Research Report DFE-RR181

The independent evaluation of the pilot of the linked pair of GCSEs in mathematics

First interim report

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Background

This report is the second of seven formative evaluation reports on the pilot of the linked pair of GCSEs in mathematics. The linked pair of GCSEs in mathematics qualifications are 'methods in mathematics' and 'applications of mathematics'. The two qualifications together cover the entire Key Stage (KS) 4 programme of study (PoS) for mathematics and contain some additional content. Neither qualification by itself covers the full KS4 PoS. A new single GCSE in mathematics was also developed for first teaching in September 2010 – the single qualification is 'nested' in the pair. A final, summative evaluation report will be presented in December 2013.

The pre-pilot report (December 2010) focused on pre-pilot planning, preparation and communication; pilot centres' state of readiness; and what centres and wider stakeholder groups, consulted before the first delivery of the pilot in September 2010, expected the impact, risks and issues of the linked pair of GCSEs to be. This report follows on from the pre-pilot work and focuses on centre and student participation and engagement in the pilot, reported changes to teaching and learning as a result of the pilot qualifications and their assessment, and the extent to which these changes parallel those resulting from the introduction of the new single GCSE in mathematics.

The evaluation is based around four key themes:

- attitudes to mathematics
- comparability of demand of the pilot qualifications with each other and with other GCSEs in mathematics (including the new single GCSE)
- the views of pilot and non-pilot centres on the pilot
- the support offered to pilot centres by the awarding organisations.

At this stage the report can give only an indication of the potential impact of the pilot, based on stakeholders' perceptions and an initial round of classroom observations. There has been no new statistical data since the development of the baseline for the pre-pilot report. Only three of the four awarding organisations offered examinations in January 2011 (Edexcel did not), so the analysis of examination papers reported here is currently restricted to those awarding organisations.

At the time of reporting there were 244[1] pilot centres in England and Wales across the four awarding organisations taking part in the pilot,[2] compared with 255 reported as participating in autumn 2010. The centres that have withdrawn from the pilot (citing change of centre personnel as the main reason for doing so) have mostly been replaced.

Methodology

This report is based on the analysis of three sources of data collection.

In-depth interviews and observations at case study centres involved 13 case study pilot centres and interviews with 3 case study non-pilot centres. Eleven of the case study pilot

[1] One centre appears to be registered with two awarding organisations.

[2] Participating awarding organisations: AQA (89 centres), Edexcel (92 centres), OCR (50 centres) and WJEC (13 centres).

centres had previously been visited for the pre-pilot report. Data was collected during spring term 2011. The observation of pilot qualification lessons in case study centres was central to the focus for this report.[3] Centres were asked to identify changes that had been made to teaching and learning as a result of piloting the linked pair of GCSEs; centres that were teaching the new single GCSE as well as the linked pair were also asked to identify the extent to which the same changes were being made for the single GCSE.

Observers were asked to record the variety and frequency of activity in the classroom, and instances and examples where the pedagogy observed corresponded to the wider aims of the linked pair of GCSEs. A framework was developed for the observations based on ideas from work by Greg Brooks[4] and Malcolm Swan.[5]

An online survey of pilot centres focused on centres' participation and management of the pilot qualifications, and on the planning and implementation of any changes to teaching and learning. Where pilot centres were also offering 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 244 pilot centres, 112 responded to the survey (46%), with three-quarters of the respondents being heads of mathematics, and the remainder the teacher/manager responsible for the linked pair of GCSEs in that centre. The breakdown of centres participating in the survey by awarding organisation was: AQA – 45%, Edexcel – 51%, OCR – 22%, WJEC – 62%.

Scrutiny of assessments was applied to assessments from the November 2010 and/or January 2011 examination series for the new specification single GCSE and the linked pair of GCSEs for each of the four awarding organisations. A total of 26 examination papers from four awarding organisations across three specifications and two tiers were scrutinised. The materials were not sampled but included all the live papers available at the time of undertaking the analysis (typically single units only), along with accompanying marks schemes and assessment grids (see Table 1).

Table 1: Overview of the 26 examination papers analysed*

	Applications of mathematics	Methods in mathematics	Single
AQA	2	4	4
Edexcel			4
OCR	2	2	4
WJEC	2	2	

* Half the papers in each cell were foundation-tier and half higher-tier.

The purpose of this analysis was to describe the differences and similarities across the applications of mathematics, methods in mathematics and the single specification GCSE examinations in mathematics. The aim of this work was to provide a baseline for future analysis and scrutiny, following further assessment in summer 2011.

[3] Total number of pilot centre visits that included observations: 10. Total number of observations: 18.

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

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

Summary of findings

Attitudes to mathematics

The centres

Centres responding to the online survey gave a range of reasons for participating in the pilot. Overall, they were enthusiastic about the opportunities the pilot offered, with some recognising benefits over and above those of the new single GCSE in mathematics. The main reasons centres gave for participating were:

- the opportunity to stretch higher-attaining students and/or for students to gain two GCSEs
- the content and approach to mathematics embodied in the pair of qualifications
- the flexibility to tailor the curriculum to the needs of all students
- the additional possibility the pilot qualifications offered of gaining an A*–C grade in mathematics.

The students

In the case study pilot centres, students who participated in the focus groups saw mathematics as a difficult and highly important subject. They all believed that mathematics was important for their future employability and/or progression to further study and, on these grounds, often compared it to English. A substantial number of students said that the benefit of the linked pair of GCSEs was simply in getting more GCSEs, which looks good on students' CVs and makes them more employable.

Mathematics was generally seen as being more useful, and sometimes therefore more enjoyable, when it was based on real-life scenarios and did not just involve learning techniques to apply in an examination room. There were mixed views on some topics such as algebra, which students from three of the higher-tier groups considered to be enjoyable but of no use to them in life unless they were preparing for higher-level study. The majority of students said that they enjoyed mathematics more when the lessons were interactive and lively.

Many of the higher-tier students said that they were contemplating continuing their study of mathematics to A-level, generally because they recognised that they were very good at the subject and/or, specifically, that they needed further qualifications in mathematics to be employable in a chosen field. Those students not planning to continue studying mathematics gave a range of reasons for not doing so, including: not feeling confident in the subject; feeling that their strengths lay elsewhere; acknowledging that mathematics was useful in general, but that it was more important for them to specialise in other subjects that had direct relevance to their chosen area of employment; not needing it for their chosen area of employment.

The students interviewed had mixed views about the jump from KS3 mathematics to the linked pair of GCSEs, some feeling the change was substantial and others that mathematics had become easier or was about the same. Students from higher-tier and foundation-tier groups said that any detectable difference was just a natural step-up or progression. They also disagreed on whether methods in mathematics or applications of mathematics represented the greatest change.

Centre and student representation and participation in the pilot

Some centre types are under-represented in the pilot and others over-represented. The extent of under- and over-representation of different school types is not enough to be of major concern at present; indeed, in the case of schools with sixth forms, over-representation may even help to clarify the impact on progression to level 3 learning later in the pilot. The issue of representation of different student cohorts will need to be considered in future statistical analysis: it has the potential to skew findings if, for example, there is a higher or lower proportion of higher-attaining students than in the mainstream GCSE cohort or a greater or smaller proportion of particular minority groups. The lack of further education (FE) institutions and adult community learning centres in the pilot will also need to be addressed further through case study non-pilot activity to ensure there is sufficient understanding of the potential impact of the linked pair of GCSEs for students in these contexts.

For the most part, centres were entering either whole-year cohorts or higher-attainers/gifted and talented students in the pilot, although more middle attainers (C/D borderline) were entered in Year 11. There is strong evidence to suggest that Year 11 students are being entered for the linked pair of GCSEs assessments. These students will have started their KS4 programme of study before the first teaching of the linked pair of GCSEs in September 2010, and will therefore have been following the specifications for the legacy qualifications. It will be important to monitor the attainment of these students, as the type or amount of teaching and learning they experienced may differ. It will also be important to evaluate the extent to which the pilot qualifications are suitable for all students and, for that reason, to monitor any emerging trends of participation, with a focus on specific cohorts.

As the pre-pilot report identified, a large number of Year 9 students are taking part in the pilot. Case study centres cited this as one way to increase the amount of time available for the qualifications. What is unclear at present is the impact this will have on early entry, and whether students will continue to study mathematics in Year 11 if they have already finished their GCSE in mathematics. Case study pilot centres that had previously offered *additional* mathematics[6] or statistics in Year 11 suggested that the linked pair of GCSEs would be used as an alternative to these.

Only one in four of the centres reporting that the linked pair of GCSEs raised issues for lower attaining students or students with weaker literacy believed that the new single GCSE raised the same issues. Why centres believe this to be the case requires further investigation.

One awarding organisation reported that a significant number of pilot centres had not registered for the June 2011 assessment window, perhaps because they have opted for a linear approach to assessment (i.e. entering students for all papers at the end of the programme of study). Other awarding organisations have reported numbers of entries but not centres entering. The number of centres still participating will need to be monitored carefully to ensure they are sufficient for piloting purposes.

[6] In addition to the GCSE a*dditional* mathematics qualification offered by AQA and OCR as part of the Mathematics Pathways pilot, CCEA also offer a 'GCSE additional mathematics' which is taken by a small number of candidates in England, and which is not funded under Section 96 (Section 96 lists all qualifications which are approved for use in maintained schools and colleges). Throughout the report, the use of the term 'GCSE *additional* mathematics' refers solely to the pilot qualification in the Mathematics Pathways project.

Comparability of demand of the pilot qualifications with each other and with other GCSEs in mathematics

Centres that offered both the linked pair of GCSEs and the new single GCSE reported in the online survey that the linked pair was leading students to acquire skills and knowledge that they could transfer to other subjects, although almost two-thirds believed that the single GCSE was having the same effect. The majority of these centres also said that the linked pair of GCSEs was more demanding and challenging than the new single GCSE, and more than one-third also said that the linked pair was more interesting.[7]

Assessment

The initial scrutiny of the assessments was undertaken to give a benchmark for future analysis and suggests that:

- the weighting of marks for assessment objective 1 (AO1), AO2 and AO3 is appropriate[8]
- examination papers contain some questions that are unstructured and require longer chains of reasoning
- there was a relatively high level of analysing-procedural questions (where analysis requires only procedural knowledge of what to do) in the papers scrutinised.

It is too early at this stage to draw any conclusions from the analysis and scrutiny, given that full suites of live papers are not currently available. Awarding organisations have 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 not be sufficient time in the piloting phase for these to be evaluated fully. What will need to be monitored, given the pilot timescales, is the speed and direction of change and the extent to which the changes will allow and encourage candidates to use higher-level mathematical skills, such as generalising and constructing arguments.

Most centres participating in the online survey that had entered students for the January 2011 examination series reported that the assessments were as challenging as expected, with one in four saying they were more challenging than expected. There was no significant difference between the perceptions of levels of difficulty between methods in mathematics and applications of mathematics.

[7] None of the centres that offer the single GCSE in mathematics as well as the linked pair of GCSEs in mathematics reported that the linked pair of GCSEs in mathematics was less interesting, demanding, or challenging than the new single GCSE

[8] Assessment objective 1: recall and use knowledge of prescribed content; assessment objective 2: select and apply mathematical methods in a range of contexts; assessment objective 3: 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).

	Assessment objective 1	Assessment objective 2	Assessment objective 3
Methods in mathematics	50–60%	15–25%	20–30%
Applications of mathematics	40–50%	30–40%	15–25%

The views of centres (both pilot and non-pilot) on the pilot

Where centres reported that the linked pair of GCSEs had necessitated design changes in the curriculum, or changes to their teaching, many reported that the new single GCSE had had the same effect.

Centres were enthusiastic about the opportunities the linked pair of GCSEs offered, but many of them will have to make considerable changes to teaching and learning if these opportunities are to be realised. How far centres are able to do this depends primarily on the extent to which they embrace a more student-led, challenging and open approach in their teaching. Although there is obviously a need for some teacher input and modelling at this early stage, in the majority of the lessons observed, reasoning and conceptualisation were predominately teacher-led and structured.

Only in a minority of centres was there a high level of effective questioning, creating 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 in the level of higher-order questioning and reasoning observed between foundation-tier and higher-tier lessons, 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 activities, 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 assessment objectives and grade descriptions that require different mathematical behaviour from candidates.

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 this report suggest that three levels of support may be required if all centres are to realise the full potential of the linked pair of GCSEs:

(i) A minority of centres require a minimal level of input, clarifying the difference within and between the two qualifications that make up the linked pair. This should in particular focus on what problem solving looks like in methods in mathematics.

(ii) For the majority of centres, in addition to the support outlined in (i) above, the evidence suggests that what is needed is help in implementing planned changes to their teaching in terms of developing more approaches that are skills-based and interactive, and fully recognising the move from topic-based to process-skills assessment in their practice.

(iii) A significant minority, as well as needing (i) and (ii) above, also need support to enable them to recognise what changes need to be made to their teaching and learning, which teaching approaches and strategies are likely to be most effective, and how these can be managed and planned for.

Some teachers will also need to undertake continuing professional development (CPD) which specifically addresses 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 three 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 Introduction

This is the second 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 report focuses on the centres and students who participated and engaged in the pilot, on reported changes to teaching and learning caused by the pilot qualifications and their assessment, and on the extent to which these changes parallel those caused by the introduction of the new single GCSE in mathematics.

The report is divided into four main sections:

- introduction
- methodology
- research findings
- summary and conclusions.

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 per cent of students
- was inadequate preparation for progression beyond level 2
- was perceived by 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 criteria and a new single GCSE in mathematics was 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.[9] The single specification GCSE and the pilot qualifications[10] 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

[9] 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).

[10] 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 (Alpha*Plus*, MLP pre-pilot report, December 2010).

to stretch and challenge all students. But 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).

Each qualification in the linked pair of GCSEs is intended to have a distinctive quality, so that students are explicitly aware of the skills they are developing, the topics covered – and of their relationship to problem solving in everyday life, to mathematical conceptualisation, and to critical thinking. Since September 2010 the assessment objectives (AOs) for both the linked pair of GCSEs and the new single GCSE are no longer set out largely in terms of subject content. Instead, they are set out as mathematical skills,[11] and in the linked pair of GCSEs these are weighted differently across the two qualifications.[12] 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.

1.1.1 Aims of the evaluation

The aim of the evaluation, to consider the extent to which the linked pair of GCSEs offers a different experience of learning mathematics from the new single GCSE, 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 linked pair of GCSEs and their comparability with the new single GCSE in mathematics
    - challenges in the development of assessment for the linked pair of GCSEs 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 GCSE mathematics or to perceptions of its value

[11] Assessment objective 1: recall and use knowledge of prescribed content; assessment objective 2: select and apply mathematical methods in a range of contexts; assessment objective 3: 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).

[12]

	Assessment objective 1	Assessment objective 2	Assessment objective 3
Methods in mathematics	50–60%	15–25%	20–30%
Applications of mathematics	40–50%	30–40%	15–25%

- 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 linked pair 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 main findings and risks identified in the pre-pilot report (autumn 2010)

The pre-pilot report focused on pre-pilot planning, preparation and communication; pilot centres' state of readiness; and expectations of the impact, risks and issues of the linked pair, as identified by centres and wider stakeholder groups before the first delivery of the pilot in September 2010. The pre-pilot report findings were based on: a document review, including documents from Ofqual and the awarding organisations, QCDA's June 2009 pilot communications strategy, and baseline statistical data; a literature review; case study data from 14 pilot centres and 5 non-pilot centres; 24 interviews with wider stakeholder groups and the 4 participating awarding organisations; and an online survey (368 responses, just under 10%).

1.1.2.1 Pilot engagement and participation

Overall, the pilot centres and wider stakeholders interviewed in autumn 2010 were enthusiastic about the pilot qualifications and their potential impact.

There was clear evidence that the opportunity the linked pair offered students to gain a target grade, especially the 'C' grade, was a key reason for participation in the pilot. This is likely to reflect the significance of the measure on which Ofsted and school improvement processes place most emphasis – the achievement of five A*–C grades including English and mathematics.[13] The number of GCSEs achieved by a student is often also an important factor in determining their progression to further study and employment.

1.1.2.2 The impact of changes to assessment objectives

Early indications seemed to suggest that most of the case study pilot centres did not understand the distinction between assessment objective 2 (AO2: select and apply mathematical methods in a range of contexts) and AO3 (applications of mathematics: interpret and analyse problems and generate strategies to solve them; methods in mathematics: interpret and analyse problems and use mathematical reasoning to solve them) within and across the qualifications. This lack of understanding influenced the degree

[13] The statistical analysis undertaken on achievement data from the national pupil database (NPD) shows that candidates consistently perform less well in mathematics than in English (by around 10%). The data also suggests that the five A*–C achievement including English and mathematics is closely linked to attainment in English and mathematics, with mathematics being the more difficult qualification to achieve.

of change, or the lack of change evidenced: problem solving, for example, was being taken to mean the extent to which a question was asked within a context and scaffolding was, or was not, provided to help students work through possible solutions to a question. At this early stage of the pilot there was little evidence of problem solving being taken to an abstract, theoretical level to engage with the problem-solving cycle in its entirety.

1.1.2.3 Approaches to teaching and learning

Centres proposed a range of models of delivery, categorised in the case study data as:

- sequential – one GCSE being taught first, followed by the second GCSE
- parallel – the two GCSEs being taught alongside each other as distinct subjects
- integrated – the two GCSEs being taught together.

There was some evidence to suggest that, at least initially, the integrated model was in practice *business as usual,* with very little difference being made to teaching and learning.

The full impact of the move from modular, topic-based assessment to unitised assessment approaches did not appear to have been fully recognised in autumn 2010. Many schemes of work continued to reflect the familiar topic-led approach. Any changes made were mainly to incorporate the 'functional elements' of the applications of mathematics GCSE, as was also the case with the new specification single GCSE.

1.1.3 Focus for this report

This report focuses on:

(i) centre and student engagement and participation in the pilot

(ii) reported changes to teaching and learning as a result of the pilot qualifications and their assessment

(iii) the extent to which the assessment of the pilot qualifications is seen to be different enough to allow a full understanding and realisation of the specific aims for the linked pair in the pilot.

The report will draw on the following data sources:

- an initial baseline review of assessment materials
- case study data from 13 pilot centres
- case studies of three non-pilot centres
- a summary of the data from an online survey of pilot centres (112 responses)
- interviews with the four awarding organisations included in the pilot.

1.1.3.1 Focus 1: centre and student engagement and participation in the pilot

Identifying the reasons for centres' participation in the pilot and the choice of student cohort included may give a clue about the extent to which the wider aims of the pilot will be realised. It may also indicate what can be learned about how the pilot pair of qualifications works across all contexts and student groups.

Centres' reasons for participating in the pilot and the choice of student cohort affect the piloting process in two ways. Firstly, if participating centres do not generally share or understand the underlying philosophy of the linked pair of GCSEs, it will be more difficult to identify whether any changes observed to teaching, learning and student engagement with

mathematics are the result of the pilot qualifications as opposed to other, unrelated, factors. Secondly, the data, and hence the overall understanding of how the pair of qualifications works across all contexts and student groups, may be skewed if the cohort is not representative of the whole population of centres. (This could occur if the pilot has attracted more or less than would be expected of any particular variable – for example, an over-representation of selective schools, or a centre's inclusion of only its higher or lower attainers.)

The findings from the pre-pilot data also suggest that there are a number of external influences on centres' behaviour which the evaluation needs to take into account. For example, all schools operate in the context of performance measures, Ofsted inspections and policy decisions affecting school funding. The measures that are used to account for a school's performance (school accountability measures) have a key influence on what happens in most GCSE mathematics classrooms and have to be considered when assessing the extent to which curriculum change on its own can drive change at centre level. What is expected from the pilot, and consensus on what this will mean and look like in practice, need to be clearly defined. Centres will be able to engage fully with all the wider aims of the pilot qualifications only if what the pilot involves is clearly defined and the practical form this will take is equally clearly identified.

1.1.3.2 Focus 2: reported changes to teaching and learning as a result of the pilot qualifications and their assessment

The most recent Ofsted report (2008) on mathematics 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.[14] At Key Stage 3 (KS3), test results were improving and a greater percentage of students were reaching the threshold of grade C in mathematics at GCSE level.

However, the report included a major caveat. Given the gains being made at KS3, more students would be expected to reach the higher grades at GCSE than was currently the case. 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 to gain the qualifications, they were:

> *not equipping them well enough mathematically for their futures. It is of vital importance to shift from a narrow emphasis on disparate skills towards a focus on pupils' mathematical understanding. Teachers need encouragement to invest in such approaches to teaching.*

Currently standards in the aspect of applying mathematics to a variety of open-ended, novel or complex tasks remained lower than in other areas of the mathematics curriculum. The report concluded, therefore, that the fundamental issue for teachers was how to develop students' mathematical understanding and to ensure their ability to use and apply it.

The Ofsted report suggests that, if students are to have the 'rich experience' of mathematics and the greater focus on mathematical understanding that lie behind the introduction of the

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

pilot qualifications, many centres will need to change the way in which mathematics is taught. In this context, both the online survey and the second round of visits to case study pilot and non-pilot centres focused on the extent to which teachers were planning and/or introducing different approaches to their teaching and learning, what the drivers for this were, and early perceptions of the benefits and challenges this brings.

The Ofsted report also found that, no matter what kind of school students attended, they were remarkably consistent in what they said about their experience of learning mathematics, and about their expectations of the subject. Many students described a lack of variety, which they found dull. Typically, their lessons concentrated on the acquisition of skills, solutions to routine exercises and preparation for tests and examinations. 'It should', the report suggested, 'be of serious concern nationally that so many secondary [students] seemed to accept that this was what learning mathematics should be like, despite their recognition that teaching and learning in other subjects were not the same.'

Focus groups with students at the case study pilot centres concentrated on students' early perceptions, expectations and experience of the pilot qualifications.

1.1.3.3 Focus 3: the extent to which the assessment of the pilot qualifications is seen to be different enough to allow a full understanding and realisation of the specific aims for the linked pair in the pilot

Integral to the linked pair is the adequate assessment of the higher-order skills of using and applying mathematics and their role in underpinning what it means to behave mathematically. Unless external assessments reflect these important processes, the linked pair is unlikely to effect a significant shift in teaching and learning mathematics.

Of specific interest, as identified by the evaluators of the Mathematics Pathways project,[15] is the mathematics used by examination candidates, in contrast to the mathematics intended by the assessment writers. The Evaluating Mathematics Pathways (EMP) project found that, in general, assessment of algebra at GCSE is such that those who are 'taught to the test' are not necessarily well versed in manipulative techniques and have little understanding of the major role that algebra plays as a problem-solving tool**.** The findings indicated that, although around one-third of the GCSE higher-tier assessment is intended to assess algebra, the nature of questions and mark schemes means that there is insufficient incentive for developing the algebraic competence that is the foundation for further mathematical study.

This issue has an obvious impact on progression. The EMP project recommended improved assessment design in order that examination items might better serve the desired learning outcomes in relation to algebra at GCSE.

If this issue is not resolved for the assessment of the linked pair of GCSEs, particularly for methods in mathematics, the qualification may not recognise and reward higher-level mathematical thinking and the use of algebra in solving problems and constructing arguments. This report is focused on the challenges that awarding organisations face in developing effective examination questions for the linked pair.

1.1.4 The scope and limitations of this report

The report focuses on early changes to teaching and learning as a result of the pilot. It outlines the activity centres planned and the first six months of implementation. But, at this

[15] EMP Report, 7 April 2010: http://www.nottingham.ac.uk/emp/

stage, it can only use stakeholders' perceptions and an initial round of classroom observations to give an indication of the potential impact of the pilot. There has been no further statistical data available, following the development of the baseline for the pre-pilot report. Only three of the four awarding organisations offered examinations in January 2011 (Edexcel did not), so the analysis of examination papers reported here is currently restricted to those awarding organisations.

2 Methodology

2.1 Sources of data collection

This report is based on the analysis of three sources of data collection: in-depth interviews and observations at case study centres, an online survey of pilot centres, and scrutiny of assessments. Research instruments can be found in Appendix 1.

- **In-depth interviews and observations at case study centres** involved 13 case study pilot centres (13 heads of mathematics, 18 mathematics teachers and 100 students participated) and interviews with 3 case study non-pilot centres (3 heads of mathematics, 1 mathematics teacher). Further details on the case study centres included can be found in Appendix 2.

The observation of pilot qualification lessons in case study centres was central to the focus of this report.[16] Centres were asked to identify changes that had been made to teaching and learning as a result of piloting the linked pair of GCSEs and, for centres also teaching the new single specification GCSE, to what extent the same changes were being made for the single GCSE.

Observers were asked both to record 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 linked pair. Observers were particularly asked to include examples of:

- interactions – whether work is teacher-led, student-led or independent
- groupings – pair work, group work, individual work[17]
- 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.

Observers were also asked to use a pedagogical framework for mathematics teaching based on work by Malcolm Swan to record the teaching and learning they observed:[18]

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

[16] Total number of pilot centre visits that included observations: 10. Total number of observations: 18.
[17] Ideas developed from work by the University of Sheffield: Brooks, G. *et al* (2007) *Effective Teaching and Learning:* Reading. London: NRDC.
[18] Swan, M (nd) Mathematics Matters: Final Report.
https://www.ncetm.org.uk/public/files/309231/Mathematics+Matters+Final+Report.pdf

- stretching and challenging – opportunities for resolving through discussion, opportunities to struggle and learn through perseverance, rather than just repeating previous success
- creating connections – encouraging identification of related concepts, 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 of how learning takes place and what is learned
- developing 'mathematical' language – supporting development of mathematical language for description, modelling, framing and argument.

These descriptors were '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 are differentiated according to the starting point of the students involved. The pedagogical framework reflects the teaching strategies encouraged by the aims and nature of the pilot qualifications.

- **The online survey of pilot centres** 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 244 pilot centres, 112 responded to the survey (46%) and, of those responding, three-quarters were heads of mathematics, with the remainder being the teacher/manager responsible for the linked pair in that centre. Pilot centre participation broken down according to awarding organisation was AQA – 45%, Edexcel – 51%, OCR – 22%, WJEC – 62%.
- **Scrutiny of assessments** was carried out on the November 2010 and/or January 2011 examination series for the new specification single GCSE and the linked pair of GCSEs for each of the four awarding organisations. A total of 26 examination papers from the awarding organisations across three specifications and two tiers were scrutinised (see Table 2), without sampling the materials but including all the live papers available at the time of the analysis (typically single units only), along with accompanying marks schemes and assessment grids.

Table 2: Overview of the 26 examination papers* analysed

	Applications of mathematics	Methods in mathematics	Single
AQA	2	4	4
Edexcel			4
OCR	2	2	4
WJEC	2	2	

* The papers in each cell were divided evenly between foundation tier and higher tier.

The purpose of this analysis was to describe the differences and similarities across the applications of mathematics, methods in mathematics and the single specification GCSE examinations in mathematics. The aim of this work was to provide a baseline for future analysis and scrutiny, once further assessment in summer 2011 had been completed.

3 Research findings

3.1 Centre participation in the pilot

There are currently 244 centres in England and Wales taking part in the pilot. One centre is entered in the pilot with both OCR and Edexcel, so the centre dataset from the awarding organisations reports 245 centres in the pilot.

The three English awarding organisations all report some drop-out of centres from the original list participating in the pilot, although these have since been replaced by other centres. Those centres giving a reason for withdrawing from the pilot gave changes of staff as the main reason, especially when it was the pilot 'champion' leaving.

It is too early to see any emerging patterns of entry based on the examination entries from the pilot centres so far. Three of the four awarding organisations offered January 2011 assessment windows (entry numbers can be found in Appendix 3.1). Candidate registrations for the June 2011 window are relatively low, with one awarding organisation reporting that less than half their pilot centres have registered students (see Appendix 3.2). Edexcel did not offer a January 2011 assessment window.

3.1.1 Rationale for participation in the pilot

The most common themes given in the online survey for participating in the pilot were (in descending order, with 1 being the most cited):

1. **the opportunity to stretch higher-attaining students** – there was no obvious connection here with centres entering only higher-attaining students, and this response was also given by centres that liked the opportunity for students to gain two GCSEs or to have two chances of getting an A*–C grade GCSE in mathematics
2. **the opportunity for students to gain two GCSEs** – this response was often given alongside the opportunity to stretch higher-attaining students
3. **enthusiasm about the pilot qualifications** in terms of content and approach, and the opportunity to tailor the curriculum to suit all students

4. **two GCSEs represents the level of effort and content in mathematics at GCSE** – parity with English and science in terms of two GCSEs for the future was considered inevitable: pilot centres wanted to be ready for the future
5. **two opportunities for students to gain an A*–C grade GCSE in mathematics**
6. **the linked pair provides better preparation for A-level and life** – with preparation for A-level most cited.

3.1.2 Representation within the pilot cohort

Table 3 shows the number of each of the different types of centre represented in the pilot. On average, 4% of the whole population of centres took part in the pilot. The second column illustrates how well or poorly represented the centre type is compared with what would be expected by chance (i.e. a participation of 4%, based on 240[19] centres in the pilot out of 6,232 in Edubase[20]): the figure shows the extent to which the centre type is over- or under-represented – a figure of 1 indicates participation at 4% of that type; a figure of 2 indicates 8%, etc. Mainstream schools of the various types are over-represented in the pilot (academies are particularly well represented) and special schools, independent schools and post-16 providers are under-represented.

Table 3: Extent of over- and under-representation of centre types in the pilot compared with national statistics for England and Wales

Type of establishment	Difference between proportion of centres of this type in the pilot and proportion of all centre types in the pilot	Number of centres in pilot	Number of centres in database
Academy Converters	2.7	15	142
Academy Sponsor Led	2.7	29	276
Foundation School	1.9	56	764
Community School	1.6	77	1,284
Voluntary Aided School	1.2	23	483
Welsh Establishment	0.7	*13	502
Voluntary Controlled School	0.7	2	77
Other Independent School	0.4	16	942
Community Special School	0.2	5	730
Other Independent Special School	0.1	2	470
Further Education	0.1	**1	358
City Technology College	0.0	0	3
Foundation Special School	0.0	0	44
Non-Maintained Special School	0.0	0	70
Sixth Form Centres	0.0	0	28
Special College	0.0	0	59
Total		**239**	**6,232**

*One centre is not a WJEC centre
**Welsh centre

[19] Five centres were not listed on Edubase: four PRUs and one new school.

[20] There are some issues about using Edubase: some data, especially that relating to independent schools and post-16, appears incomplete. In addition, data received from awarding organisations is not presented in a uniform way because different internal systems and the self-categorisation of schools taking part in the online survey do not always agree with Edubase or awarding organisation records.

Schools with sixth forms participate proportionately slightly more than those without (with 162 in total in the pilot cohort), as might be expected, given that the pilot, in part at least, is about improving progression to A-level in mathematics.

The number of students in a school eligible for free school meals (FSM) is one measure of deprivation. The average number of students eligible for FSM across all schools is about 15%. Table 4 shows the participation of schools in the pilot by deprivation level – schools with fewer students eligible for FSM are substantially better represented in the pilot.

Table 4: Representation of centre type by deprivation (based on FSM) in the pilot (England only)

Type of school (FSM %)	Difference between proportion of centres of this type in the pilot and proportion of all centre types in the pilot	Number of centres in pilot
FSM 1–12%	1.6	113
FSM 13–17%	1.5	25
FSM 18–25%	1.0	22
FSM 26–40%	1.2	29
FSM 41+	0.6	7
No data	0.4	30
Total		**226**

Average grade scores for GCSE mathematics (taken from the National Pupil Database – NPD) demonstrate that the poorest students (about 10% of the NPD cohort) do significantly less well than others (see Table 5).[21]

Table 5: Average grade score for candidates with and without FSM

Average grade score for GCSE mathematics (NPD)			
FSM	**2008/09**	**2007/08**	**2006/07**
No FSM	4.868	4.771	4.698
FSM	3.734	3.595	3.500
Difference	1.134	1.176	1.198

Source: NPD.

Table 6 shows school participation in the survey for those schools in special measures.[22] Although these centres appear to be better represented in the pilot, it is too early to tell what impact this might, or might not, have on the representativeness of the pilot cohort, as there is

[21] In order to consider grade trends over time, each GCSE grade is given a weighting on a scale as follows:

For single award full GCSE qualifications								
Grade A*	**Grade A**	**Grade B**	**Grade C**	**Grade D**	**Grade E**	**Grade F**	**Grade G**	**Grade U**
8	7	6	5	4	3	2	1	0

[22] Ofsted places a school in special measures if that school receives the poorest rating in an Ofsted inspection and the management does not have the capacity to improve. Schools with a poor rating but capacity to improve are given a 'Notice to improve'. Special measures is recorded on the Edubase, but 'Notice to improve' is not.

only a small number of pilot centres (5) in total and no further information about them from the online survey.

Table 6: Representation of centre type by Ofsted special measures in the pilot (England only)

Type of school (special measures)	Difference between proportion of centres of this type in the pilot and proportion of all centre types in the pilot	Number of Centres in pilot
In special measures	2.2	5
Not in special measures	1.0	208
Not applicable	1.0	13
Total		**226**

Source: Edubase, September 2010 update.

3.1.3 Student engagement in mathematics

One of the overall aims for both the single specification and the pilot was for more students to become engaged in mathematics and to progress to higher-level study in the subject or in related subjects. Previous research into student experience of 14–19 education suggests that enjoyment of a subject does not necessarily encourage learning, although it can help (Gorard *et al*, 2009).[23] In the case study pilot centres, participants in student focus groups saw mathematics as a difficult and highly important subject. They were unanimous in the belief that mathematics is important for their future employability and/or progression to further study and, on these grounds, often compared it to English.

Mathematics was generally seen as being more useful, and sometimes therefore more enjoyable, when it involves using scenarios from real life rather than learning techniques to apply in an examination room. For a minority, however, the complication was that these techniques often carry more marks on the examination papers, so students seem to attach more value to them and thus associate them with greater enjoyment. Students in the focus groups had mixed views on the role of some topics, such as algebra, which were considered by students from three of the higher-tier groups as enjoyable but not useful to them in life. Such topics were seen as valuable only if students were preparing for higher-level study.

Teachers from the case study pilot centres stated that students' engagement was often linked to the level of success students felt and the extent to which an activity was familiar. One example quoted was that students had 'enjoyed' spending a whole lesson on simultaneous equations, but the teacher felt that the students had already known how to do the questions at the beginning of the lesson. Nothing new had been learned but students had enjoyed the experience of knowing what to do.

The majority of students expressed the view that they enjoy mathematics lessons more when the lessons are interactive and lively. As examples of what they meant by 'interactive' they mentioned working in groups and pairs, kinaesthetic activities, use of the interactive whiteboard, whole-class discussions, quizzes and puzzles. Most students expressed the view that their enjoyment wanes when they work from textbooks, which they found tedious

[23] Gorard *et al* (2009) *14–19 reforms: QCA Centre Research Study, commentary on the baseline of evidence 2007–2008.* London: QCA.

and repetitive; others were happy to report that they use textbooks less now than they did at KS3.

A substantial number of students said that the benefit of the linked pair of GCSEs was simply in getting more GCSEs, which looks good on their CVs and makes them more employable. Other students talked about the two aspects of the linked pair, saying that it gave them two chances, especially if they turn out to be 'bad' at one aspect. Some students, however, see the idea of two qualifications more negatively, explaining that it means more work to cover in the same amount of time, more exams and more pressure.

Many of the higher-tier students spoke about how well they felt they were doing in mathematics. The majority of these students said that they were doing as they had expected or better than they had expected. A minority of these students, however, expressed concern over their future attainment, saying that they felt the examinations were not a fair reflection of their learning as they frequently under-perform in this pressurised situation.

Many of the higher-tier students said that they were contemplating continuing their study of mathematics to A-level, generally because they perceived that they were very good at the subject and/or specifically that they needed further qualifications in mathematics to be employable in a certain chosen field. Students who did not wish to carry on with the study of mathematics gave various reasons for their decisions, for instance not feeling confident in the subject, feeling that their strengths lay elsewhere, not needing it for their chosen area of employment, or acknowledging that mathematics was useful in general, but that it was more important for them to specialise in other subjects which had direct relevance to their chosen area of employment.

Fourteen different student focus groups, the majority of them higher-tier students, discussed the jump in level and difficulty from KS3 mathematics to the linked pair. There was, however, much disagreement about this: two groups, one of foundation-tier and one of higher-tier students, felt the work was now much harder and more complicated. Of these two groups, the foundation-tier students also expressed some concern over the increase in specialist vocabulary. Other students, from a mixture of higher and foundation sets, felt that the work had become easier, while others still felt there had been no jump and the work was about the same. Two focus groups of higher-tier students said that any detectable difference was just a natural step-up or progression. There seemed to be a general feeling, among students of all tiers, that they would expect there to be a jump and for the work, being GCSE, to be harder.

Out of those students who felt there had been a noticeable jump, a few said that this was down to the methods part of the linked pair of GCSEs rather than the applications, which they claimed was easier because it was based on real life. Others, however, felt exactly the opposite: the applications work had created the biggest jump for them as it required them to think more before doing it, it had more parts to it and, unlike mathematics lower down the curriculum, it was made more challenging because there was often more than one way of doing things.

Two groups of students, one a foundation group and one intermediate, reported that the 'jump' they had experienced was because they spent less time on each topic area now. Two other groups (foundation and higher) claimed that, if there was a jump, it was because they now knew that the course would affect their GCSE grade whereas, previously, it hadn't been as important.

The majority of the centres responding to the online survey that offered both the linked pair and the single GCSE said that the linked pair of GCSEs was more demanding and challenging than the new single GCSE; more than one-third also said the linked pair was more interesting. These centres also reported that the linked pair was enabling students to acquire skills and knowledge that they could transfer to other subjects, although almost two-thirds believed that the single GCSE was having the same effect.

3.2 Centres' management of the pilot

3.2.1 Resources

The majority of centres responding to the online survey reported that piloting the linked pair had required more staff time, with one in six centres reporting that significantly more staff time had been necessary. A minority of centres said that the impact on budget had been significant.

Centres reporting a significant impact on resources as a result of the pilot commented on the extra time required to plan and prepare, and also the cost of new or additional resources. The centres offering the single GCSE as well as the linked pair were fairly evenly split on whether the single GCSE had had a similar effect on centre resources.

Centres had mixed views on whether the demand on resources (staff time, budget, timetabling) would increase or decrease as the pilot progressed. Most expected some changes on the use of staff time, although they were divided on whether more or less staff time would be required. One in five centres expected that a larger budget would be required as the pilot progressed, but gave no reasons for this.

3.2.2 Approaches to implementation

3.2.2.1 Cohorts entered for the pilot

For the most part, centres responding to the online survey elected to include either whole-year cohorts or higher-attainers/gifted and talented in the pilot. In two centres only, more middle attainers (C/D borderline) were entered in Year 11 (see Figure 1).

The majority of the case study pilot centres were entering whole-year groups. Only one centre was focusing on a C/D grade borderline set, while in another all students were following the single specification GCSE with the intention that higher-attaining students would later be taught additional content to take the linked pair of GCSEs.

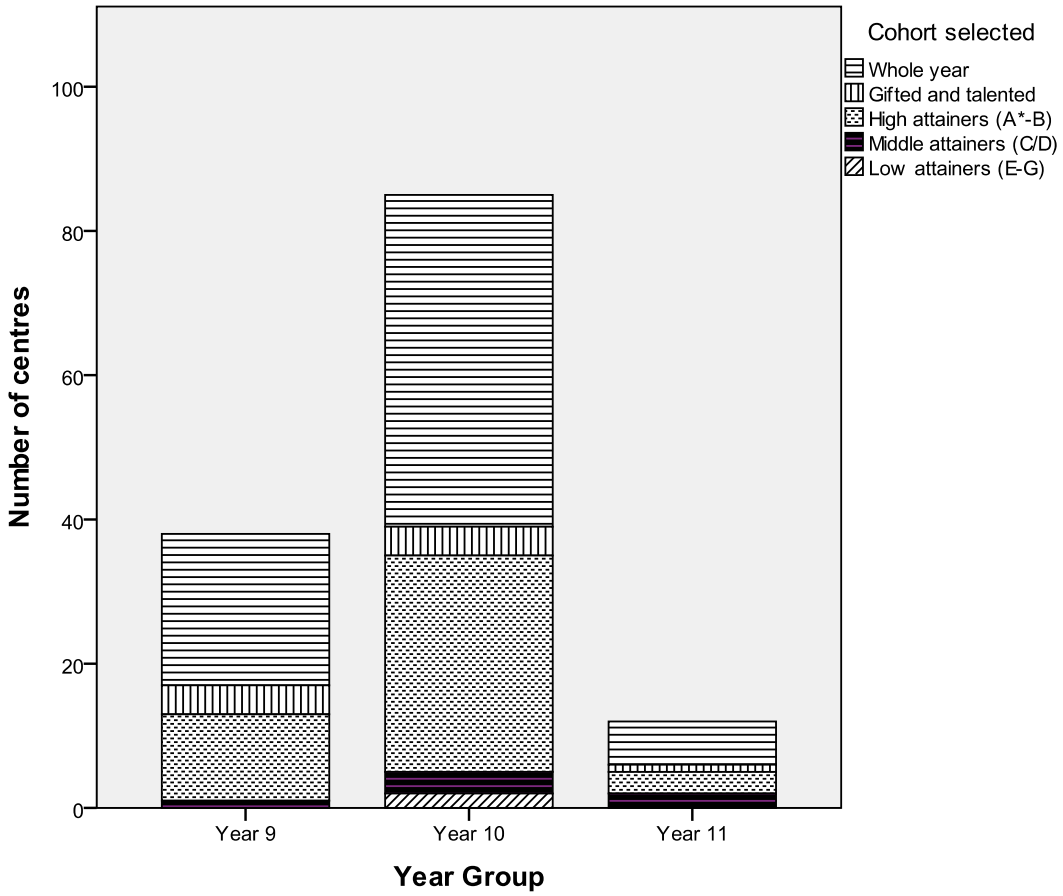


Figure 1: Breakdown of student cohort entered for the linked pair for school year

3.2.2.2 Starting point for student cohorts

Where centres had Year 9 students participating in the pilot, there was a fairly even split between those who began studying at the start of the academic year and those who began in the summer term – few centres started in January. Where centres had Year 10 or 11 students participating, the start of the year was by far the most common time to begin studying.

Some case study pilot centres reported that they started students in the summer of Year 9 as a way of increasing time for teaching the pilot.

3.3 Teaching and learning

Centres that offered both the linked pair of GCSEs and the new single GCSE reported in the online survey that the linked pair was leading students to acquire skills and knowledge that they could transfer to other subjects, although almost two-thirds believed that the single GCSE was having the same effect. The majority of these centres also said that the linked pair of GCSEs was more demanding and challenging than the new single GCSE, and more than one-third also said the linked pair was more interesting. None of the centres that offer the single GCSE in mathematics as well as the linked pair of GCSEs in mathematics

reported that the linked pair of GCSEs in mathematics was less interesting, demanding, or challenging than the new single GCSE.[24]

Only one in ten centres reported in the online survey that they had allocated more lesson time to the linked pair than to the legacy GCSE. In terms of lesson time for the linked pair, the most common figure was around 180 minutes a week (e.g. 3 one-hour lessons). The second most common allocation tended to be around 240 minutes (e.g. 4 one-hour lessons per week). Where additional time was allocated, it was mostly one extra hour; no centre reported allocating more than one extra hour a week. Very few centres (fewer than one in twenty) reported that they allocated more lesson time to the linked pair than to the new single GCSE.

Four out of ten centres, however, reported that they were offering other kinds of additional learning time to the students participating in the linked pair, most commonly in the form of learning offered after school. Only 15% of centres reported that they had increased the amount of homework students are set as a result of the linked pair, with very few centres describing the increase as significant. The one centre that did set extra homework for the new single GCSE said it was not 'significantly more'.

A significant minority, approximately one in five centres, expressed the concern that the linked pair is creating barriers or specific issues for specific groups of students, primarily weaker students. Some cited the pace of lessons as a particular worry for these students, and said that the level of language was also a barrier to students with weaker literacy skills. Approximately three-quarters of centres offering the single GCSE as well as the linked pair believe that the new single GCSE does not raise the same issues.

Almost one-third of centres already believed that students were gaining skills and knowledge through the linked pair that they can transfer to other subjects, most commonly geography, physics, and business studies. Only one centre reported that students were definitely not gaining transferable skills and knowledge; most centres reported that it was too early to say. Almost two-thirds of centres offering the single GCSE as well as the linked pair believed that the single GCSE was having the same effect.

3.3.1 Models for teaching

As noted previously, three models of teaching are emerging for the pilot:

- sequential – one GCSE being taught first and then the second GCSE
- parallel – the two GCSEs being taught alongside each other at the same time
- integrated – the two GCSEs being taught together.

Approximately half the centres responding to the online survey reported that they were using an integrated model of delivery, just under one-third of centres were using a sequential mode of delivery, and approximately one in eight were teaching methods in mathematics and applications of mathematics in parallel. Of the remaining centres, a small number

[24]

- 19 out of 55 centres reported that learners found the linked pair of GCSEs in mathematics to be more interesting than the new single GCSE, with 26 centres reporting they found it about the same.
- 39 out of 55 centres reported that learners found the linked pair of GCSEs in mathematics to be more demanding than the new single GCSE, with 11 centres reporting they found it about the same.
- 39 out of 54 centres reported that learners found the linked pair of GCSEs in mathematics to be more challenging than the new single GCSE, with 12 centres reporting they found it about the same.

reported adopting a sequential approach for the lower-year group, and an integrated approach for higher-year groups; and a few centres were delivering the GCSEs in sequence, but also by paper (for example, methods in mathematics 1, followed by applications of mathematics 1, followed by methods in mathematics 2, followed by applications of mathematics 2). For those adopting a sequential approach, methods in mathematics tended to be taught first. Further data collection and analysis during the autumn term will seek to gain a clearer understanding of these emerging models and any subsequent changes made for the second year of the pilot.

3.3.2 Planning changes to teaching and learning

Those centres that gave teaching and learning as their reasons for taking part in the pilot (e.g. wanting to challenge higher-attaining students, or the opportunities offered by the additional content and the linked pair of GCSEs approach) suggest that changes to teaching and learning should become apparent during the lifetime of the pilot. At present, however, only one-third of centres responding to the online survey reported that they had made significant changes to the design of the curriculum as a result of planning for the linked pair, with the figure being slightly higher for applications of mathematics than for methods in mathematics. More than three-quarters of centres, however, reported that they had made some changes to the design of the curriculum as a result of planning (see Figure 2).

The changes most commonly identified were to schemes of work, when teaching started, or the order in which material was taught; changes to the style of teaching, often related to the style of the questions tackled in the classroom, were also frequently mentioned. Almost three-quarters of the centres that offered both the single GCSE and the linked pair of GCSEs reported that the new single GCSE in mathematics had necessitated similar design changes in the curriculum.

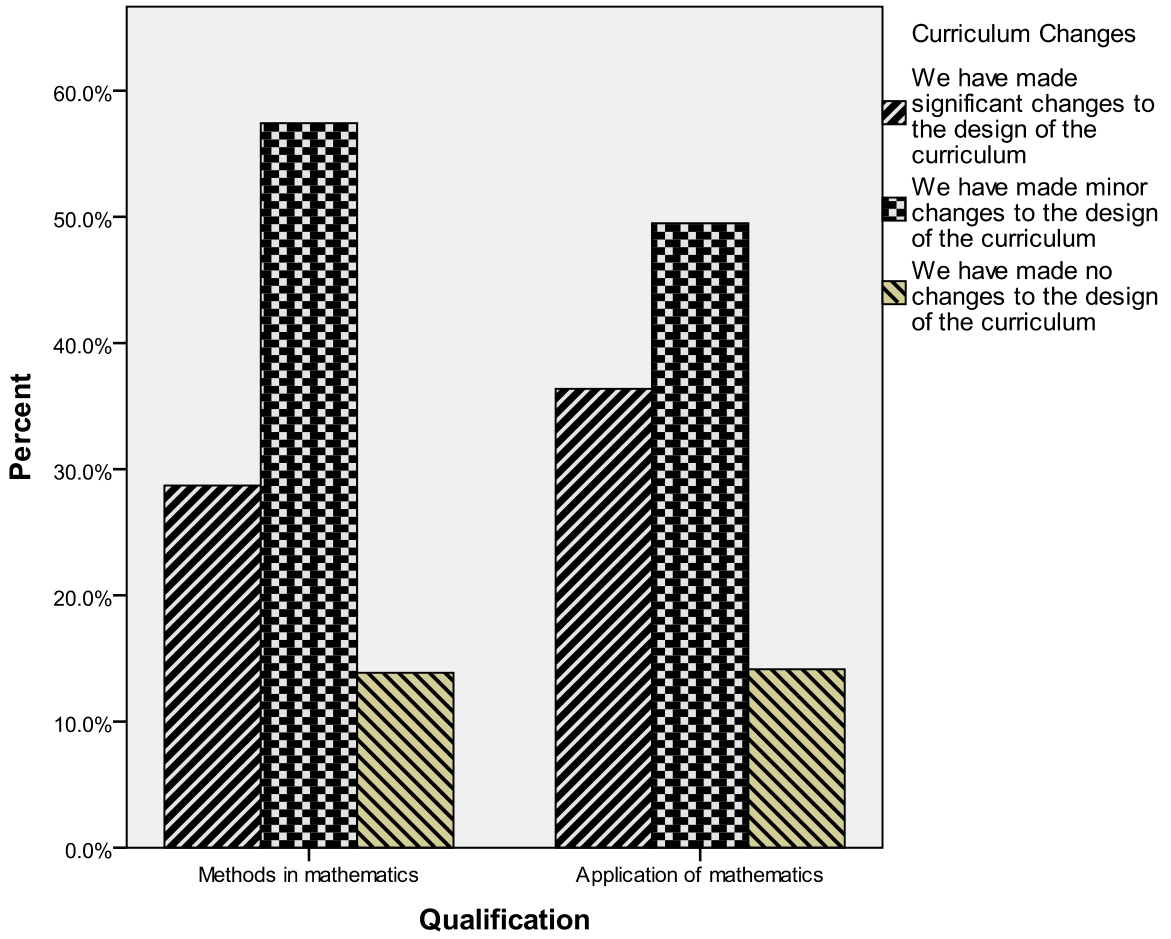


Figure 2: Changes made to teaching and learning as a result of the pilot, by qualification (n=101 for methods in mathematics, n=99 for applications of mathematics).

The most common changes made for the methods in mathematics GCSE included:

- using new materials/teaching resources provided
- teaching thinking skills and problem solving
- using a more investigative style in lessons
- changing the order of topics taught.

Some centres reported that they were now teaching more in context and making cross-curricular links for methods in mathematics, although this would be an approach more applicable to applications in mathematics.

For applications of mathematics, of the 42 centres responding with more detail about changes made, 13 of these indicated that they were placing a greater emphasis on functional and/or application aspects. Almost three-quarters of the 57 centres that offered the single GCSE in mathematics as well as the linked pair of GCSEs reported that the single GCSE had required similar changes in teaching.

In the main, according to the online survey, teachers were aware of the additional content of the linked pair and had already included it in their planning of teaching. More teachers of applications of mathematics (approximately one in ten) were aware of the additional content

but had not yet planned for it than was the case for teachers of methods in mathematics (one in twenty).

More than two-thirds of centres reported that teachers had made changes to accommodate the functional elements and problem solving. Earlier visits to the case study pilot centres (autumn 2010) had also suggested that, where reported, changes to teaching and learning were predominantly focused on incorporating the functional elements and problem solving for the applications of mathematics. Schemes of work generally continued to be designed in terms of topics to be covered rather than process skills.

3.3.3 Teaching and learning in practice

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 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. Circling a point at the lower end of the scale (1 or 2) means there was little or no evidence of the pedagogic approach being attempted effectively and/or opportunities were missed in the opinion of the observers. Circling at the higher end of the scale (4 or 5) means 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 were scored at a point between 1 and 3 (details of the process used to moderate the scores given can be found in Appendix 4.1). The range of classes observed and the score for each pedagogic approach used can be seen clearly in the diagrams in Appendix 4.2. The diagrams show a stark difference between the teaching for students working towards the foundation-tier GCSE and that for those working towards the higher-tier GCSE. This difference is summarised in Figure 3. The scale used for presenting the data starts at ‘0’ for ease of reading but it should be noted that ‘0’ was not an available point on the summary table.

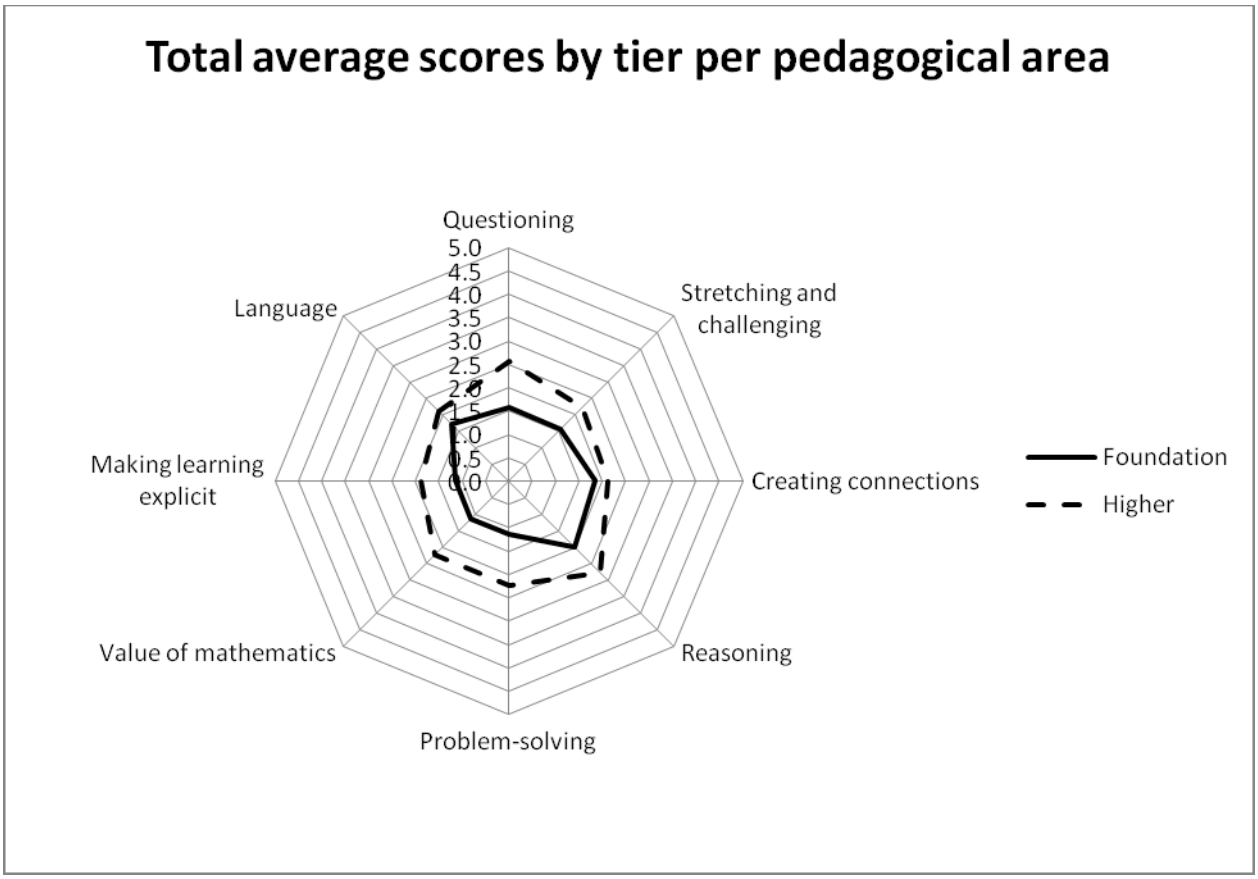


Figure 3: Total average scores from classroon observation summaries per pedagogical area by tier

Three observations (out of a total of 18), all of higher-tier classes, scored 4 or above on some aspects of pedagogy (see graphical data).

- High-order questioning and reasoning scored most highly (an average of 2.5 for high-order questioning and nearly 3 for reasoning in higher-tier classes). This score reduced for foundation-tier classes to 1.6 for high-order questioning and 2 for reasoning.
- Stretch and challenge was observed when teachers used questioning to encourage students to think through what they were working on, scoring 2.3 for higher-tier classes and 1.5 in foundation-tier classes.
- Though teachers were observed creating connections with students, these connections were likely to be with 'the real world' (value of mathematics) rather than with mathematics as a discipline in itself or with its philosophical and historical roots (2.2 in higher-tier classes and 1.1 in foundation-tier classes). Creating connections in terms of mathematical connections recorded 2.1 in higher-tier classes and 1.8 in foundation-tier classes on average.
- The development of problem-solving skills was mostly led from the front by teachers and again was more likely to be seen in higher-tier classes than in foundation-tier classes (2.2 and 1.6 respectively).
- There was only one actual example in which an observer noted a teacher making learning explicit, although this scored 1.9 for higher-tier classes and 0.6 for

foundation-tier classes. Teachers were observed using mathematical language and encouraging students to describe and frame their arguments using the appropriate terms.

Most of the questioning was characterised by teachers asking questions that required little other than a short answer. There were examples where teachers used questioning to draw out explanations from students but the majority of questioning was closed, and observers reported that teachers rarely used open questions that encouraged students to explain what they were doing or why they were reaching the conclusions they came to.

Four examples of stretch and challenge were cited, where teachers resisted the temptation to give explanations and allowed the students to think things through for themselves, often with the teacher posing open-ended questions. This was also observed on the few occasions when students were working in pairs or groups.

There were relatively few instances of creating mathematical connections; when this was observed, it was exclusively teacher-led. When connections were made, they were in relation to the value of mathematics in terms of recognising its use and application in everyday situations and contexts.

In half the lessons observed, students were asked to reason to some degree. One observer gave a high score for reasoning because 'the teacher asked many questions which probed understanding and gave the learners the opportunity to reason and communicate mathematically'. Learners were able to work in groups and write their own questions. Reasoning in all cases was prompted by teacher questioning, although there were examples of students trying to reason things out with each other as they worked through their tasks.

There were only two examples in which students were asked to solve problems for themselves, both in higher-tier classes. One was a lesson on congruency, the other on the profit and loss of a company selling science books. In both cases, students worked together, although only in the congruency example did the teacher specify working in pairs. 'Two pupils couldn't get their triangles to line up using tracing paper, even though they felt that they were congruent. They compared angles in each triangle and then found that one length had been drawn inaccurately.' In thinking through the task on profit and loss 'two students debated different ways of going about the task, exploring alternatives and hypothesising about the best way to approach it before trying out an approach'.

Teachers encouraged students to use mathematical language both by using terms themselves and asking students to use them when giving explanations.

Teachers led the learning in all 18 lessons observed. The interactions fell into a number of categories:

- beginnings and endings
- demonstrating
- questioning
- asking for or giving answers
- presentation of information
- explaining.

Student-led activity in the classroom was confined to one or two examples where students were invited to demonstrate something on the interactive white board (IWB) rather than lead the learning. The majority of interactions were not only teacher-led but also consisted of students working individually. In one case the teacher had a deliberate policy of students working individually to avoid joint working; another teacher in the same centre was happy for students to sit in friendship groups. The lessons observed were shaped by teacher-led interactions, followed by individual work, and then a coming-together again to go through the answers.

Students talked to one another about their work and there were few examples of students working in silence. In addition to these informal discussions, 6 of the 18 classes were observed engaging in pair or group work. In some instances teachers asked students to discuss particular aspects of their work – 'talk to the person next to you about congruency' (foundation tier), or 'talk to the person next to you to see which is the best expression' (foundation tier). Other paired activity in the higher-tier classes involved working on calculations together or exploring ways of tackling a task. One teacher in a higher-tier lesson on probability asked pairs of students to put four statements in order of the probability of them happening:

> There was a certain amount of subjectivity in the task, which allowed some open-ended, lively discussion within the pairs … the class was brought back together to discuss their conclusions. The teachers used open-ended questions to enable the [students] to articulate their thoughts and decisions … because there were no correct answers, the discussion remained open-ended with humour and high participation.

Many of the centres were enthusiastic about pair and group work, but others were more cautious. They recognised that they need to move away from a broadly teacher-led environment and that peer and group work is an important part of developing problem-solving skills in students but that the success of this approach sometimes depends on how mature particular groups of students were. Centres were often concerned about how much work students – particularly those in foundation-tier classes – would cover if they were allowed to work together: one foundation-tier teacher also reported that she was teaching the GCSE in one year.

Case study pilot centres that reported changes in teaching and learning said that the focus of these changes was still predominantly on the applications of mathematics. A significant minority of the centres felt that the way they taught already encompassed the changes needed, in terms of rich open tasks and 'lateral enrichment', and observations at these centres had recorded high levels of activity relating to the majority of the pedagogical criteria in the higher-tier lessons. In other centres that recognise they need to change, the evidence suggests it will take time and support for this to filter through to classroom practice. There is less evidence to suggest that this will reach foundation-tier classes.

In the relatively early stages of teaching for the pilot, the development of important skills such as reasoning and problem solving are predominantly teacher-led, and a high level of modelling was observed. In the interviews following the observations, the majority of teachers recognised the need for some change to teaching if students are to be supported to become more independent learners and to think for themselves. Many of the pilot centres relate topics to GCSE grades and seem unaware of the implications of the changes to AOs and grade descriptions that require different mathematical behaviour from candidates.

The biggest concern for the pilot comes from responses to the online survey and evidence from case study pilot centres which shows that a small number of pilot centres see little need to change their teaching.[25]

The three case study non-pilot centres also spoke to some degree about how the new single GCSE in mathematics had prompted them to think about how they teach. Two centres already teaching the new single GCSE spoke about how they tried to do more investigative, group and discussion work, but that time restrictions and an extensive curriculum ultimately demanded that the learning was teacher-led and teacher-focused. One non-pilot centre felt that weaker students found investigative work hard, while another centre explained that their students were 'apprehensive' about this way of learning.

All case study non-pilot centres said that the functional and problem-solving elements of the new single GCSE present the biggest change to the skills students are now required to develop and demonstrate. One of these non-pilot centres said that weaker students found investigative work harder and that teachers had found it a challenge to find example tasks and materials. Another non-pilot centre said that early experiences with students had shown that they found it difficult to access functional problems, adding that problem solving was an additional challenge as they felt that they had to not only cover the content of the course but also teach this new skill.

Two of the case study non-pilot centres commented on the increased literacy skills students need to succeed with the new style of examination questions. One non-pilot centre said that such questions stretch especially those students who are working around the C/D borderline. Another non-pilot centre explained that they had worked, with some success, across the curriculum with the English department to develop their students' reading skills so that they can 'read with understanding before … they can do the appropriate maths'.

Two of the case study non-pilot centres explained they offered the mathematics pathways' *additional* mathematics GCSE to their higher-attaining students, seeing this as a better preparation for study at A-level than the new single GCSE. One centre explained that they needed the *additional* mathematics GCSE to stretch their highest-attaining students. The new single award was considered to lack interest and challenge for these students as 'such a very small proportion of the higher tier is A/A* level work' and higher-attaining students are, therefore, merely expected to 'plough through this really fairly trivial maths' before they get on to the material which interests them. This centre also expressed the view that it was getting easier for weaker students to achieve a grade C in mathematics GCSE, and easier for students who were not considered to be higher-attaining to get grade A by learning some of the 'easy grade A stuff'. But the centre also argued that the true A* students often missed this grade as they were not sufficiently challenged by examination papers, because 'more-able mathematicians will focus very well when something is difficult, not so well when something is relatively trivial'.

[25] Of the 14 centres responding to the online survey that said they had made no changes to the curriculum for methods in mathematics, 12 also responded they had not made any changes to the curriculum for applications of mathematics. Of the 14 centres, half were also offering the new single specification GCSE. A further 2 centres that said they had made no changes to the curriculum for applications of mathematics responded that they had made minor changes to the curriculum for methods in mathematics. Neither centre is also offering the single GCSE.

3.4 Changes in assessment

The linked pair of GCSEs examination papers that were scrutinised had been developed at the start of the pilot. The awarding organisations stated that their understanding of writing examination questions that assess problem solving had developed since the January 2011 papers were written. With examination questions currently being written for papers for the final year of the pilot (2013), any early issues need to be reported and understood now. The key question to be answered is the extent to which the papers assess what they are intended to assess.

Awarding organisations have up to now held two joint meetings to discuss the development of questions that assess problem solving effectively. Issues are not specific to the linked pair of GCSEs, but they are exacerbated in the linked pair as a result of the need to ensure both the distinctiveness of approaches to problem solving in each of the qualifications in the pair and also the division of content across and within the two GCSEs. The writing of AO3[26] questions has been a significant challenge for the examiners. One danger is that a large proportion of weaker candidates simply score zero, being unable to formulate a way to approach a problem and break it down. This can have a doubly negative effect: it can make discrimination of lower grades difficult, but it can also end up demoralising such candidates.

Awarding organisations reported that in some cases the division of content across the GCSEs made the writing of problem-solving questions more challenging in the linked pair of GCSEs. The examiners cannot go as far as they would like with the questions they set on one paper, as the content to do this is on the other unit or GCSE. It was felt that these were teething issues that will get ironed out in the fullness of time in the pilot phase.

In their responses to the online survey, most centres reported that the January 2011 assessments were as challenging as expected, with one in four saying they were more challenging than expected. Very few centres reported that the assessments were less challenging than expected. There was no significant difference between the perceptions of levels of difficulty between methods in mathematics and applications of mathematics.

The high-level findings below are based on January 2011 papers for the linked pair of GCSEs and the single GCSE (November 2010 and January 2011). These very early findings should be treated with caution as they are based on initial live papers at the start of the pilot, many of which had been developed 18 months before the January 2011 assessment window.

3.4.1 Chains of reasoning

In the light of recent criticism that GCSE papers do not support sustained chains of reasoning[27] but instead contain too many short, piecemeal items, the lengths of chains of reasoning across the examination papers relating to the three new specifications (applications of mathematics, methods in mathematics, single GCSE) were compared. To measure this, the number of marks per question-part for the papers in each specification was tallied (see Figure 4). There was little variation across the specifications, with applications of mathematics papers requiring slightly longer chains of reasoning than methods in mathematics and single GCSE papers. The average size of question-parts was

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

between 2 and 2.5 marks, with some papers having an average size of question-parts of less than 2 marks, and the papers with the longest chains of reasoning having an average question-part size of around 3 marks.

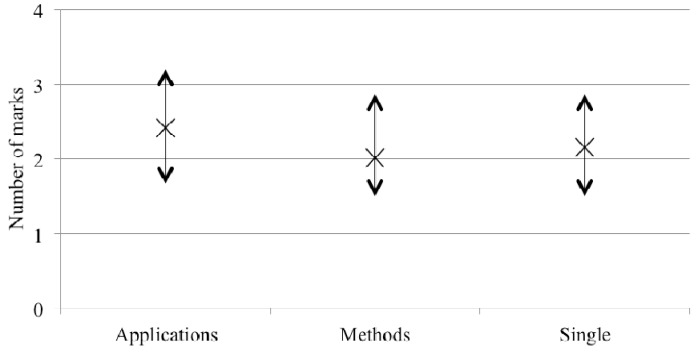
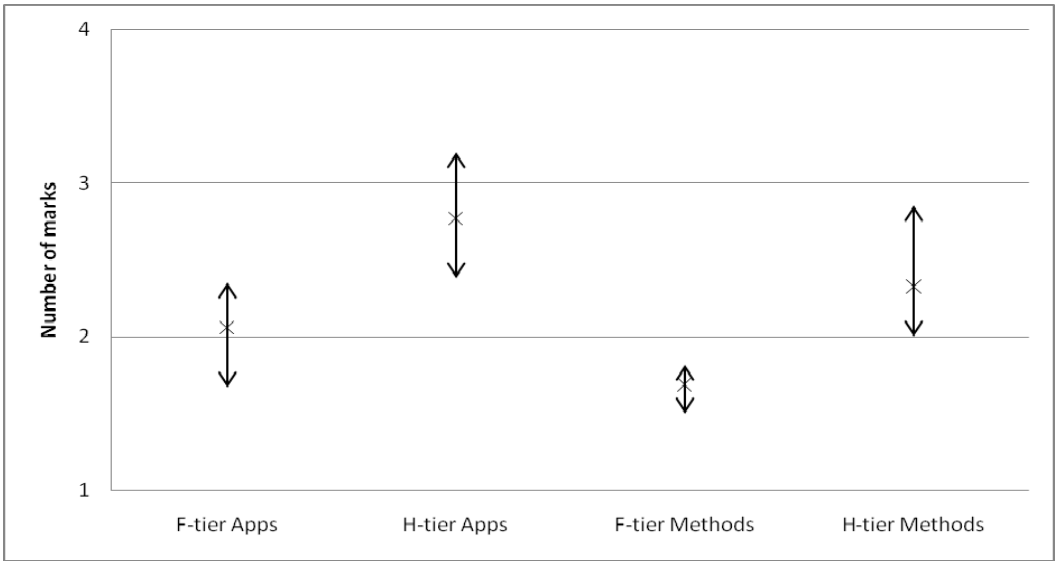


Figure 4: The maximum (↑), minimum (↓) and average (x) number of marks per question-part for the papers in each specification

Some caution must be exercised, however, when drawing conclusions from Figure 4. The fact that a given question-part is worth 5 marks might suggest that it is relatively unstructured and supports a chain of reasoning of around five minutes. But, on closer inspection, such questions are sometimes highly structured, using tables or other devices in which candidates fill the blanks. To check how common such 'stealth structure' was, a random sample[28] was selected from across all 26 papers of four question-parts worth 4 or more marks (i.e. question-parts that were worth more than the maximum average size of about 3 marks). All four question-parts were found to be free of 'stealth structure' and genuinely supported longer than average chains of reasoning. This suggests that the data shown in Figure 4 is reasonably reflective of the lengths of chains of reasoning across the three specifications.

There is some discrimination between foundation-tier and higher-tier questions within the linked pair of GCSEs (see Figure 5).

[28] Four question-parts with ≥ 4 marks (i.e. question-parts that are larger than the maximum average size of about 3 marks).



Note: The scale starts at 1 not 0.

Figure 5: The maximum (↑), minimum (↓) and average (x) number of marks per question-part for higher- and foundation-tier applications of mathematics and methods in mathematics papers

A detailed analysis of the difference between foundation-tier and higher-tier questions will be undertaken once complete suites of papers are available, but this early analysis suggests that there are some unstructured questions across all the new specifications. How particular groups of students manage these unstructured questions will be of interest in the future.

3.4.2 Process skills

The process skills in GCSE mathematics are those aspects of mathematical activity required for problem solving, namely representing, analysing, interpreting and communicating.[29] Each paper was assessed for process skills, using a modified version of the method developed as part of the QC(D)A-funded Evaluating Mathematics Pathways (EMP) project.

Analysing was subdivided into 'analysing-conceptual' (that is, analysis requiring a conceptual understanding of the problem) and 'analysing-procedural' (that is, analysis requiring only procedural knowledge of what to do).

It was noted particularly that there was a relatively high level of analysing-procedural skills in these papers, with lower levels of analysing-conceptual skills recorded. However, it should be recognised that the papers assessed were the first live papers only, and conclusions should not be drawn until full suites of papers are available for analysis.

[29] This should not be confused with 'quality of written communication' (QWC).

3.4.3 Mark allocations

All the linked pair of GCSE papers reviewed were set up with approximately the correct percentage of marks for each of the assessment objectives.[30] The number of marks available at AO1 was on average towards the top end of the recommended range, whereas the number of marks available at AO3 was on average towards the lower end of the recommended range. While scrutinising examination questions and their allocated mark distribution across the awarding organisations has been useful, it does not show how students have approached answering each question and how their responses have been interpreted by the examiners.

3.4.4 Question context

The awarding organisations reported that writing questions for the applications of mathematics assessments needed to take into account the use of context relative to the students' 'life experience'. One example given was a question used in the January 2011 series which required students to compare prices from two builders' merchants and decide which was most cost effective. The prices quoted included a delivery charge, which some students calculated per item in their responses rather than per delivery. This example, however, was unlikely to have been a scenario that 15 or 16 year olds would have encountered in their lives thus far. Against this, teachers discussing the development of real-life problem-solving questions gave an example of working out which different combinations from the McDonald's menu a student could afford for a particular amount of money. There were mathematically more combinations possible than the students recognised, as they argued that in real life you would not want to buy a thick shake with a McFlurry®, as they were too similar.

3.5 Support needed and resources

Centres generally reported a good level of support from their awarding organisation. Eight out of ten centres surveyed online scored awarding organisation support as either 4 or 5 (on a scale of 1 to 5, where 1 is not at all supported and 5 is very supported). In terms of the level of support given, there appears to be very little difference between awarding organisations.

When asked about other kinds of resource they would find useful, both case study centres and those responding online mentioned mock/practice papers, lesson ideas, exemplifications and practice exercises, face-to-face support meetings, and textbooks.

Six out of ten centres responding to the online survey reported receiving support from other sources, with NCETM, links with other schools, and local authority advisory services being most often cited. Similar responses were gained from the case study centres, although two out of the four centres that discussed this sort of support noted that geographical limitations

30

	Assessment objective 1	Assessment objective 2	Assessment objective 3
Methods in mathematics	50–60%	15–25%	20–30%
Applications of mathematics	40–50%	30–40%	15–25%

and the occasional reluctance of centres to release staff from teaching made it difficult to take full advantage of this sort of support.

Centres reported some changes in the kind of resources teachers are using as a result of the linked pair of GCSEs. There seemed to be greater use of online resources and of other resources provided by their awarding organisations, which would seem to indicate a reliance on the material provided by their awarding organisation for the pilot. Two case study centres also reported dipping into resources devised for the *additional* mathematics qualification.

Almost two-thirds of the centres surveyed online that offer the single GCSE as well as the linked pair of GCSEs said that these statements about resources equally apply to the new single GCSE.

Three case study pilot centres talked about an established culture of informally sharing ideas and practices among mathematics teaching staff. Two centres also said that staff development time needed to be set aside in order to share in-house experience and expertise and for teachers of the linked pair to develop professionally. One of these centres wished to have this sort of time specifically to explore the issue of integrating applications in mathematics with methods in mathematics.

Only one in twenty centres surveyed online reported that teachers teaching the linked pair of GCSEs were not qualified to teach mathematics or did not have a mathematics-related teaching qualification. Many centres reported, through the online survey, that younger teachers needed support, not having previously encountered some of the new content in their own learning.

4 Summary and conclusions

4.1 An overview of the reported findings

To aid continuity between the pre-pilot evaluation report, this report and future reports for the pilot phase of the evaluation, the summary and conclusions follow the four main themes for the evaluation. These are:

- attitudes to mathematics
- comparability of demand of the pilot qualifications with each other and with other GCSEs in mathematics
- the views of centres (both pilot and non-pilot) on the pilot
- the support offered to pilot centres by the awarding organisations.

4.1.1 Attitudes to mathematics

4.1.1.1 The centres

Centres responding to the online survey gave a range of reasons for participating in the pilot. Overall they were enthusiastic about the opportunities it offered, with some recognising benefits over and above those of the new single GCSE in mathematics. The main reasons given were the:

- opportunity to stretch higher-attaining students and/or for students to gain two GCSEs

- content and approach to mathematics embodied in the pair of qualifications
- flexibility to tailor the curriculum to the needs of all students
- additional possibility that the pilot offered of gaining an A*–C grade in mathematics.

4.1.1.2 The students

One of the overall aims for both the single specification and the pilot was that more students would become engaged in mathematics and would progress to higher-level study in the subject or in related subjects. In the case study pilot centres, participants in the student focus groups saw mathematics as a difficult and highly important subject. They were unanimous, however, in the belief that mathematics was important for their future in terms of employability and/or progression to further study and, on these grounds, often compared it to English. A substantial number of students said that the benefit of the linked pair of GCSEs was simply getting more GCSEs, which looks good on their CVs and makes them more employable.

In addition:

- Mathematics was generally seen as being more useful, and sometimes therefore more enjoyable, when it moved beyond learning techniques for application in an examination room to involve scenarios from real life. For a minority of students, however, this was complicated by the fact that 'learning-technique' questions often carry more marks on the examination papers, so students seem to attach more value to them and thus equate them with greater enjoyment.
- Students in the focus groups had mixed views on the role of some topics, such as algebra, which were considered by students from three of the higher-tier groups as enjoyable but of no use to them in life. Such topics were seen as valuable only in preparation for higher-level study.
- The majority of students expressed the view that they enjoy mathematics lessons more when these are interactive and lively. They cited working in groups and pairs, kinaesthetic activities, use of the interactive whiteboard, whole-class discussions, quizzes and puzzles as examples of interactive lessons.
- Many of the higher-tier students said that they were contemplating continuing their study of mathematics to A-level, in the main because they realised that they were very good at the subject and/or, specifically, that they needed further qualifications in mathematics to be employable in a certain chosen field. Students who gave reasons for not wishing to carry on with the study of mathematics gave various reasons: not feeling confident in the subject; feeling that their strengths lay elsewhere; acknowledging that mathematics was useful in general, but that it was more important for them to specialise in other subjects with direct relevance to their chosen area of employment; not needing it for their chosen area of employment.

These responses need, however, to be viewed in the context of the particular cohort of students involved in the pilot. Some centre types (such as special schools, independent schools and further education) are under-represented in the pilot, while schools with sixth forms are slightly over-represented (see 5.2.3). Most participating centres also have a low percentage of FSM students, so this cohort group may be underrepresented, too.

4.1.2 Comparability of demand of the pilot qualifications with each other and with other GCSEs in mathematics

- Centres that offered both the linked pair of GCSEs and the new single GCSE reported in the online survey that the linked pair was leading students to acquire skills and knowledge that they could transfer to other subjects, although almost two-thirds believed that the single GCSE was having the same effect. The majority of these centres also said that the linked pair of GCSEs was more demanding and challenging than the new single GCSE, and more than one-third also said the linked pair was more interesting.[31]
- All case study non-pilot centres said that the functional and problem-solving elements of the new single GCSE presents the biggest change to the skills students are now required to develop and demonstrate.
- Two of the case study non-pilot centres commented on the increased literacy skills students need to succeed with the new-style examination questions. One non-pilot centre said that such questions especially stretch those students who are working around the C/D borderline. Another non-pilot centre explained that they had worked, with some success, across the curriculum with the English department to develop the reading skills of their students.
- Two of the case study non-pilot centres explained they offered the mathematics pathways' *additional* mathematics GCSE to their higher-attaining students, seeing this as a better preparation for study at A-level than the new single GCSE. One centre explained that they needed the *additional* mathematics GCSE to stretch their highest-attaining students. The new single award was considered to lack interest and challenge for these students.

4.1.2.1 Assessment

Initial work has been undertaken to give a benchmark for future analysis. Findings suggest:

- the weighting of marks for AO1, AO2 and AO3 is appropriate
- examination papers contain some questions that are unstructured and require longer chains of reasoning
- there is a relatively high level of analysing-procedural questions (where analysis requires only procedural knowledge of what to do) in the papers scrutinised.

It is too early at this stage to draw any conclusions from the analysis and scrutiny, given that full suites of live papers are currently not available. Awarding organisations have confirmed that the development of examination questions that assess problem-solving skills is on-going and changes are being made. It is expected, therefore, that future papers will contain questions that reflect this.

What will need to be monitored in the future is the speed and direction of change given the pilot timescales, and the extent to which the changes will allow and encourage candidates the opportunity to use higher-level mathematical skills, such as generalising and constructing arguments.

[31] None of the centres that offer the single GCSE in mathematics as well as the linked pair of GCSEs in mathematics reported that the linked pair of GCSEs in mathematics was less interesting, demanding, or challenging than the new single GCSE.

Most centres participating in the online survey that had entered students for the January 2011 examination series reported that the assessments were as challenging as expected, with one in four saying they were more challenging than expected. There was no significant difference between the perceptions of levels of difficulty between methods in mathematics and applications of mathematics.

4.1.3 The views of centres (both pilot and non-pilot) on the pilot

- Where centres reported that the linked pair of GCSEs had necessitated design changes in the curriculum, or changes to their teaching, many also reported that the new single GCSE had necessitated similar changes.
- While centres reported enthusiasm for the opportunities offered by the linked pair of GCSEs, many of them will need to make considerable changes to teaching and learning if these opportunities are to be realised. How far centres are able to do so depends primarily on the extent to which they embrace a more student-led, challenging and open approach in their teaching. Although centres recognised the need for some teacher input and modelling at this early stage, in the majority of the lessons observed reasoning and conceptualisation were predominantly teacher-led and structured.
- Only in a minority of centres was there a high level of effective questioning, with 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. Higher-order questioning and reasoning were observed much more in higher-tier lessons than in foundation-tier lessons (where these were barely evident). Most teachers, however, 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 provide real-life scenarios for the application of mathematics. There was a general understanding of the need to teach students how to approach problem-solving activities that are less structured – 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. They seemed unaware that the change to assessment objectives and grade descriptions will require different mathematical behaviour from candidates.
- Students interviewed had mixed views about the jump from KS3 mathematics to the linked pair of GCSEs. Some felt the jump was substantial and the work was now much harder, more complicated and involved more-specialist vocabulary. Others felt that the work had become easier or had stayed about the same. There was no consensus as to whether it was methods in mathematics or applications of mathematics that offered any noticeable jump. However, students recognised that any detectable difference was a natural step-up or progression and some felt they were more aware of this because they felt it was important to get a good GCSE grade.

4.1.4 The support offered to pilot centres by the awarding organisations

Pilot centres reported that they had been well supported by awarding organisations, but they also appear to be over-reliant on resources generated by these organisations. The findings for this report suggest that three levels of support may be required if centres are to realise the full potential of the linked pair of GCSEs:

(i) For a minority of centres there is a need for a minimal level of input clarifying the difference within and between the two qualifications making up the linked pair. In particular this should focus on what problem solving looks like in methods in mathematics.

(ii) For the majority of centres, in addition to the support outlined in (i) above, the evidence suggests that what is needed is help in implementing planned changes to their teaching. The changes required are in terms of developing more approaches that are skills-based and interactive, and fully recognising the move from topic-based to process skills assessment in their practice.

(iii) For a significant minority of centres, as well as (i) and (ii) above, support is needed to enable them to recognise how they need to change their teaching and learning, which teaching approaches and strategies are likely to be most effective and how these can be managed and planned for.

Some teachers will also need to undertake continuing professional development (CPD) which specifically addresses the new content. The extent of the support they will require is likely to depend on the overall position of the centre in which they teach in the three levels of support identified above.

4.2 Identification of any emerging risks and issues for the qualifications

- One awarding organisation reported that a significant number of pilot centres had not registered for the June assessment window, maybe because centres have opted for a linear approach to assessment (i.e. entering students for all papers at the end of the programme of study). Other awarding organisations have reported the numbers of entries but not the centres entering. The number of centres still participating will need to be monitored carefully to ensure there are enough for piloting purposes.
- There is a potential mismatch between the external factors behind some centres' reasons for taking part in the pilot and the underlying aims and philosophy of the pilot. This may affect the extent to which centres are able to engage fully with the pilot and change their teaching and learning.
- Some centre types are under-represented in the pilot and others over-represented. The degree of under- and over-representation of different school types is not enough to be of major concern at present; indeed, in the case of schools with sixth forms, it may even help to clarify the impact on progression to level 3 learning later in the pilot. The issue of representation of different student cohorts will need to be considered in future statistical analysis: it has the potential to skew findings if, for example, there is a higher or lower proportion of higher-attaining students than in the mainstream GCSE cohort or a greater or smaller proportion of particular minority groups. The lack of further education (FE) institutions and adult community learning centres in the pilot will also need to be addressed further through case study non-pilot activity to ensure

there is sufficient understanding of the potential impact of the linked pair of GCSEs for students in these contexts.

- For the most part, centres were entering either whole-year cohorts or higher-attainers/gifted and talented in the pilot, although more middle attainers (C/D borderline) were entered in Year 11. It will be important to evaluate the extent to which the pilot qualifications are suitable for all students and therefore monitor any emerging trends of participation, which focus on specific cohorts.
- As identified in the pre-pilot report, a large number of Year 9 students are taking part in the pilot. Case study centres cited this as one way to increase the amount of time available for the qualifications. What is unclear at present is the impact this will have on early entry, and whether students will continue to study mathematics in Year 11 if they have already finished their GCSE in mathematics. However, case study pilot centres that had previously offered *additional* mathematics or statistics in Year 11 suggested that the linked pair would be used as an alternative.
- Where centres reported that the linked pair of GCSEs raised issues for lower-attaining students or students with weaker literacy, only one in four believed that the new single GCSE raised the same issues. The reasons for this require further investigation.
- Although many centres recognise the possibilities afforded by the linked pair of GCSEs, the majority need support with the necessary development of classroom practice, particularly a greater understanding of pedagogic approaches for developing problem-solving skills with all students. Teachers recognise the need for this development, but problem solving is currently mainly modelled by the teacher. The rate of change needed in teaching styles and approaches for the linked pair of GCSEs and the new single GCSE may have a bigger impact on lower-attaining students who find investigative approaches challenging. Likewise, examination papers that contain unstructured questions may result both in a demoralising experience for lower-attaining students and also in a bunching of marks that makes it difficult to differentiate lower grade bands.
- Awarding organisations have recognised the need to develop more-effective examination questions for the assessment of problem-solving skills, but questions are being written already for 2013, so there may not be sufficient time in the piloting phase for these to be evaluated fully. There needs to be a clear picture of how issues are being identified and addressed for future papers.
- The findings from the Evaluating Mathematics Pathways project indicated that although around one-third of the GCSE higher-tier assessment is intended to assess algebra, the nature of questions and mark schemes means that there is insufficient incentive for developing the algebraic competences that are essential for level 3 mathematical study. If this issue has not been resolved for the assessment of the linked pair of GCSEs, particularly for methods in mathematics, the qualification may not recognise and reward higher-level mathematical thinking and the use of algebra in solving problems and constructing arguments.

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