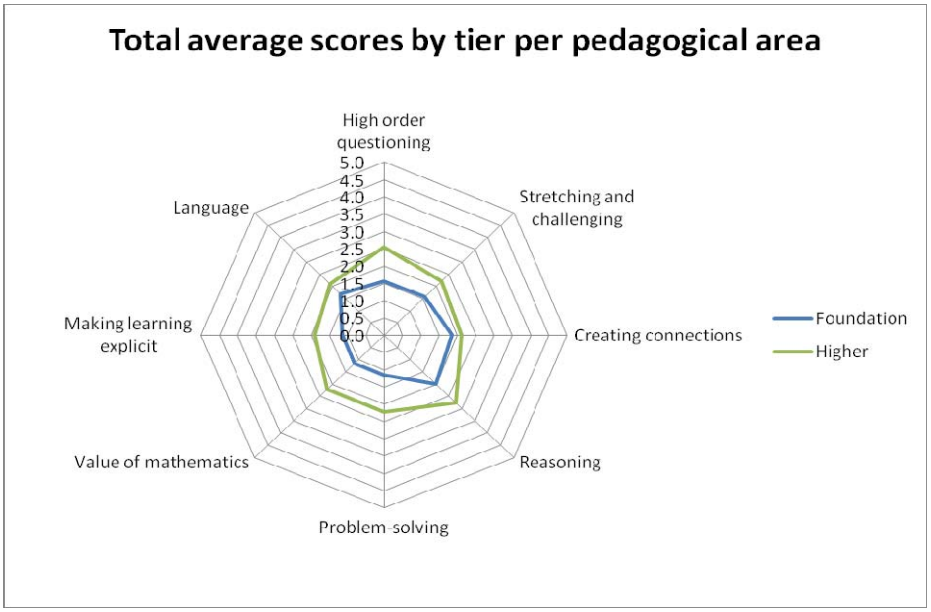

Figure 5: Total average scores by tier from spring 2011

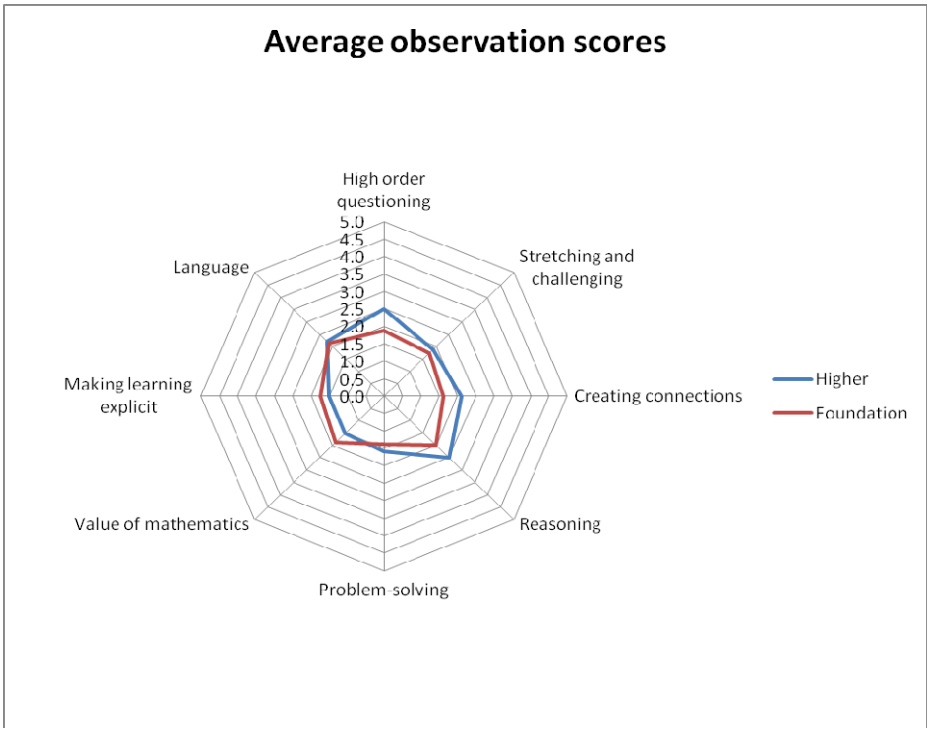

Figure 6: Total average scores by tier from autumn 2011

In spring 2011 the majority of teachers of foundation-tier groups in the case-study centres had concerns about using more-interactive, investigative approaches in their teaching because of the need to control the class and keep the students on task. The visits in autumn 2011 recorded a small change in the teaching pedagogy in several of the foundation-tier classes. In these classes, however, teaching was teacher led with a high level of initial modelling being used, with questions to the whole group, followed by individual work – usually in the form of a worksheet or an exercise from the textbook. Students in these foundation-tier groups were allowed to talk to one another, but the activities set were not intended to promote task-related discussion and working together. In four of the observed classes there was evidence of developing 'mathematical language' through the group discussions.

The majority of the foundation-tier lessons observed focused on applying mathematics. These generally started with the presentation of an everyday 'scenario', with the teacher explaining the context and modelling a mathematical approach. In many of the lessons the emphasis remained on 'unpicking' the context and practising the application of a given mathematical technique that had been previously learned. In a minority of the foundation-tier classes, new mathematics techniques were introduced through a 'realistic' group activity.

The majority of higher-tier classes observed also focused on the application of mathematics. There was more investigative work seen in some of the higher-tier classes, where initially basic trial-and-error techniques were discussed and applied to a pseudo-realistic problem,

before revisiting and evaluating the mathematics to look for new mathematical ways of approaching the problem. There was one example of exploratory, investigative work within a mathematical rather than a realistic context. This example was a revision class consolidating rather than introducing a mathematical concept.

The classes observed across this and the previous round of fieldwork can give only a 'snap-shot' of what is happening in MLP lessons. The interviews with mathematics staff and the focus groups with students have been used to give a more complete picture of the impact so far of the MLP in the case-study centres visited in autumn 2011.

3.3.3.2 Changing approaches to teaching mathematics for the MLP

Many of the case-study centres acknowledged that they needed to change their approach to teaching mathematics. For some, this realisation is as a result of the MLP; for others, the reasons are to do with the greater emphasis on problem solving in GCSE mathematics generally. The focus of change for all the case-study centres is on problem solving, though one centre also mentioned the introduction of functional mathematics as a reason for a change of approach.

The main changes to teaching approaches suggested were teaching in a more interactive way, teaching for understanding rather than teaching to the exam, scaffolding problem solving through a step-by-step approach to support students to learn to think for themselves, teaching the student rather than the subject, and offering more open tasks and investigative work. However, a number of centres admitted that they were finding the introduction of problem solving into the MLP problematic, with several centres citing time constraints as a reason for not offering more open and investigative work; this type of activity in several of the centres occurs only at times when the normal timetable is collapsed and students can have a 'bit of fun'. There is evidence that some centres are not comfortable with introducing problem solving into the curriculum because the teachers either are not confident about teaching it or feel they do not have the resources yet to develop this area of work.

The majority of teachers of mathematics and heads of mathematics found it difficult to articulate the different methods of enquiry promoted by the MLP until prompted with examples. The methods of enquiry were considered implicit rather than explicit in their teaching: 'I wouldn't put a name to – it's just something that you just – it's something that you just do.' Several teachers, when asked about promoting the use of mathematical language in the classroom, acknowledged that they should possibly be *explicitly* promoting the use of and understanding of such language. There was also relatively little evidence of making learning explicit within the observations. Some teachers considered that it was important for students to reflect on what had been learned, as it was for teachers to make the learning

explicit; one teacher, however, commented that, as students become more fluent and proficient, explicit reflection slowed down the mathematics.

Several of the case-study centres indicated that they were teaching mathematics (topics) and then looking at the different types of questions in the two qualifications before the assessments. The teaching and learning of mathematics was not differentiated, but assessment was. Both students and staff at the case-study centres saw the main difference between the two qualifications as 'methods' and 'scenarios'. As one teacher explained, the mathematical skills were considered 'identical' across the two GCSEs; the difference was recognised in terms of needing to interpret the situation for the applications of mathematics questions to decide which mathematics to use.

Several centres reported being unsure about how much 'depth' was required and wanted more guidance from the awarding organisations. In a few centres, depth was recognised in terms of creating connections across mathematics topics and development of conceptual knowledge and understanding. The head of mathematics in one centre felt that this was not about a holistic approach across the two qualifications, but this was the value in seeing the MLP as two distinctive qualifications.

The majority of the case-study centres focused on mathematics that was in the realm of horizontal rather than vertical mathematisation. A minority of centres recognised and/or promoted vertical mathematisation, and only with higher-attaining students. The problem solving described by the case-study centres can generally be defined[43] in terms of word problems with arithmetical steps or worded contexts which require the learner to decide to use standard techniques. In a minority of centres, problem solving involved either worded contexts in which there was either no standard relationship to apply, or algorithm to use, but an answer was expected – or exploratory situations in which there was an ill-defined problem. With the exception of the latter definition, problem solving related to a 'realistic' rather than to a mathematical context and was not described by case-study teachers in terms of abstract, mathematical problems that required methods of enquiry and thinking specific to mathematics. Many of the teachers interviewed, however, welcomed and valued the addition of a greater emphasis on proof in the MLP.

3.3.3.3 Progression to further study

Pilot centres participating in the online survey were asked whether they had a sense that more students would continue to study or progress to mathematics qualifications or mathematics-related qualifications at level 3 and beyond as a result of the MLP.

[43] For the analysis, Watson's (2009) typology of problem solving has been used.

Respondents were fairly evenly split (with 47 of the 90 who responded saying ‘Yes’, and 43 saying ‘No’). When asked to explain their answer, of the 75 respondents who answered, 17 were unsure at this time, 33 thought (or had evidence, for example from surveys) that more students were likely to progress to mathematics or mathematics-related qualifications at level 3 (specifically, to A level), while 16 thought that the MLP would make no difference to progression to level 3 – many of these last respondents explained that they already had a high take-up and did not expect the MLP to make any difference. Only three respondents thought the MLP made it less likely that students would progress to level 3, with two of these mentioning that obtaining lower grades than expected at GCSE might put students off.

All 11 joint-offer centres and approximately half of the 22 single-GCSE-only centres were of the view that the MLP would prepare students better for level 3 mathematics and related qualifications. Most of the joint-offer centres thought this was because it provides a better foundation for mathematics at A level and stretches and challenges their students more than the new single GCSE. The added stretch and challenge was seen to be due to the emphasis on problem solving and open questions.

The other half of the single-GCSE-only centres thought that the MLP would not prepare their students for A level any better than the new single GCSE or would prepare them less well than the iGCSE or single GCSE combined with a level 2 further mathematics qualification, a position that the high-achieving schools tended also to take. A few of them stated that they had found the applications of mathematics specifications too functional and wanted more ‘pure’ mathematics to provide sufficient intellectual challenge to their students. They did not think that there was any more pure mathematics in the MLP than in the single GCSE.

Several of the high-achieving, single-GCSE-only centres had chosen, or would choose in the future, to offer the new single GCSE as opposed to the MLP. They thought that the new single GCSE – complemented with a free-standing, additional or further mathematics qualification – would provide the best preparation for A level study for all their students, or at least the top sets. Conversely, several of the pilot case-study centres felt that students would benefit from taking the MLP rather than the single GCSE with an additional qualification in mathematics.

3.3.3.4 Joint-offer and single-GCSE-only centres’ perceptions of breadth and depth

Most of the 22 single-GCSE-only centres and all 11 joint-offer centres thought that the MLP provides, or would provide, greater breadth of mathematical study than the new single GCSE in mathematics.

One head of mathematics from a joint-offer centre captured the reasons a number of centres gave for believing that the MLP promotes greater breadth of teaching, learning and student development:

> *The breadth of study is much wider, much nicer topics, a greater range of topics ... one or two topics tend to go into a bit more detail ... the focus on problem solving and proof and things like that, and it is just a much more holistic mathematical qualification and I would have much more confidence about a pupil's ability in maths had they been through that route compared to the whittled-down sort of single GCSE.*

Nearly half the single-GCSE-only centres expected the MLP to offer a better opportunity for students to develop greater depth of mathematical understanding than the new single GCSE. However, only a minority of the joint-offer centres shared this view; most of these felt that the MLP had a greater variety of topics than the single GCSE, but was not more difficult.

Most of the joint-offer centres reported that there was valuable additional content in the MLP over and above the content of the single GCSE in mathematics. Many saw particular value in the financial applications, and some mentioned the introduction of Venn diagrams as being of benefit to students. A minority of the joint-offer centres thought that algebra and trigonometry connected with circles would be best left out of the MLP, as these were either too demanding or just not useful areas of study for their students.

Just over half of the 11 joint-offer centres mentioned that there was too much content to teach within the time they currently had available for teaching mathematics. The heads of mathematics at all joint-offer centres reported that they and their teachers had enjoyed teaching the MLP more than the single GCSE, although a few were somewhat unhappy about having to rush to cover all the necessary content.

All joint-offer centres and most of the 22 single-GCSE-only centres thought that there would be value in having two mathematics GCSEs available, although only a minority of the centres made specific reference to the value of having two distinct GCSEs. The majority argument was that getting two GCSEs would be fairer, considering the amount of time and effort students put into studying mathematics compared with English and science, where they got two or even three qualifications. In their view, having a linked pair of GCSEs in mathematics would also raise the profile of mathematics. In addition, if students did not do well in one of the two GCSEs, they would have a chance of doing better in the other. Those who saw value in having two distinct GCSEs reasoned that Methods would suit one type of student and Applications another and that, taken together, the two qualifications would give students a broader, more holistic grounding in mathematics than the single GCSE.

Some single-GCSE-only centres, including both PRUs, were of the view that students, and lower-attaining students in particular, would not see the value of two GCSEs and that, moreover, it would be unfair and unproductive to ask them to take two GCSEs in mathematics where they already struggled to achieve one. A few single-GCSE-only centres were concerned about public, and especially employer, perceptions of mathematics GCSEs. The concerns focused on having both the single and linked pair available alongside each other. It was seen that a single GCSE was already highly valued in the workplace and that, if students were to present two GCSEs to an employer, this would just enhance the employer's perceptions that the mathematics examinations had been made easier (by splitting them into two).

The heads of mathematics at the 11 joint-offer and 22 single-GCSE-only centres were asked whether they would prefer for the MLP to replace the single GCSE or for the MLP and single GCSE to exist alongside each other. A similar number of joint-offer centres supported each model and a few of them thought that, either way, the decision should be made at a national level. There was equal support for both approaches among the single-GCSE-only centres also, although some centres did not have a view on the matter.

3.3.4 Student engagement with, and commitment to, mathematics

A majority of the heads of mathematics from the case-study centres felt that their higher-attaining students were highly motivated and committed to mathematics. Some accredited this to the MLP, but others felt that by Year 11 the higher-tier students were usually very focused on their mathematics and, in particular, on achieving their target grade. The consensus was that what promoted engagement and commitment for many students was not so much a love of mathematics as the extrinsic value of gaining the required grade at GCSE or the perceived relevance and usefulness of mathematics for further study or life. A minority of (higher-tier) students mentioned how they liked the fact that connections between different topics were now being made explicit to them; they enjoyed mathematics because they were good at it and were confident taking on more-challenging mathematics, as it built on their previous knowledge.

All the 11 joint-offer centres had found that students doing the MLP were equally or more engaged with and committed to mathematics. A majority of these centres stated that their MLP students were clearly more engaged; a minority felt that they were marginally more engaged. Over half the 22 single-GCSE-only centres expected the MLP to enhance their students' engagement with mathematics, or to give them a better grounding in it than the single GCSE. However, the heads of mathematics at the highest-achieving schools thought that the MLP would make no difference to their students' engagement and commitment, as they were very highly committed already.

The joint-offer centres referred to Applications and thought that introducing more mathematics that related to the students' everyday life had increased student engagement. They had found that students could see the relevance of the Applications course, and its financial aspects in particular, and were motivated to study it. A few centres also made the point that having to work on more-realistic real-life problems meant that students had to think about, and understand, what they were doing.

Some joint-offer centres also mentioned that the introduction of new styles of question, which had led to staff having to change the way they teach, had had a positive impact on the level of student engagement. Finally, several joint-offer centres stated that the opportunity to get two GCSE for the effort that they put into studying mathematics had had a positive effect on their students' motivation to study mathematics.

Pilot-centre student perceptions of the MLP

Several foundation-tier student focus groups were motivated by the need to gain the gate-keeper grade C – they could not see any value or role for mathematics other than for shopping or other money-related activities. For some of the foundation-tier students who had not had positive experiences of learning mathematics in the past, the approach of the teacher was now of more importance. These students often expressed nervousness about being made to look stupid in class if they asked questions, which was why they also disliked whole-group discussions. Overall, foundation-tier students were most comfortable and engaged when they could work with their peers, had opportunities to think about what they had to do, and when the teacher was felt to care about how they were doing.

There was not always consensus within the foundation-tier focus groups about whether the pace of the lesson was right. Although some students felt everything was rushed and there was constant preparation for examinations, students also became concerned that they would not be introduced to all they needed for their examinations if they spent too long on a topic.

Where students took part in a focus group following a lesson where new learning had been introduced through a realistic scenario – whether this was foundation tier or higher tier – they were positive about mathematics and had enjoyed the lesson. Borderline C/D grade students who had self-selected to take part in a centre where the rest of the pilot cohort was the higher-attaining students were very positive about the experience and about the grades they had achieved in the examinations so far. The students were very motivated by their achievement.

Some students, especially foundation-tier students, did not see any change in the teaching and learning for the MLP compared with previous programmes of study. These students reported that learning was usually individual, working from the textbook or worksheet. Foundation-tier students in one centre always worked individually: peer discussion and

collaborative working were not allowed. The lessons focused on teaching techniques and practising examination questions. The students did well in the examinations. In contrast, students at the same centre in the higher tier were encouraged to work collaboratively, and discussion was promoted to develop students' understanding of mathematics. The teacher hoped that they were moving away from a tendency to teach to the test.

Students from a majority of centres, and across both tiers, saw the extrinsic benefits of mathematics, but several foundation-tier focus groups viewed this extrinsic value not so much in terms of the usefulness of mathematics as in terms of getting the required grade C.

Many heads of department felt that the MLP was at the heart of the greater commitment and engagement with mathematics that they saw, but a few centres thought that by Year 11 most students were quite focused on mathematics anyway, as they wanted to secure a good grade. One head of mathematics thought that the students were highly engaged but, again, related motivation to achieving the highest grade they could rather than to a love of mathematics itself. One head of mathematics said that they detected little difference in attitude or engagement among students as a result of the MLP but then went on to say that the confidence of foundation-tier students on the MLP had increased dramatically because of their success in examinations, and that they appeared much more committed to their mathematics.

There was often a stark contrast within the same case-study centre between how higher-tier and foundation-tier students felt about mathematics – this contrast seems to relate to prior as well as current experiences of success in mathematics and to how individual teachers relate to and engage students.

3.4 Appropriateness of the MLP for a range of contexts and student groups

Of the 96 respondents to the online survey, 32 felt that particular groups of students were benefiting from the MLP and 16 that they were not; 31 believed that the qualification was appropriate for all students, and 17 were unable to say. When asked to explain their answer, of the 75 respondents who answered, 20 reported that more-able/high-attaining students were benefiting, and 21 that lower attainers were not. Often these two views were expressed in the same response:

> *The high-ability students get a lot out of it, whereas the lower ability find it extremely challenging.*

Conversely, nine respondents reported that borderline C/D students were benefiting, either from the increased opportunity to gain a grade C or from the nature of the paper (usually mentioning Applications). The final group of students identified are those with weak literacy, who are seen to be disadvantaged. This is broadly in line with the results of the March 2011

survey, where 21% of respondents reported that the MLP in mathematics was creating barriers or specific issues for specific groups of students. Some case-study centres also reported an issue with the literacy aspect of the applications of mathematics qualification. Lower-attaining students might be able to read the words but did not have the comprehension skills to understand the scenario and interpret this into a problem. This issue of comprehension was felt to relate to everyday language but, in a few cases, to the mathematical language used as well.

Views from the 11 joint-offer centres (centres offering both the MLP and the new single GCSE) were mixed on the appropriateness of the MLP for different student groups. Six of them thought that the MLP would be appropriate for all their students, although most of these centres qualified this statement in some way. The main qualifying statement was that they would envisage offering the MLP to all their students only if they were given more time to teach it; otherwise, it would be suitable only for their higher sets or high and middle attainers. A few of the joint-offer centres thought at the outset that the MLP would be suitable for higher attainers only, and some that it would suit higher and middle attainers. Only one joint-offer centre thought that it would suit their foundation-tier students best. Some joint-offer centres stated that they would like to see a reinstatement of the intermediate tier, making the MLP more appropriate for all student groups.

A third of the 22 single-GCSE-only centres were of the view that Applications would be likely to be suitable for all their students and Methods only to their higher-attaining students or to none. Another third thought that the MLP would be likely to be of interest only to their higher-attaining students, and the final third that it would not be appropriate to any of their students. The last group included both high-attaining schools and PRUs.

The PRUs stated that their students were already switched off and not mathematically able, so offering them two qualifications was not appropriate. However, the PRUs also thought that they could envisage their students doing Applications only, as functional mathematics was most appropriate to their needs. The very high-attaining schools thought that the MLP would not stretch any of their students enough, as it did not have an emphasis on pure mathematics.

3.5 Centre behaviour

3.5.1 Participation of different cohorts

In the March 2011 and September 2011 online surveys, centres were asked which year group(s) was (were) participating in the linked pair of GCSEs in mathematics pilot. In order to provide a general indication of participation, data from the two surveys has been

aggregated and plotted in Figure 7.[44] As this chart is an aggregation of two snapshots (one in March 2011 and one in September 2011), it can provide only a general indication of participation. However, this aggregate view does reflect the case-study centre data, which also suggests that the majority of centres are entering either whole cohorts or higher-attaining students for the pilot, for the reasons discussed in detail above.

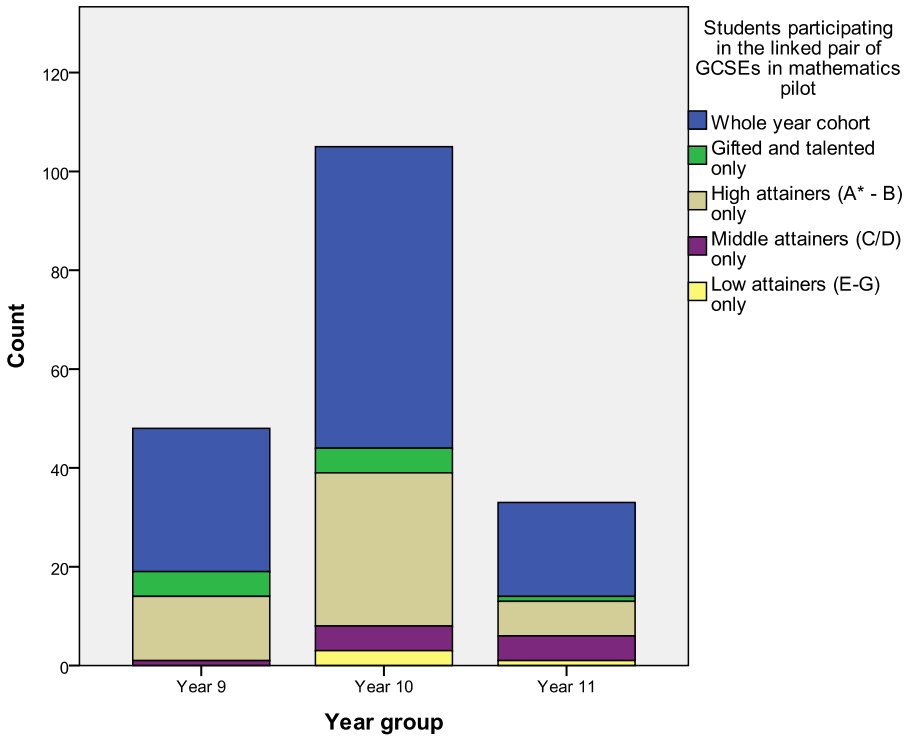

Figure 7: Breakdown of student cohort participation across each year group

3.5.2 Mode of delivery

The most common study pattern for the MLP is for Year 10 students to begin studying at the start of the academic year. Where centres have Year 9 students participating in the pilot of the MLP, there is an even split between those who begin studying at the start of the year and those who begin studying in the summer term. Where centres are also teaching the new single GCSE in mathematics, the pattern is similar.[45] These results are very similar to those obtained from the March 2011 survey and reflect delivery patterns seen in the case-study data.

[44] In the September 2011 survey, only centres that had not responded to the March 2011 survey were asked which year groups were involved in the pilot. There is therefore no double-counting in the chart (i.e. each centre was asked the question only once). The chart does not, however, capture any changes to year group participation since the March 2011 survey (and nor did the survey). It is for this reason that it is important to recognise that the chart is indicative only.

[45] Data from the September 2011 online survey from centres that did not participate in the March 2011 survey (n=28 for centres offering the MLP, n=17 for centres which also offer the new single GCSE in mathematics).

Heads of mathematics at a small number of case-study centres felt that the MLP gave time for more-interesting mathematics and lessened the pressure to focus only on what will be in the assessments. This was because there was no expectation that GCSE mathematics would be covered in one year: two qualifications warranted at least two years of study. In addition, there was still an opportunity to gain one GCSE (A*–C) by the end of Year 10, which pacified senior leadership teams anxious about KS4 floor targets.

The case-study centres reported little change in the student cohort or groups entered. Most of the 10 centres visited were continuing to enter the whole cohort, and one centre was entering more foundation-tier students and giving them the opportunity to improve from grade C in Year 11. In contrast, two centres were putting in only high-attaining students, with one of the centres saying this was because they did not want to risk grade C students in a pilot.

Although the majority of the case-study centres continue to use an integrated model of teaching for the GCSEs, for a few of these the assessment focuses on one or other of the GCSEs first.

3.5.3 CPD and resources

There continued to be a reliance on the use of textbooks endorsed by the awarding organisations and written either for the legacy or new single GCSE, with new materials for the extra content supplied separately by the awarding organisations. One centre reported following schemes of work specifically developed by the awarding organisation for each of the qualifications. Some adjustments needed to be made, as it was thought that the scheme emphasised a topic-based approach, which was not always appropriate. Many of the case-study centres continued to feel they needed further support with developing their students' problem-solving skills.

3.5.4 Potential impact of future policy decisions on centre perceptions of the MLP

Pilot centres were asked three questions either in the online survey or during case-study visits relating to the possible effect that changes in government policy may have on their decision to offer the MLP. The heads of mathematics at joint-offer centres and single-GCSE-only centres were also invited to answer the same questions at interview.

3.5.4.1 Linear assessment

The majority of case-study centres felt that linear assessment was appropriate for higher-tier students, although some thought that the unitised system was better for students at foundation tier because it enables students to 'chunk' their learning and revision. One centre thought that linear assessment would work for foundation-tier students only if they could take one GCSE in one year and the second in the following year. Two centres welcomed the

possible introduction of linear assessment: one felt that the unitised assessment encouraged students to take assessments at too young an age; the other was concerned that increased unitisation had increased the stress levels of both students and teachers, partly because of the sheer number of assessments but also because of the increased numbers of re-sits.

The suggestion of a move to a linear model of assessment had mixed reactions from students. Some welcomed the idea of taking assessments at the end of the course; others were concerned that it would increase their levels of stress. Students at foundation tier were most concerned about the move to linear-only assessment. Several centres were using unitised assessments of the linked pair of GCSEs in mathematics in a linear way, either leaving all assessment to the second year or entering students for both papers for one of the GCSEs at the end of the first year and both papers for the MLP GCSE at the end of the programme of study.

Well over half of the pilot centres responding to the question in the online survey (n=78) said a change to linear assessment would have no effect on their decision to offer the MLP. One-quarter felt they were more likely to offer the MLP, while a minority said it would make them less likely to do so. When asked to explain their answer, of the 55 respondents who answered, 16 stated their intention to continue with the MLP irrespective of the government decision, and 14 that they would continue because they were in favour of running the MLP in a linear form (and for the most part already did this). Against this, 14 said that it might/would affect their decision, since they were not in favour of a linear approach; six of these specifically stated that they were concerned about, or actually against, having all the examinations at the end of a two-year period.

A third of the 33 joint-offer and single-GCSE-only centres reported that they had traditionally been a linear-only assessment centre, so this would have no impact on their choice of offering the MLP. Another third expressed strong negative views on the move to linear-only assessment, saying that the repercussions of the proposed change would go beyond their decision to offer the MLP. The final third did not have any strong views on linear versus unitised assessment. Of these centres, a majority thought that a move to linear-only assessment would increase the likelihood of their offering the MLP, provided that students could sit two exams at the end of the first year and two at the end of the second year. They would be less likely to offer the MLP if all four exams would have to be taken at the end of a two-year course. One head of mathematics at a joint-offer centre said, ‘The linked pair is a very, very good compromise between negative aspects of a modular course and the negatives aspects of a linear course, and it is the best of both worlds, getting rid of the negative of each.’

3.5.4.2 GCSE A to C pass rate*

The majority of pilot, joint-offer and single-GCSE-only centres already achieve the proposed level of five GCSE passes at A* to C; a move to a 50% minimum target for A* to C in GCSEs would therefore have no effect on their decision to offer the MLP. In the online survey, just over one-quarter of respondents thought the move would make it more likely that they would offer the MLP, and only a small number that it would make them less likely to do so. A minority of joint-offer and single-GCSE-only centres, currently performing below the 50% target, thought that the change would make them less likely to offer the MLP, unless the senior leadership team was backing the introduction of the MLP. One head of mathematics did say that they thought the move to increase the target would be demoralising for schools that do a good job but do not reach the proposed targets.

3.5.4.3 A change in emphasis to core curriculum subjects

The vast majority of pilot centres felt that the change in emphasis to core curriculum subjects would have little impact on their decision to offer the MLP. A handful of pilot centres said that it would make it less likely that they would offer the MLP.

A small minority of joint -offer and single-GCSE-only centres thought that the increased emphasis on core curriculum subjects would increase the likelihood of their offering the MLP in the future, because it provided better preparation for level 3 mathematics qualifications. A larger minority thought that it would have a negative impact on the senior management team's and/or the mathematics department's willingness to offer the MLP. The two main reasons given for this were that the increase in the number of subjects within the EBacc (for example) would make it hard to justify two GCSEs in mathematics and that, if it was going to be more difficult for students to get a C in either of the linked pair of GCSEs in mathematics than it was in the single GCSE, then the choice would be the single GCSE.

3.6 Wider stakeholder perceptions

The consensus among all six wider stakeholder[46] organisations interviewed is that the MLP has the potential to fulfil its wider aims over and above that of the single GCSE in mathematics. Organisations agreed that the MLP is likely to create better mathematicians and provide a richer experience for students. However, all the organisations interviewed expressed the view that the success of the MLP was dependent on a number of factors, principally the quality of teaching, improvements to the assessments and the opportunity to revisit the specifications at the end of the pilot.

[46] Subject associations, including other expert and advisory groups, professional bodies and workforce development organisations.

Wider stakeholders hoped that revisiting the specifications and the AOs would be part of the evaluation of the pilot. Two of the organisations had concerns that constraints imposed by regulation meant that the specifications for each of the MLP GCSEs were not as distinctive as they might have wished, making them too similar to the single GCSE in mathematics. One organisation was particularly keen to see changes made to the AOs, particularly as they felt that there was too little distinction between AO2 and AO3 in the Applications GCSE in terms of weighting. Two wider stakeholders also expressed the hope that the content of the two GCSEs would be revisited – one because they felt there was too much overlap between the two GCSEs, the other because there was too much content in one and not enough in the other.

There was consensus that the success of the MLP relied on good teaching. One organisation felt the emphasis should be less on changing the curriculum and more on 'changing what happens in the classrooms'. Good teaching meant a number of things: widening the scope of mathematics teaching to address other curriculum areas, understanding the relationship between the real world and that of mathematics, interpreting and translating between the two, encouraging students to work out what they need to know rather than telling them, and getting 'the students to feel that they are in control of the maths rather than the maths being in control of them'. One organisation felt that good teaching depended on not focusing on the assessment – 'teaching to the test'. Another organisation believed that teachers under pressure to get through the syllabus forget 'that they have already taught (the students) for three years … they start again at the bottom rather than develop the mathematical skills they already have'.

The organisations interviewed thought it was important for students to see both the distinctiveness of each GCSE and the connections between the two. Good teachers, they suggested, draw out the different aspects of mathematics, making clear the distinction between conceptually based mathematics and functional mathematics. On the whole, organisations thought it important that students take both qualifications, although one felt that a minority of students could take one 'where it doesn't actually improve their life chances or their wider education'.

All organisations agreed that there were examples of good practice in teaching mathematics but felt that there is a need for support in developing pedagogy appropriate to the MLP. Problem solving was seen as a key area for development. Concern was expressed that professional development offered by the awarding organisations tended not to focus on pedagogy and that there was therefore a need for other forms of professional development that focused on pedagogy and support for the development of resources. One organisation believes that 'there is a myth that mathematics teaching is somehow different from other

subject teaching' and suggested that it could be a powerful learning experience to offer mathematics teachers the opportunity to observe good practice outside the mathematics department.

Organisations were keen to see assessment that is fit for purpose and reflects the wider aims of the MLP. They felt that any measure of performance should reflect the skills students should be developing, although they also acknowledged that effective assessment, particularly of problem solving, was challenging. There was some suggestion that there are technical reasons that make it difficult to devise 'a seriously challenging problem-solving paper' and that some other form of assessment – in which students can use real data, calculators and software – might be more appropriate.

Two organisations talked about the appropriateness of the MLP in terms of progression in education or employment. One of these thought that the MLP prepared students for study at level 3 in terms of problem solving and an introduction to proof better than the single GCSE in mathematics. Another organisation said that the MLP provided students with the mathematics employers want, that is, the ability 'to be able to apply maths ... to be able to reason (and) communicate their maths more effectively'.

There was strong support among the organisations for the replacement of the single GCSE by the MLP, in part because they see it as a better qualification but also because they felt there should be just one option. They considered that the single GCSE offered less in terms of breadth and depth and that students taking it would not get the introduction to the wider curriculum that the MLP offered. Too many GCSEs in mathematics, it was feared, would prove confusing, and continuing to offer the option of the single GCSE would prove too tempting for some schools in terms of ease of administration and timetabling. One organisation, recognising the benefits of the MLP, expressed doubts about replacing the single GCSE with the MLP because of possible complications where students were taking re-sits at a sixth form or FE college.

All organisations were broadly in favour of linear examinations. Some organisations acknowledged that this would not be popular with some teachers and students but expressed concern that unitised assessment has a tendency to atomise the curriculum and prevents students seeing the connections between different aspects of mathematics that use similar skills. One organisation stated that they had no problem with the introduction of linear assessment as long as it did not jeopardise the MLP.

Of the organisations expressing a view on the impact of the EBacc on the MLP, one organisation commented that the content of the mathematics in the current EBacc was different from that in the MLP. This organisation was concerned that, if the EBacc was

introduced together with the single GCSE and the MLP, schools would opt for the single GCSE, because it would be seen as 'straightforward and easy'.

4 Summary and conclusions

Understanding the potential impact of the MLP for a range of different student groups and in schools with fewer, or no, qualified mathematics teachers is made more problematic by the fact that the pilot cohort for this programme, as is often the case with pilots, may not be representative: high-achieving centres and students are over-represented in the attainment data for examination entries seen to date, and there is a higher-than-average proportion of qualified mathematics teachers involved in the pilot programme. It should be noted, however, that many centres report their intention to enter whole-year cohorts of students for the MLP. It may be that some of the centres that have already entered students for examinations have entered their higher-attaining students first.

The 'value' of the MLP is interpreted differently across the pilot centres. Many pilot centres gave their main reasons for taking part in the pilot as the opportunity for students to gain two GCSEs in mathematics, together with the opportunity to stretch and challenge their students, but the opportunity for some students to have two chances to gain a grade C at GCSE was also influential in centres' decision to participate. In some of the pilot centres, enthusiasm for the MLP was tempered in part by students' performance in the examinations, which determined whether more or fewer students were entered from subsequent cohorts.

Most stakeholders recognised the value in the wider aims of the MLP, but there is currently no widespread recognition of how the structure and additional content of the two GCSEs are intended to work together to meet these aims. In the case-study centres this appears to be due, in part, to centres not fully recognising the 'difference' promoted by the MLP and/or to a nervousness to embrace the full possibilities of the MLP because of perceived restrictions of time, lack of guidance on the range of pedagogies required, and uncertainty of the short-term impact of new teaching approaches on examination grades, especially for the traditionally higher-attaining students chasing A* grades or for the C/D borderline students.

The pressure to complete – with certification of GCSE mathematics by the end of Year 10, and with Year 11 focusing on re-sits if needed – may be the reason for the perception of a lack of time for teaching and learning in some centres.[47] Two case-study centres, however, felt that having two GCSEs had 'created' time to do more than just teach to the test in that they were perceived to be, at least, a two-year programme. Nine of the ten case-study

[47] See also DfE (2011) *Early entry to GCSE examinations* https://www.education.gov.uk/publications

centres visited in autumn 2011 also reported that they were delivering the MLP as at least a two-year programme. The statistical data for results from the first year of the pilot also suggests that most MLP candidates taking qualifications in the first year of the pilot will continue to take mathematics in their second year.

Ofsted reported (2008) that the high-stakes nature of mathematics in school performance targets (floor targets) often results in schools teaching to the test.[48] There is evidence across the range of primary and secondary data analysed for this study that schools focus strongly on C/D borderline students, monitoring them closely and providing additional intervention. The data shows that as a gate-keeper qualification, grade C at GCSE is important to students and centres. However, the emphasis on teaching to the test reported in the secondary data suggests the quality of teaching and learning for GCSE mathematics is often skewed by the focus on threshold attainment data. The importance of the C (and the A/A*) grade in mathematics at GCSE is evident in pilot centres' perceptions of 'value' of the MLP as well as in the extent to which centres have (or have not) changed their approaches to teaching and learning.

The attainment data to date suggests that early entry is resulting in under-achievement. Pilot centres consider it important to change and to improve teaching and learning, but they are constrained by the heavy focus on assessment, the perceived lack of time to 'teach' content and by their uncertainty about how to teach problem solving effectively.

Problem solving and functionality are central to mathematics at KS4. The previous reports on the MLP have identified centres' lack of a shared understanding of what problem solving and functionality mean in relation to mathematics teaching and learning generally and in particular relation to the revised AOs for GCSE mathematics. The fact that there is no common definition for these terms across the range of instances and contexts in which they are used – such as the two MLP qualifications – is problematic. An absence of clear definitions might lead to a failure to realise the recognition and understanding of the different types of problem solving which the structure of the MLP promotes.

It has previously been reported that the effective teaching and assessment of problem solving and functionality are still in relatively early stages of their development. This is not an issue specific to the MLP: centres offering the MLP together with the single GCSE, awarding

[48] Ofsted (2008) reported the use of 'booster' lessons, revision classes and extensive intervention, coupled with a heavy emphasis on 'teaching to the test'. While these strategies were successful in preparing students to gain the qualifications the narrow emphasis on 'disparate' skills did not necessarily support mathematical understanding. Ofsted (2008) *Mathematics: understanding the score*. London: Ofsted.

organisations and wider stakeholders, all suggest that the issues regarding the teaching of problem solving are also evident for the single GCSE in mathematics.

The potential for the structure of the MLP qualifications to promote depth as well as breadth (vertical and horizontal mathematisation) of mathematical understanding and application will only be realised if centres are supported to recognise the full spectrum of problem-solving activity in their teaching. Many centres consider that the additional content promotes breadth – and a smaller number of centres recognise the potential of the additional content to promote depth through creating connections and recognising relationships across mathematical 'topics'. Currently, problem solving predominantly focuses on the application of known mathematical techniques to a realistic context or scenario, rather than exploratory or developmental mathematical problem solving.

The three levels of support that the previous MLP report identified teachers as needing are still valid.[49] However, CPD should also support teachers to:

- reflect on and make explicit the different methods of enquiry they use
- recognise the full spectrum of problem-solving activity in their teaching and have strategies for teaching it
- recognise the different types of knowledge within the MLP and the significance of different pedagogical approaches.

Centres offering both the MLP and the new single GCSE found MLP students to be more engaged with and committed to mathematics than those doing the single GCSE. Overall, students reported that the extent to which they enjoyed and engaged with mathematics related directly to their levels of confidence and their sense of achievement in the subject. There was often a stark contrast within the same case-study centre between how higher-tier and foundation-tier students felt about mathematics – this contrast seemed to relate to prior as well as current experiences of success in mathematics and to how individual teachers related to and engaged students.

The consensus was that what promoted engagement and commitment for many students was not a love of mathematics so much as the extrinsic value of gaining the required grade at GCSE or the perceived relevance and usefulness of mathematics for further study or life.

---

[49] A minority of centres require a minimal level of input; most centres, however, although they recognise the need for change, will require support to implement planned changes to their teaching in terms of developing more skills-based, interactive approaches, and fully effecting the move from topic-based to process-skills assessment in their practice. A significant minority, however, require support to enable them to recognise that changes to their teaching and learning are needed.

A majority of the heads of mathematics from the case-study centres felt that their higher-attaining students were highly motivated and committed to mathematics. Some centres attributed this to the MLP, but others felt that by Year 11 the higher-tier students were usually very focused on their mathematics and, in particular, on achieving their target grade (A*/A). Some stakeholders saw the MLP as providing a better foundation for studying mathematics at A level than the new single GCSE did.

Centres with higher-attaining students have historically offered more than one qualification in mathematics at KS4. The majority of case-study and joint-offer centres that have previously offered additional mathematics qualifications felt that the MLP offered a sufficiently challenging or better alternative. Some single-GCSE-only centres, however, were concerned that the MLP would not be sufficiently challenging.

There is evidence to date to suggest that some centres feel that the MLP may not be appropriate for all student groups and contexts. The MLP may not be suitable for some lower-attaining students: learning takes much longer for these students and their language/literacy skills may mean, for example, that they struggle to make connections between ideas or transfer knowledge between contexts, or to read more ‘wordy’ tasks with comprehension. There was, however, no consensus across the range of centres interviewed as to which of the MLP qualifications was likely to be more challenging for lower-attaining students. Although it is not possible to understand at this stage of the pilot the implications for the full range of contexts, there is some evidence to suggest the MLP may be less suitable in centres where students are already disengaged and/or may have greater restrictions on the amount of time possible for teaching (for example, PRUs, FE institutions or adult education).

In response to questions in the online survey about the possible effect that changes in government policy may have on their decision to offer the MLP in mathematics, pilot centres largely indicated that the changes would have no effect on their decision. Where an effect is foreseen, it seems likely to make centres more likely to offer the MLP, by a factor of approximately three to one.

The value of a move to linear-only assessment was recognised by many of the centres, although there was concern that this was likely to affect the results of lower-attaining students who benefited from being able to ‘chunk’ their learning and revision for unitised assessment. Several case-study centres reported using the unitised approach flexibly, using the assessment in a linear form as appropriate for their groups of students. Feedback from centres suggested that many would, if possible, enter students for one MLP GCSE one year and the other at the end of the following year, to ease the pressure on students. Generally,

students were concerned that taking examinations for two mathematics GCSEs at the end of Year 11 would be very stressful.

Ref: DFE-RR207

ISBN: 978-1-78105-097-2

April 2012