Research Report DFE-RR143

Evaluating Mathematics Pathways

Final Report

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Prologue

In 2004 the Smith and Tomlinson reports paved the way for rethinking the 14-19 mathematics curriculum. Smith urged the government to develop, amongst other things, "a highly flexible set of interlinking pathways that provide motivation, challenge and worthwhile attainment across the whole spectrum of abilities and motivations" (Smith 2004, p.8)

In 2005 the ***Mathematics Pathways Project*** was established by the QCA[1]. The Pathways Project comprised two phases.

In Phase 1 proposals for new pilot qualifications in mathematics at GCSE and A-level were developed during 2005-2006 by two consortia: The University of Leeds and King's College London/Edexcel.

Phase 2 saw the development and piloting of new qualifications by two awarding bodies, AQA and OCR from 2006 - 2010.

The qualifications beginning pilots in 2007 were:

- OCR: GCSE Mathematics incorporating Functional Mathematics, GCSE *Additional* Mathematics; GCE Mathematics, Further Mathematics.
- AQA: GCSE Mathematics incorporating Functional Mathematics, GCSE *Additional* Mathematics, GCSE Use of Mathematics; GCE Mathematics, GCE Further Mathematics, GCE Use of Mathematics.

Over 600 schools and colleges participated in the pilots.

The ***Evaluating Mathematics Pathways*** (2007-2010) project was awarded by the QCA to independently evaluate the new qualifications, in particular to answer the following questions:

- What is the likely impact of the proposed qualifications on take up of mathematics at all NQF/QCF levels, particularly post-16, including candidate engagement and confidence?
- Do the benefits of a new system lead to sufficient gains which justify replacing current provision?

There were four strands to the work

1. Meeting students' needs
2. Providing pathways and progression
3. Assessment
4. Manageability of implementation

The Evaluating Mathematics Pathways Project was conducted by teams from the Universities of Nottingham, Manchester and Sussex.

[1] The Qualifications and Curriculum Authority (QCA) became the Qualifications and Curriculum Development Agency (QCDA) in April 2010. Following the 2010 General Election, the Coalition Government announced the abolition of QCDA, subject to the passage of the Education Bill 2011.

1.Executive Summary

This is the Final Report of the Evaluating Mathematics Pathways Project and covers activities in Stage 8 of the project (May–December 2010) as well as reviewing the whole Pathways Project. The Evaluation has been formative in nature so findings have been reported as they occurred throughout the three and a half years since we were appointed, and interested readers are encouraged to request these reports from the University of Nottingham[2].

During Stage 8 of the evaluation we completed various strands of activity including case study visits to pilot centres and interviews with representative employers. We carried out the analysis of the survey data collected from students involved in the piloting of the GCE Use of Mathematics qualification during Stage 7. In addition we planned, implemented and reported to QCDA on a national survey of GCSE centres that explored patterns of early entry and issues arising from the move to two-tier GCSE. The two reports from these surveys are included as Appendices A and B to the main report and summaries of the findings can be found in Section 4.

The Pathways Project – an overview

In 2004 the Smith and Tomlinson reports paved the way for rethinking the 14-19 mathematics curriculum. Smith urged the government to develop, amongst other things, "a highly flexible set of interlinking pathways that provide motivation, challenge and worthwhile attainment across the whole spectrum of abilities and motivations". Since 2005 QC(D)A have overseen the development of models for post-14 mathematics pathways. This has included the design of new qualifications which have been piloted in hundreds of schools across England and Wales. We have tracked these developments and although many of the original proposed qualifications have not been adopted we have learnt a great deal about the experiences of students of mathematics in the 14-19 age range, and the behaviour of schools with respect to the processes of piloting.

The Pathways Project has run in parallel with the new secondary curriculum that has been phased in by schools from 2007. This curriculum, with its renewed emphasis on mathematical processes and applications, has also incorporated functional skills, and is the driver for GCSE 2010.

What's new?

In the last three years there have been national consultations on both GCSE and GCE Mathematics. As a result a new GCSE in Mathematics started in 2010 but at GCE there have been no agreed changes to Mathematics and Further Mathematics. The original model for a 'pair of GCSEs' in mathematics that was piloted from 2007-10 has not been adopted. However, the process of piloting examination questions aimed at assessing functionality and the capacity to solve mathematical problems, which are at the heart of the new secondary curriculum, has helped to prepare awarding bodies for the introduction of the new GCSE which started in 2010.

[2] Please email educationresearchstaff@nottingham.ac.uk

For the last two years QCDA, together with the awarding bodies, the Advisory Committee on Mathematics Education (ACME) and other stakeholders has been developing a 'linked-pair' of GCSEs. Around three hundred schools are now engaged in piloting these qualifications: 'methods in' and 'applications of' mathematics.

Performativity

The standards agenda, particularly the dominance of 'league tables', has produced a culture of performativity which has resulted in unhelpful pressures on teachers and students. Teaching to the test reduces the quality of the learning experience to a narrow focus on procedural competence (Ofsted, 2008). The pressure on schools to maximise the number of students attaining a grade C or better, combined with the decision to discontinue Key Stage 3 tests, has resulted in an increasing trend of early entry.

Early entry leads to thousands of students not achieving their full potential, or having their mathematical skills atrophy during Year 11. We have found that many students, including the highest attainers, can end up doing no mathematics in Year 11 if they have 'banked' a good grade and that students in 11-16 schools are more likely to be entered early. This can create serious discontinuities in mathematical learning. The corollary of 'successful' early entry is resitting failed examinations, which has an equally dispiriting impact upon learners, who in the first place take examinations for which they are not ready, followed by repeating material rather than engaging with new mathematics.

It is six years since Smith reported that "it is clear that the overwhelming majority of respondents to the Inquiry no longer regard current mathematics curricula, assessment and qualifications as fit for purpose." Since then there have been changes to the national curriculum and the recent introduction of a new GCSE in mathematics with increased emphasis on functional elements and problem solving. There is a new Level 1/2 Certificate in Use of Mathematics which could potentially meet the needs of a range of post-16 learners and the pilot of GCE Use of Mathematics is continuing and growing in popularity. Whether we can say that the suite of mathematics qualifications now available for 14-19 year olds is 'fit for purpose' is a moot point and the full report raises some outstanding issues in 14-19 mathematics.

Successes

The more innovative question styles in the pilot GCSEs, particularly in the GCSE *Additional* Mathematics, have motivated some learners, especially higher attainers. Questions which are less structured and explore mathematical problems have engaged learners, which is encouraging given the increased emphasis on problem solving in the new GCSE.

The piloted GCE Use of Mathematics has been enthusiastically adopted, albeit only in a small number of schools and colleges so far. This qualification has attracted new populations of students into mathematical study and is inspiring pedagogies that motivate and engage learners. The pilot of these qualifications is ongoing and there is work under way to support teachers to further develop these programmes.

The pilot GCSE Use of Mathematics is to become a Level 1/2 Certificate post-pilot. This pilot qualification was also well received and the new Certificate has the potential to provide a more worthwhile learning experience for students leaving school at 16 without achieving a grade C in GCSE *Mathematics.* Not allowing it to be called a GCSE is a risk to its status and impact.

Remaining Challenges

- *Transition at 16*

Transfer at 16 need not necessarily impact adversely on overall student experiences. But, in terms of participation in mathematics post-16 there are some disadvantages for those changing institution at this age. Curriculum continuity and advice on post-16 course options in mathematics is generally better for students who can continue in the same school to age 18 than those who transfer to new schools and colleges at age 16, Structural impediments, such as discontinuities in data sets, make it difficult for teachers on either side of the transition to keep track of and monitor student choices.

- *Algebra*

Mathematics GCSE broadly covers the Key Stage 4 programme of study, but many schools do not teach the most difficult material, including challenging algebra, to all higher tier students. The core of Level 3 mathematics programmes is algebraic and GCSE mathematics experience does not prepare most students sufficiently well for this. This is a longstanding problem which has not been tackled in the Pathways Project and which raises serious issues for progression to, and retention on, GCE mathematics courses.

Scrutiny of candidate scripts at GCSE highlights that students' understanding of algebra at 16 is often so rudimentary as to provide a significant hurdle for progression to GCE mathematics.

- *Recruitment to GCE*

Schools and colleges aim for 'the clever core' when recruiting to GCE mathematics. The Use of Mathematics pilot GCE is attracting new cohorts of students. One notable group seems to be high attaining girls for whom the purpose and pedagogy of this non-traditional route is appealing. However, this does raise concerns about why such students do not see the traditional GCE Mathematics route as being equally attractive.

Future possibilities

The Pathways Project aimed to develop different routes through 14-19 mathematics for learners with different needs. Schools are already trying to create pathways but these are largely variations on a theme - GCSE and GCE (for high attainers) – with other currently available qualifications being employed in a rather ad hoc way. For example, the *International Baccalaureate* provides routes that include mathematics, but only for the highest attaining 40% of any cohort.

The Pathways Project has contributed to the development of a qualifications framework that now includes a range of FSMQs at all levels. This framework offers new possibilities for schools and colleges to construct 14-19 mathematics pathways for learners of different abilities and needs.

There remains an ongoing need for the development of coherent and well-targeted mathematics pathways. Clear advice and guidance is needed that can support schools in using the range of available qualifications to construct appropriate curriculum pathways.

Recommendations

We make four major recommendations at the close of this project. These are areas that we feel would be worthy of serious consideration and further research:

Recommendation 1:

We strongly recommend that the Use of Mathematics qualifications be adopted post-pilot in order to create new learner pathways that will widen and increase participation and engagement in mathematics.

Given the current Nuffield Foundation study which highlights how poorly we fare in terms of post-16 participation in mathematics internationally, combined with the inappropriateness of GCE mathematics for the vast majority of learners (Matthews and Pepper, 2007) this approach is necessary.

Recommendation 2:

There needs to be effective CPD for curriculum leaders on how to design learning pathways, relevant curricula and engaging pedagogy, using the available suite of mathematics qualifications. This should also take account of school structures, such as 11-16 & 11-18 schools and FE & VIth Form colleges, as these have also been found to make a difference to teachers' understanding of progression issues.

Leaving this to Awarding Bodies is not sufficient as they make different products available to their centres (e.g. Level 3 FSMQ Additional Mathematics (OCR), level 1 to 3 FSMQs (AQA), BTEC level 1 and 2 Mathematical Applications (Edexcel)). A more holistic, impartial set of guidance materials, including case studies already in existence, would be a useful resource here but meetings with teachers would be better still. Given the upheaval in the landscape of mathematics support for schools (e.g. loss of the National Strategies, QCDA, and local cut backs of advisory teachers) it is not clear who is best placed to develop and offer this CPD support.

Recommendation 3

High attaining students need to develop greater facility with algebra by age 16 and assessments should incentivise high quality teaching and learning in this critical area.

Given the central importance of algebra to GCE mathematics programmes and mathematically demanding programmes of higher education, it is imperative that high attaining students develop greater algebraic facility. The GCSE A grade descriptor includes the following:

> "Candidates use a wide range of mathematical techniques, terminology, diagrams and symbols consistently, appropriately and accurately. Candidates are able to use different representations effectively and they recognise equivalent representations for example numerical, graphical and algebraic representations. Their numerical skills are sound, they use a calculator effectively and they demonstrate algebraic fluency. They use trigonometry and geometrical properties to solve problems." (Ofqual, 2009)

From our analysis of the complete GCSE assessments of one hundred students attaining grade A in the summer of 2009 we can state with some confidence that the typical student does not 'demonstrate algebraic fluency' at this level.

Given the value of this analysis in explaining what students actually know and can do and how their work gets rewarded in the assessment process we make the following fourth recommendation:

Recommendation 4

There should be further scrutiny of qualifications which combines analyses of assessment design with careful examination of students' responses. This would give a far better indication of the extent to which assessments are measuring what they purport to assess. In turn this would inform future assessment design thereby offering better means of impacting teaching and learning. This would be particularly relevant for the newly introduced problem solving questions.

Scrutiny and tracking of assessment over time together with analysis of students' responses to assessment items (in GCSE algebra) suggest the need for ongoing analytic work of this type to be carried out. This could ensure that in future we are much better informed about the detail of how assessment interacts with students' experiences of mathematics and how we might improve teaching and learning by intervention in assessment.

Section 3 of the Final Report outlines the structure of the evaluation and summarizes the key findings. The recommendations from all of the interim reports are included in the appendices.

EMP Management Group

December 2010

2.The Pathways Project

In this Final Report of the Evaluating Mathematic Pathways Project it is appropriate to revisit the underpinning aims and objectives of the project in order to understand what has been achieved and what challenges for 14-19 mathematics education remain. This means reflecting on the report of the Smith Inquiry (2004).

Looking back to Smith

The report of the Smith inquiry was the most comprehensive review of 14–19 mathematics education for over two decades. It gave a thorough overview of available qualifications at the time and the extent to which they defined pathways in mathematics. Although this overview identified the full range of qualifications available, for the majority of students there was potentially only one pathway; the Key Stage 4 curriculum culminating with the GCSE qualification at age 16 followed, for the most able, by GCE (i.e. A Level) Mathematics post-16. In general terms this progression pathway resulted, and continues to result, in approximately 50% of the annual cohort attaining what is considered a good grade at GCSE (that is, a grade C to A*) with about 10% of the total annual cohort progressing through to completion of A level. Other qualifications in the system, such as Free Standing Mathematics Qualifications (FSMQs), attracted a small number of students. When combined as the AS Use of Mathematics they offered another level 3 pathway but without the option of proceeding to the A2 this pathway appeared as something of a dead end to many students.

Smith reported that his Inquiry had been informed of general dissatisfaction with the single pathway, writing,

> *"It is clear that the overwhelming majority of respondents to the Inquiry no longer regard current mathematics curricula, assessment and qualifications as fit for purpose."* (Paragraph 0.25)

This highlighted the lack of responsiveness of the GCSE and GCE (A Level) pathway in meeting the varying needs and aspirations of the full range of young people. In general, the report also reflected the wider debate about the 14-19 curriculum that was then current, in particular the findings of the Working Group on 14-19 curriculum and qualifications reform in England. The Tomlinson Report (2004) sought to establish coherent pathways for all 14-19 year olds and it was hoped that the mathematics pathways that Smith advocated would be an integral part of Tomlinson's pathways. Fundamental to the 'pathways vision' of the Tomlinson review was a move to coherence across the 14-19 phase rather than seeing this as two phases (pre- and post-16) and a transition across these.

Smith argued strongly for curriculum development in mathematics that would see a new range of qualifications defining different pathways that might better serve young people than the 'one size fits all' framework that was dominant at the time, noting:

> *"We do not believe that a one-size-fits-all model is appropriate. We wish to see a highly flexible set of interlinking pathways that provide motivation, challenge and worthwhile attainment across the whole spectrum of abilities and motivations, but avoid the danger of returning to the O-level/CSE "sheep and goats" divide." (Para. 32)*

Chapter 4 of the report set out some fundamental principles to which it was thought that a system of mathematics pathways should conform. These are reproduced here in full:

> *The Inquiry believes that the following principles should guide the construction of a future pathways approach to mathematics provision 14-19 in the UK:*
>
> - *all learners should be provided with a positive experience of learning mathematics and should be encouraged to realise their full potential;*
> - *it should be recognised that not all learners learn in the same manner, or at the same speed, or respond positively to the same styles of assessment;*
> - *all pathways should include progression up the qualifications ladder, with each pathway having clearly defined destinations into training, employment, further or higher education;*
> - *there should be flexibility within the overall structure and maximal opportunity to make transitions among the pathways; it will be important to avoid regression to old style O-level versus CSE, or any other now defunct rigid qualifications divide;*
> - *new approaches to pedagogy and, in particular, the use of ICT should be adopted to ensure that all students acquire an appreciation of the power and applicability of mathematics;*
> - *the uses and applications of mathematics, including working with ICT, should be made central to the mathematics curriculum wherever appropriate, but without compromising appropriate levels of abstraction and generalisation.*

The report also discussed a number of possible pathways structures that were based on two distinctively different approaches: one premised on a single pathway for all but with students having different rates of progression through, and the other that developed distinctively different pathways with students engaged in different mathematical content at varying levels of difficulty, abstraction and application. Choosing between these two different pathway structures is confounded by arguments around equity of access and the values that are culturally and historically attributed to different genres of mathematics. Crucially, this desire for equity of access generates tension between the two different models, as clearly the single pathway provides equality of access (with consequently unequal and unacceptable outcomes) whereas multiple pathway models require careful design if they are to avoid a rigid qualifications divide yet meet the mathematical needs and aspirations of different learners.

Phase I

There were additional factors that needed to be taken into account in the development of pathways by the two teams appointed to carry out this pathway development work in Phase I of the Pathways project (The University of Leeds and King's College/Edexcel):

- *the requirement that the assessment of mathematics at GCSE would move to two tiers of entry;*
- *the expectation expressed in Smith that students would have an opportunity to gain two GCSE qualifications in mathematics, in line with possibilities in English and science;*

- *the expectation that all students would continue to study the National Curriculum Key Stage 4 programme of study for mathematics*
- *the assessment of functional skills in mathematics was to be introduced.*

These latter two requirements were part of the Tomlinson review recommendations (DfES, 2004), and although the main thrust of the Tomlinson Report was rejected, these were taken forward.

The notion of pathways that was threaded throughout the Smith Inquiry report, and was also prominent in the Tomlinson Report, is very much focused on qualifications structures, whereas in the resulting developments in Phase I that followed more attention was paid to issues of pedagogy and learner experience at the same time as considering qualification structure.

The Leeds team proposed a model that incorporated the requirements to move to two-tier assessment at GCSE, to include functional skills within all pathways, and develop an additional GCSE qualification. Their model provided a single pathway to age 16, with the possibility of some diversity of mathematics post-16 through the use of the Free Standing Mathematics Qualifications, which it suggested were renamed as supplementary mathematics modules.

The King's College/Edexcel team offered a similar pathway structure providing what might be considered a single pathway with possibilities of enhancement/extension, particularly post-16, although without the additional use of Free Standing Mathematics Qualifications to cater for diversity of students' needs. Their plans focused primarily on how their proposed qualifications would impact on learner experience rather than suggesting any radically different structure. To this end the proposal was for qualifications that would have a distinctive emphasis on mathematical modelling and the use of ICT, both within the course and in the assessment of the mathematics. Two models were proposed for the two GCSE qualifications. Model A provided for a mix of Applications, Skills and Techniques across the two qualifications. Model B proposed that one of the GCSEs assessed applications of mathematics across the grade range; and the other, pure mathematics and an appreciation of the nature of mathematics and mathematical thinking. It was recommended that successful completion of both GCSEs be required to start A level.

There was a strong emphasis on modelling and use of ICT as it was felt that this would have the potential of providing a mathematical experience with "immediate relevance to students of lower level abilities, placing mathematics into context and giving it an obvious purpose". For higher attainers it was argued that this would allow them "to engage in problems and encourage thinking and investigative skills, which will be useful in future study or employment".

Although it might be argued that these proposed pathway models reflect the requirements of Smith it was not clear how they catered for students with different aspirations for future training, employment, further or higher education. However, the lack of movement towards a 14-19 curriculum with pathways that might have been expected to have resulted from Tomlinson, meant that mathematics pathways were compromised from the outset by the requirement that the 14-16 phase remained very much focused on the key stage 4 programme of study for mathematics with all students continuing very much as before with a diet of predominantly academic GCSEs.

Early in the evaluation it became clear that regulations would not allow for the GCSE *Additional* Mathematics to continue beyond the pilot as it was based on the same programme of study as GCSE Mathematics. When the pathways GCSE pilot model was devised it was consistent with the regulations in force at the time. A double award had been rejected and two distinctive, two-tier GCSEs assessing the KS4 programme of study were agreed. One GCSE incorporated functional mathematics but in other respects was similar to the GCSE available at the time, except that it was two-tier and did not include coursework. The other GCSE was also 100% external assessment but had a greater emphasis on mathematical thinking and problem solving. It was to include longer, less structured items offering learners the opportunity to make choices about what mathematics to use and how to tackle a given problem. OCR's 2nd GCSE was also not tiered. Unfortunately by the time the work began on the post-pilot qualifications the regulations had changed, not least the overlap restriction that limits the amount of common content between two GCSEs had been quantified as 30%. This meant that the pilot model was not viable from early in the pilot phase as it contravened these new regulations. Such regulatory changes cannot necessarily be anticipated. However, the impact upon the pathways project has been considerable. Regulatory changes need to be marked as high level risks in future long-term curriculum and assessment development projects with clear strategies for mitigating the impact of such changes.

Our ongoing work with case study schools suggests that recent assessment items for the GCSE *Additional* Mathematics have developed a more distinctive shift towards engaging students in a different mode of mathematical activity with problem-solving being given greater priority. This has seen the inclusion of a larger number of less structured assessment items requiring students to engage with a broader range of process skills, notably requiring more reasoning. What has been learned from the development of assessment for this qualification by Awarding Bodies and their examining personnel has been invaluable in informing the introduction of the new GCSE in mathematics in 2010 and is also informing the development of the linked pair of GCSEs now in their pilot phase. However, across all qualifications in the mainstream provision (GCSE and AS/A2) we found a continuing tendency for assessment to be highly structured and mainly focused on procedural analysis in the context of pure mathematics.

Assessment development

The assessment of mathematics has become overly concerned with the reliability of assessment, arguably at the expense of its validity. Questions can be asked that do allow some variation of method by candidates in examinations, but openness in general is avoided and exact answers are sought. Although it would be possible to set tasks that require, for example, mathematical modeling or investigation these are avoided. The demise of coursework in all examinations at GCSE and almost all at AS/A2 has resulted in a narrowing of the curriculum in this regard and it is likely that recent and current students working at this level meet very little activity of this type.

The relatively slow, ramped development of assessment in the pilot of the GCSE *Additional* Mathematics is indicative of the whole assessment process as it is developed by the awarding bodies and experienced in schools. This points to the challenges faced by those senior examiners who are keen to innovate in this public examinations market place. Schools are very sensitive to assessment change in the current performative climate. There is also a certain degree of systemic conservatism caused by some Awarding Bodies being more risk averse and protective of their market share. This is not

to say that new forms of assessment items cannot be developed but such risky activity takes time and requires support and space for experimentation and so on. The mathematics pathways project did not allow sufficient time and space for development of this type of assessment before decisions were being made about the success or otherwise of component qualifications. Even in current manifestations of assessment there is a need for better understanding of how assessment frames curriculum and pedagogy. For example, numerical methods are quite often used by candidates in response to some algebra items and these appear to be given full credit by the assessment process. This is an obvious area of concern, as are mark schemes that do not reward most highly those with the greatest algebraic facility.

Developing pathways

At the outset of the piloting, there was a perceived lack of distinctiveness of GCSE *Additional* Mathematics and GCSE Mathematics. This reflected a concern that the evaluators have expressed through the pathways project: the lack of a clearly articulated framing vision for 14-19 mathematics pathways. As explained above, the process of assessment change is perhaps best understood as evolutionary but perhaps such change could occur more rapidly with very clear and shared initial understanding of the ultimate goals.

The focus of the Pathways project became concentrated on the constituent stepping stones of the component qualifications at the expense of an overarching vision of how these might work across schools and colleges for young people. Perhaps inevitably given that the projects were situated almost entirely with Awarding Bodies they became focused too narrowly on curriculum specification through assessment and did not consider effectively enough how this would play out in teaching and learning and how the pathways might be situated as part of the overall options for students to continue with mathematics. That said, there have been other parallel developments (e.g. new Key Stage 4 Programme of Study) that have complemented the pathways developments and have a more explicit curriculum focus. The key point here is that, at risk of overstretching the metaphor, pathways were realised more as sequences of qualification *gateways* rather than learning *journeys*.

Functional skills

At the outset of the Pathways Project the focus on functional skills was viewed positively as offering a means of reconnecting the mathematics curriculum with something relevant for students, particularly lower attaining students. Those more likely to progress to A level were believed to derive motivation and satisfaction in working purely in mathematics itself. It was intended that gaining a level 2 pass in GCSE Mathematics was dependent on also gaining a pass at level 2 in Functional Mathematics. This introduced a ‘hurdle’ and so schools considered entering their high attaining students for Functional Mathematics as early as possible to “get it out of the way”. If this situation had prevailed it seems clear that the value of the qualification would have been undermined. However, the integration of functional elements into the assessment papers for the GCSE qualification meant that for students in compulsory education this scenario was circumvented. The legacy of this development has been a heightened awareness in mathematics departments of what functionality might mean, although there remain varied interpretations of what it means to be functional with mathematics. Ofsted’s (2009) report on the implementation of the new Key Stage 3 curriculum in a small sample of schools notes that functional skills are ‘well served’ in mathematics so it might

be that understandings of functionality become clearer as these terms/pedagogies become more deeply embedded.

FSMQs

The main innovations in developing mathematics pathways have been in post-16 mathematics. These have been underpinned by the existing Free Standing Mathematics Qualifications (FSMQs), relatively small qualifications in focused areas of mathematics that are already provided at levels 1 to 3 of the National Qualifications Framework. These had been designed in preparation for curriculum changes in 2000 to support students with their post-16 studies in other subject areas. Initially they had been designed to meet a need for units of mathematics in pre-vocational programmes. Their potential to support students on academic programmes was soon recognised and they have since been used by a relatively small but enthusiastic group of advocates, mainly in colleges. FSMQs focus on applications of mathematics and the use of mathematical models to solve meaningful problems in areas that students are likely to meet, either in other studies or in general daily life at home and work.

In the pathways developments the FSMQs at levels 1 and 2 were used in combination to provide a GCSE Use of Mathematics qualification for those students failing to gain a GCSE grade C (or higher) by the end of Key Stage 4. The programme that would lead to this new qualification was attractive to students who would not wish to progress to level 3 study of mathematics and would find the focus on applications valuable. Throughout the evaluation, pilot centres have been very positive about GCSE Use of Mathematics. The decision by Ofqual that after the pilot period this qualification can no longer be designated a GCSE has struck a serious blow to one of the significant developments of the Pathways Project. Although the qualification will exist, re-badged as the AQA Certificate in Use of Mathematics, it is possible that without explicit support it will struggle to flourish in the qualifications marketplace because of the kudos accorded to the label of GCSE Mathematics and its specific role as a gatekeeper to subsequent opportunities.

At level 3 FSMQs combine to form GCE Use of Mathematics and this qualification has considerable potential to provide attractive new pathways following on from either GCSE Mathematics or the level 2 Certificate in Use of Mathematics. Evaluation surveys, case studies and assessment scrutiny work all suggest that Use of Mathematics qualifications at all levels provide something new in terms of curriculum provision. They have the potential to engage more post-16 students in studying mathematics in ways that would equip them with appropriate knowledge, skills and understanding for their future learning and work. There remain some development needs in the assessment and design of these qualifications. Assessment items do not always connect mathematical models well with the reality they are intended to represent and can at times privilege abstract knowledge above applications. In general, however, they do provide a distinctively different approach to learning and meet the needs of students who study them.

Despite a lengthy process of consultation there have been no changes to GCE Mathematics. There have been strong advocates for change at A level but these seem to have been counterbalanced by a particularly vociferous and influential ‘no change’ group.

Outcomes

Overall, has the Pathways Project met the needs identified by Smith? There is not a definitive ‘yes’ or ‘no’ answer to this question: the models investigated have not been

adopted wholesale but they have informed the development of new GCSEs, a new pilot of a linked pair of GCSEs and the development of functional skills assessments. It will take time to establish the extent to which students are having their needs better met than previously. Particularly important is the development of new Use of Mathematics pathways which have proved both attractive and engaging for learners. However, the future of the Use of Mathematics approach to mathematics teaching and learning and the pathways that might then be available is not ensured at the end of the period of the project. What is clear is that schools and colleges, and indeed individual students, will map out their own pathways with whatever qualifications and structures exist.

The focus of the pathways developments on qualifications and the intensive work that surrounded this has meant that concerns about pedagogy have not taken centre stage. This was realised in centres by them often seeing the pilots as opportunities to get more 'bites at the cherry' rather than rethinking the curriculum and pedagogic experiences of their learners. However, over time some of the piloted qualifications have tended to lead to the development of different pedagogies (e.g. GCSE *Additional* Mathematics or GCE Use of Mathematics), albeit this is only the start of a process. It is easier to change qualifications and national curricula than it is to effect real, deep and sustained change in classrooms. So it remains to be seen how typical, non-pilot classrooms will be impacted by recent changes in the 14-16 curriculum. The opportunity for curriculum enrichment that could have arisen from within the Pathways Project has not been fully grasped, due in large part to the principal, and generally worthwhile, focus on assessment development. We note that considerable efforts continue to be made by QCDA, working with, for example, the NCETM and SSAT, to embed the new secondary curriculum and develop and embed desired changes in curriculum and pedagogy.

Overall, we recognize that systemic change of the scope and nature envisaged by Smith was difficult to achieve. This is particularly true because a large amount of detailed work over a number of years was required and during this period a number of other systemic changes inevitably had an impact. As the Pathways Project draws to a close, there is the potential for effective pathways to be further developed and established. However, much remains to be done, especially in supporting the newer pathways that are emerging in Use of Mathematics. This work would need to include supporting and informing curriculum leaders to showcase how various qualifications might be combined to make meaningful learning pathways. The demise of the QCDA may prove problematic in this regard as there is now no obvious home for oversight of curriculum development at the level of pathways. Should the Awarding Bodies be charged with this work there is something of a conflict of interests as they do not all offer the same portfolio of qualifications.

It is critical that a strategic vision be developed for what might be achieved, and for how to achieve it, and that it builds on the work around new curriculum implementation that has been kick started by the National Strategies (Secondary) for pre-16 learners.

3.The Evaluating Mathematics Pathways Project

In this section we report on the extent of the EMP project. The tender for the evaluation of the Pathways Project was advertised in the summer of 2007, by which time the Mathematics Pathways Project was well under way: Phase I was completed and Phase II had started. This delay was far from ideal (and we are pleased to note that the evaluators for the linked pair evaluation have been appointed from the outset of that study). We summarise the activities of the evaluation, outlining how the various strands of work developed throughout the project. During the period 2007 – 2010 there have been significant changes in the project and we have also provided relevant evaluation evidence and recommendations at these junctures during the three years.

The EMP management group has met regularly throughout the project and we have continued to meet with QCDA and the awarding bodies in each stage of the project. The executive summaries, or interim briefing papers, have been presented to the meetings of QCDA's Mathematics Pathways Advisory Group. We also brought the whole team together during each stage in order to analyse data, conduct scrutiny of assessment and/or student scripts and to plan future fieldwork.

Stages 1 and 2 (October - December 2007)

Noyes, A., Murphy, R., Wake, G. and Drake, P. (2007) **Evaluating Mathematics Pathways: Stage 2 report, December 2007 (confidential report to QCDA)**. Nottingham: University of Nottingham.

The EMP contract was signed at the start of October 2007 and an independent auditor, Professor Gordon Stobart of the Institute of Education, was appointed. Sub-contracts were agreed between the University of Nottingham and the Universities of Sussex and Manchester.

The project methodology that had been outlined in the bid was detailed for the four strands of the project.

- Meeting students' needs
- Providing pathways and progression
- Assessment
- Manageability of implementation

Due to the late start of the evaluation the team had to work quickly to set in place ways of working and develop research instruments. The project website and VRA (virtual research area) were set-up during this stage and CRB checks were carried out for project personnel.

Several project meetings took place and EMP began to present its plans to stakeholders. We also met with the QCA and both of the awarding bodies involved in the pathways projects.

A code of conduct for case study visits was written and agreed and plans for initial visits to 25 'long' case studies were designed and piloted prior to the commencement of visits.

A revised timetable for surveys was agreed with the Survey Unit at The University of Nottingham with a draft of the teacher survey completed by December 2007.

During Stage 2 we designed the processes for scrutinising assessment items, qualifications, papers and pathways during the next stage.

Stage 3 (January - April 2008)

Noyes, A., Murphy, R., Wake, G. and Drake, P. (2008) **Evaluating Mathematics Pathways: Stage 3 report, April 2008 (confidential report to QCDA)**. Nottingham: University of Nottingham.

The first EMP team residential took place in February 2008. During the stage we attended the Functional Mathematics Conference; ACME Annual Conference; AQA Pathways Project Board; QCA Advisory Group and also met with the NFER team evaluating the functional skills pilots.

By the end of Stage 3 the EMP project had visited over 50 centres piloting various combinations of Functional Mathematics and GCSE qualifications, several on more than one occasion.

An online survey of teachers with responsibility for leading pilots across the full range of centres was piloted, completed and analysed. Response rates were encouraging with 64 responses from GCSE/Functional Mathematics centres (representing 34% of the cohort), 20 responses from AS/A2 Mathematics and Further Mathematics centres (45% of cohort), and 14 responses from FSMQ/Use of Mathematics centres (42% of cohort).

In March 2008, we wrote to 36 organisations representing a wide range of stakeholders explaining the nature of the EMP project and requesting invitations to various meetings, events, and mailings. Following responses from 12 of these members of the team attended a range of meetings.

We began work on the detailed scrutiny of specimen and live assessments. This work was continued into the summer and Stage 4 but by the end of Stage 3 we had analysed fourteen papers from the January examination series and several of the specimen papers from across the range of the pilot qualifications.

Stage 4 (May - December 2008)

Noyes, A., Murphy, R., Wake, G. and Drake, P. (2008) **Evaluating Mathematics Pathways: Stage 4 report, December 2008 (confidential report to QCDA)**. Nottingham, University of Nottingham.

Stage 4 saw the completion of the first year of piloting and throughout this academic year the EMP team visited 74 GCSE pilot centres to interview a range of teachers of mathematics as well as curriculum leaders. Work also began during this Stage on visiting post-16 centres with the team visiting 25 centres piloting FSMQs and GCEs.

The survey which ran during Stage 3 was completed by more teachers during the summer term of 2008 and the analysis was updated accordingly.

Stakeholders were consulted in three ways during this period. Firstly, a presentation was prepared at the start of Stage 4 in order to introduce the project to the various stakeholder groups. The presentation was made to the British Society for Research into Learning Mathematics (BSRLM), The Mathematical Association (MA), the Engineering Professors' Council (EPC), the Institute for Mathematics and its Applications (IMA), the Joint Mathematical Council of the United Kingdom (JMC), and the Specialist Schools and Academies Trust (SSAT). Secondly, a consultation with secondary school heads of mathematics via Local Authorities took place. Thirdly, EMP representatives attended a wide range of stakeholder meetings and conferences including: OCR (3 meetings), AQA (3 meetings), ACME conference in February 2008; QCA Advisory Group; several further meetings with QCA; a symposium presented at the British Education Research Association conference (Heriot-Watt University, September 2008); paper presented at the Association for Education Assessment conference (Bulgaria, November 2008). By the end of this reporting period the EMP team had engaged with a total of 42 stakeholder groups.

Continuing the scrutiny work from Stage 3 we completed an analysis of 56 examination papers from the January and June examination series in total. This included a full suite of AS papers and the full range of FSMQs across the three available levels. This analysis was reported in some detail in the stage report.

Stage 5 (January - April 2009)

Noyes, A., Wake, G., Drake, P. and Murphy, R. (2009) **Evaluating Mathematics Pathways: Stage 5 report, April 2009 (confidential report to QCDA)**. Nottingham, University of Nottingham.

During this stage the EMP team continued its programme of case study visits to centres, largely focused upon GCE Mathematics and the Use of Mathematics pilot qualifications. A detailed qualitative analysis of these visits was presented in this report. By the end of this stage we had visited a total of 97 centres.

We started to plan teacher meetings in Manchester and London for the summer of 2009 at which heads of mathematics would be invited to meet with the evaluation team to explore some of the issues arising in the project.

A major aspect of work undertaken during this stage was the scrutiny of Mathematics and Use of Mathematics assessments. This analysis was of a more qualitative nature than our previous scrutiny work and focused on the algebraic and calculus components of the two qualifications at level 3. We also analysed available data in order to understand how the introduction of the new A2 in Use of Mathematics might impact upon participation patterns in level 3 mathematics.

Our analysis of assessments continued in this short stage with a scrutiny of those from the January series. During this second full year of piloting we were looking for evidence of the gradual evolution of question styles. This cycle of scrutiny work was completed following the summer series of examinations in Stage 6

Stage 6 (May - December 2009)

Noyes, A., Wake, G., Drake, P. and Murphy, R. (2009). **Evaluating Mathematics Pathways: Stage 6 report, December 2009 (confidential report to QCDA)**. Nottingham, University of Nottingham.

During this stage we continued to visit (and revisit) pilot centres. The nature of these visits began to shift focus though, and many of the visits to centres from this point onwards were about exploring the changes in teaching, attainment and progression that had occurred as a result of piloting the qualifications. These visits were organised into three strands, the first of which included a small number of detailed, rich case studies each of which was a case of a particular issue in the Pathways Project or 14-19 mathematics more generally (e.g. transition at 16, choice of mathematics or Use of Mathematics, etc.). The other two strands were further rounds of visits to schools piloting Level 2 and Level 3 qualifications in order to better understand the pilot process and its impact.

In the summer we conducted a small scale survey of pilot GCSE centres to explore the extent to which changes to the GCSE structure (i.e. 'two tier') and the inclusion of mathematics in the school performance measure had impacted upon school entry practices and learner experiences. Nearly 40% of pilot centres responded to the survey. Preliminary findings were presented to QCDA in July and raised concerns about the number of GCSE students being entered early and the impact that this might have on attainment, participation and progression. We agreed to conduct a larger GCSE survey with a wider sample of pilot and non-pilot schools to explore these concerns.

We tracked the continuation rates of AS Use of Mathematics students onto the A2 year of the course. Agreement was reached with QCDA that student level surveys of GCE Use of Mathematics students would be conducted in the Spring Term of 2010.

In July 2009 we held two teacher meetings in Manchester (6th July) and London (7th July). Each was attended by just fewer than thirty representatives from pilot centres. These meetings enabled us to explore a range of implementation issues and more general aspects of post-14 mathematics.

The first two interviews with representatives from relevant Sector Skills Councils (SSCs) were conducted during the Autumn term, with further interviews scheduled and contacts established with a further 15 SSCs. Linked to this work we began attempting to make contacts with a range of medium sized and large employers to explore similar issues.

During this stage we spent considerable time looking at GCSE and Use of Mathematics assessments from the summer 2009 examination series with a view to tracing the evolutionary development of the qualifications. We also started work on analysis of student scripts looking, in particular, at algebra and problem solving in the work of students awarded grades A and C at higher tier.

We completed the scrutiny of 38 pilot examination papers set during the 2008-9 academic year. These were mostly focused on GCSE and the FSMQs that formed part of the new GCE Use of Mathematics which was now in its first year of piloting.

The evaluators presented a symposium at BERA in September 2009: "Evaluating Mathematics Pathways: what does it mean to be mathematically well educated?" and also contributed to ECER 2009.

Stage 7 (January - April 2010)

Noyes, A., Wake, G., Drake, P. and Murphy, R. (2010). **Evaluating Mathematics Pathways: Stage 7 report, April 2010 (confidential report to QCDA)**. Nottingham, University of Nottingham.

In this penultimate Stage of the project we met with the QCDA to agree the intended shape of the final outputs from the project. By this stage the Pathways Project was looking quite different from what had been envisaged in the original invitation to tender. In addition to the Stage 8 Final Report we agreed to produce two further documents. The first of these would be a short flier summarising the key outcomes from the Pathways Project, highlighting the successes and lessons learnt from this comprehensive programme of curriculum modelling and qualifications development. The second publication was to be a short pamphlet focussed on raising issues pertinent to improving progression in 14-19 mathematics. It was intended that this latter publication would be launched at an event in the spring term of 2011.

We continued our programme of visiting pilot centres to investigate how the piloted qualifications have impacted student attainment, progression and teaching. Many of the centres, which originally expressed interest in participating in the pilots were no longer involved by this stage. The issue of sustained participation in the pilots was particularly acute for A level mathematics, where initial participation was low.

The final round of case study visits continued throughout the final academic year of piloting with the goal of having visited around 130 pilot centres by July 2010, 30 of these on more than one occasion. Overall we visited around 30% of our initial cohort of A level pilot centres (34) on more than one occasion. Given the importance of a possible new pathway at level 3 we increased the number of pilot case study centres in the last year (17 out of 37 AS/2 Use of Mathematics centres visited). We conducted a student survey in a majority of the Use of Mathematics centres in order to triangulate findings from the case studies. At GCSE we had originally planned to develop longitudinal case studies of around 25 centres (supplemented by a larger number of single visit centre). We visited around 80% of this number on repeated occasions.

During this reporting period we planned a summer survey of all GCSE centres in relation to entry practices, mathematics provision to age 16, preparedness for GCSE 2010 and awareness of the linked pair pilot.

During Stage 7 we interviewed representatives of eleven Sector Skills Councils in an effort to understand their views on school mathematics qualifications and on the mathematical training provided by employers. Nine SSCs were unable to help with our evaluation and another withdrew before the interview took place. Positive responses to our requests for interviews were relatively few (11 out of 39, i.e. 28%). We also began the process of talking to employers from within each of the sectors associated with these SSCs. Throughout the stage we continued to meet with QCDA and other stakeholders, and worked with the recently appointed evaluators of the GCSE linked pair pilot.

The scrutiny strand focussed on the assessment of algebra and, importantly, was targeted on the actual work produced by a sample of students from June 2009. The completed scripts of two hundred students entered for both pilot GCSEs in Mathematics and *Additional* Mathematics, divided between grades A and C, were analysed.

Stage 8 (May – December 2010)

The final case study visits to the centres were completed during this period. The Use of Mathematics survey data was analysed and the GCSE survey was conducted, analysed and reports for both surveys were communicated to QCDA during the autumn of 2010.

Interviews with key figures at the Awarding Bodies (AQA and OCR) and the Pathways Phase One teams took place during October and November. The Evaluators presented a symposium at the BERA annual conference (Warwick, Sept 2010): "GCSE Mathematics in transition: student performance, progression and the politics of change"; and also contributed to a meeting at the Nuffield Foundation in November. Other activities that had been planned could not go ahead due to the six month delay in securing DfE permission for the availability of the full Stage 7 report.

Team structure

There have been some changes in staff during 2007- 2010 and the following table includes all staff that have worked on the project during the period.

Table 1: EMP Team Structure

Project directors	Professor Roger Murphy* and Dr Andrew Noyes*			
Project Management	Tracy Sisson* (2007-2009) Richard Adams* (2009-2010)			
Project sub-teams	CDELL	Manchester Mathematics team	Nottingham Mathematics Team	Sussex Mathematics Team
Team members	Professor David Greatbatch Peter Burke Dr Carole Mallia John Wilmut Gavin Reynaud John Winkley	Geoff Wake* Anne Haworth Cliff Parry Lawrence Wo Dr Maria Pampaka	Dr Andy Noyes Professor Malcolm Swan Mark Simmons Dr Ian Jones Dr Alison Kington	Dr Pat Drake* Clare Tikly Karen Gladwin
Administration			Frances Baum Sue Davis Jo Deeley Denise Woods	Catherine Holley Imogen Reid Yugin Teo
External auditor	Professor Gordon Stobart, Institute of Education			

* Management Group members

Centres visited

The following table summarises the extent of the case study work over the past three years:

Table 2: Summary of case study pilot centres

OCR Centres	GCSE	GCE		TOTAL
11-16	13	0		13
through-16	24	4		28
post-16	1	0		1
TOTAL	**38**	**4**		**42**
AQA Centres	**GCSE**	**GCE**	**FSMQ/UoM**	**TOTAL**
11-16	16	0	0	16
through-16	21	13	8	42
post-16	3	2	17	22
TOTAL	**40**	**15**	**25**	**80**

Scrutiny of mathematics assessments 2008-2009

The table below summarises the number of papers that have been scrutinised from the summer examination series in 2008 and 2009. More details of this work can be found in the appendices of Stage reports 3 to 6.

Table 3: Summary of assessment scrutiny in 2008 and 2009

	2008		2009		Totals	
level	**Papers**	**Items**	**Papers**	**Items**	**Papers**	**Items**
1	18	281	14	218	32	499
2	23	366	16	223	39	589
3	15	139	8	45	23	184
Total	56	786	38	486	94	1272

In Appendix D this table is broken down to include all of the papers scrutinised

Key findings and recommendations

A detailed breakdown of the EMP recommendations by each stage can be found in Appendix C. Here we summarise the main recommendations from the EMP Project under the four main areas of concern set out in the original contract:

- Meeting students' needs
- Providing pathways and progression
- Assessment
- Manageability of implementation

Over the time of the evaluation the mathematics education landscape has shifted considerably. Critical incidents have changed the course of the Mathematics Pathways Project and therefore of the evaluation. We have discussed these in more depth in section 2 and feel that it is instructive to retain some of the history of the project's development. In the next part of this section we review the key findings and/or recommendations from each Stage report in an effort to show which of these were temporary issues and which represent more sustained change or obstacles to success. This is an activity that we began in the Appendix of the Stage 5 report and now complete here for the whole project. As well as discussing our recommendations we will identify the positive impacts of the pathways project when we look in more depth at the four areas listed above.

Meeting students' needs

Although much of what was planned in the Phase I models will not be implemented there are a number of successes in the Pathways Project. We have noted above how the GCSE *Additional* Mathematics has maintained its popularity throughout the pilot period and how centres have, over time, come to understand how this qualification might enrich the learning experiences of students. Although this qualification is not continuing post-pilot the approaches to assessing problem solving have been a useful preparation for the new GCSE 2010.

The Use of Mathematics qualifications at all levels have been the major new addition to the qualification framework for 14-19 mathematics, although the GCE qualification remains in pilot mode. At all levels teachers and students remain enthusiastic about their experiences of these new mathematics pathways. We have noted throughout the evaluation that the GCE Use of Mathematics offers a genuinely new Level 3 mathematics experience with potential to both widen and increase participation in post-GCSE mathematical study. It is clear that students welcome a choice of A level mathematics pathways. This is particularly so for those who would not have followed the traditional GCE route and who are not focused on STEM study in higher education.

Providing pathways and progression

In all of our early reports we expressed concern that there was no clear vision for the development of mathematics learning pathways and the focus on assessments, although necessary, was insufficient in trying to develop *"a highly flexible set of interlinking pathways that provide motivation, challenge and worthwhile attainment across the whole spectrum of abilities and motivations"* (Smith 2004, p. 8). This issue is particularly acute when thinking of the tens of thousands of students who move school at age 16. Our surveys in this report highlight how the experience of learners in some 11-16 schools

can put them at a disadvantage as there is often less of a long term perspective on learner progression and participation.

The problem of transition at 16 has been exacerbated by the existence in the past of only one option for post-16 mathematical study at Level 3: GCE Mathematics. In addition, for those students who did not achieve a GCSE grade C they have faced the prospect of retaking the same GCSE qualification again, and again, until they make the grade. Students achieving a grade GCSE C or B often found themselves shut out of GCE mathematics by colleges recruiting the 'clever core' (Matthews and Pepper, 2007) and so had no option for further mathematical study.

The welcome addition of the Use of Mathematics in the pilots has given schools and colleges genuinely new pathways for supporting learner progression. During the Pathways Project opposition to this qualification at GCE level has arisen and we have sought to address the concerns expressed by various stakeholders in earlier reports (See Stage 6). There is no evidence at this stage to fuel elitist concerns about a swing away from traditional mathematics to Use of Mathematics, particularly for the 'clever core' who will supply the old universities with STEM undergraduates.

The Use of Mathematics qualifications also appear to offer a means of reinvigorating mathematics pedagogy which helps to motivate and engage learners of mathematics and in some instances their teachers.

Assessment

We have spent considerable time evaluating the pilot qualifications' assessment. To do so we developed an analytical tool that gives an overview of the balance of the assessment across a number of important domains: structure (the extent of scaffolding), content, process skills, context, complexity, familiarity, use of technology, barriers (due to ethnicity, language etc.). Although our framework potentially allows us to capture the full richness of mathematical activity that students might be engaged with we have established in fact that almost all timed-written assessment at all levels is narrowly conceived. In almost all cases it provides highly structured assessment items that require recall and application of standard procedures. In many cases this activity is in the domain of mathematics itself, although functional and Use of Mathematics items can provide an alternative to this.

Our scrutiny has tracked the slow shift in GCSE examinations and has exposed the discontinuities between various components of 14-19 pathways. This highlights a) how assessment development requires both time and careful nurturing and b) the considerable differences in requirements between GCSE and GCE. This has been confirmed by our more recent exploration of the performance of GCSE higher tier students in Algebra. Our analysis adds much texture to our understanding of this problem and suggests that mark schemes do not always reward students who demonstrate the greatest mathematical potential. Although this probably has little impact on outcomes for individual students it can signal priorities that might not be beneficial to the promotion of teaching for algebraic competence. Of particular concern is the extent to which numerical methods are used in place of algebraic techniques at GCSE and how these can lead to candidates being rewarded full marks on "algebra items" without demonstrating any algebraic facility.

The evaluation scrutiny suggests that there is a need for ongoing analysis of assessment in mathematics that takes a broader view about the relationship between assessment,

curriculum and pedagogy. This needs to inform assessment writers to ensure that assessment does not become ossified and narrowly focussed.

Manageability of implementation

The only qualification that might be implemented as piloted is the Use of Mathematics GCE but this will not be in the immediate future – the pilot has been expanded and extended. Although there will be a level 1/2 Certificate in Use of Mathematics this is more than just a change of name when compared with the pilot GCSE Use of Mathematics. The GCSE consisted of three standalone qualifications: two FSMQs and functional mathematics. The certificate continues to use FSMQs but now has a bespoke core unit. We have made many recommendations regarding what needs to be done to improve the likelihood of any national roll out being successful (see above). The Nuffield Foundation has taken a keen interest in the challenges of supporting the implementation of the GCE qualification nationally. However, if these qualifications are to offer new curriculum pathways for substantial numbers of students the scale of this work should not be underestimated.

4. Outcomes from Stage 8

During this final stage of the EMP project we have undertaken two major surveys and completed the final case study visits. In addition we completed a small number of further interviews with representatives linked to each of the Sector Skills Councils that we talked to during Stages 6 and 7.

In this section we report on each of these areas of activity and further details of the surveys can be found in the Appendices.

GCSE survey (see Appendix A)

The following summary is from an on-line survey of schools that enter students for GCSE mathematics. It was undertaken in the second half of the summer term 2010, just prior to the introduction of the new GCSE in mathematics. The survey was publicised widely through various channels including the awarding bodies, the National Strategies (secondary), the National Centre for Excellence in Teaching Mathematics, the Association of Teachers of Mathematics and the Mathematical Association, Mathematics in Education and Industry, the Specialist Schools and Academies Trust and the National Association of Mathematics Advisors. In addition, advanced warning of the survey was given at the British Congress of Mathematical Education, which took place at Easter 2010. Responses to the survey totalled to a little over 10% of examination centres. However, this resulted in responses from 368 schools which is a large enough sample for us to be able to make some generalisations.

The sample

The majority of the responses (N=271, 74%) were from the head of mathematics department, but there were also responses from other members of the school staff. The most frequent respondents in these cases are mathematic teachers or lecturers, assistant head teachers, Key Stage 4 (mathematics) coordinators/leaders and seconds in department. We discuss the representativeness of the sample in the Appendix A1 and conclude that there is reasonable evidence to indicate that the sample is representative, based on our estimates of student populations constructed from survey responses. It is estimated that around 61% of the students in the sample schools obtained C or above in Mathematics in 2009, compared with an official figure of just below 62% in the total population. However, given that the data in this report is informed by heads of department (i.e. school level) whereas national statistics are more often at student level it is not easy to make clear statistical comparisons.

The majority of schools (66%) in the sample identify themselves as 'through 16' covering ages 11-18, 14-19 or 13-18. 30% of the schools are for ages of students 'up to 16', and only a small number (N=15, 4%) describe themselves as 'post 16 schools'. The majority of responses (80%) come from state funded schools, 13% from independent schools and 7% from other types. The majority of responses come from mixed schools (82%). The sample includes more girls' schools (46) than boys' schools (20). 148 schools (40%) reported that more than 70% of their students attained A* to C Mathematics grades in 2009. 114 (31%) reported percentages between 51 and 70%, 66

(18%) between 30 to 50 % and 40 schools (11%) less than 30%[3]. The mean number of students sitting GCSE in the schools for this sample is 172 (s.d.=134).

GCSE entry in mathematics

Respondents were asked to indicate which awarding bodies and what specification (modular or linear) they had used during the academic year 2009-10. There were many more responses to the survey from Edexcel centres than from centres using other awarding bodies, due in large part to the ways in which the awarding bodies advertised the survey to their centres but also as a result of their market share. Edexcel centres were about twice as likely to be using the linear specification as a modular one whereas for AQA the modular specification is far more popular in this sample of schools. This distinction reflects the different nature of the modular specifications offered by awarding bodies. Respondents to our evaluation have expressed particular concern about the loss of the OCR's modular (graded assessment) GCSE specification in the latest changes to GCSE. The particular concern is the loss of the graduated assessment scheme which provides stretch and challenge for the highest attainers.

The majority of schools reported that all of their students first completed a GCSE mathematics qualification at the end of Y11. The distribution of responses for early entry seems to differ depending on students' level of attainment. Nearly 20% of high attaining students have completed their GCSE by the end of year 10 and a third of higher and middle attaining student have completed their GCSE mathematics before the normal examination period at the end of year 11. It should be noted that these data are for students who were completing their compulsory schooling in 2010. That was the final cohort to have completed National Curriculum Tests in year 9 and our evidence suggests that the removal of those tests encouraged many more schools to consider early entry. So we would imagine the figure for the 2011 year 11 cohort will be higher still.

Respondents were asked to indicate 'what proportion of your current Year 11 cohort who first completed a GCSE in mathematics before the end of Y11 will have retaken GCSE by the end of Year 11?' For students obtaining A*-B and E-G, nearly one half of schools (49% and 43% respectively) report that none of their early entered students will have retaken that GCSE by the end of year 11, whereas 42% of schools report that more than 30% of their middle attaining students (C/D) will have retaken. It appears that the emphasis on retaking is more at the C/D borderline and this corroborates our wider evaluation findings and the concerns expressed across the mathematics education community.

Students who achieve GCSE grades A and B before Y11 are more likely to continue with more mathematics at a higher level. For students achieving a grade C early what they do next is fairly evenly distributed across: 'no mathematics', 'the same mathematics', 'more mathematics at a similar level' or 'more mathematics at a higher level'. In contrast, students who achieve grades D and E are more likely to do the 'same mathematics' or 'more mathematics at a similar level'.

Of the sample, 94 schools gave explanatory comments regarding their early entry policy. From these responses two opposing trends were identified. On the one hand, there are

[3] DfE data for 2008/9 indicates that the percentages of maintained schools whose students achieved five or more A*-C grade including English and mathematics in these bands (<30%, 30-50%. 50-70%, >70%) were 12.4%, 61.8%, 53.3% and 22.8% respectively. Although these figures are not directly comparable with performance in mathematics it would suggest that we have more responses from higher attaining schools.

some schools reporting positive experiences, particularly for high attainers, because it allows students greater flexibility and can be a good motivator. On the other hand, some schools are against early entry because of increased teacher workload, timetable restrictions, no improvement in results and decreased student motivation and engagement.

Introduction of strategies for Key Stage 4

Schools were asked to report whether they had recently introduced any of three strategies for students at Key Stage 4. The least frequently reported strategy is 'increased curriculum time for mathematics' which was introduced by 72 schools. The other two strategies ('Other time/support for mathematics' and 'target staffing to support C/D borderline students') have been introduced by about two thirds of the schools in the sample (N=227). Schools tended to have adopted either a combination of these strategies or none of them. These responses differed by school type:

- 'up to 16' schools (typically 11-16) are more likely to adopt early entry in order to increase attainment.
- State schools in the sample adopt early entry strategies more often than independent schools.
- Co-educational schools use early entry strategies more frequently than single sex schools (although this might be associated more with attainment than school type).
- Girls' schools are more likely to provide additional curriculum time to support early entry than boys or co-educational schools.
- Schools that typically have between 30 to 70% students gaining A* to C grades in GCSE mathematics make more use of early entry strategies than schools with more extreme mathematical attainment. This makes sense given that their average attainment is closer to that all important grade C boundary.

Two tier GCSE mathematics

In order to check for possible increase or decrease in the number of students being entered at Higher tier, schools were asked to indicate the approximate proportion of GCSE students in each Year 11 cohort who were entered at Higher tier in the last three years. Data from the two piloting awarding bodies, triangulated by our case study evidence, showed that between 2008 and 2009 there had been a significant move to enter a greater proportion of the cohort at foundation tier (Edexcel did not have quite the same shift in entry patterns). The data from the survey were not conclusive (approximately 40% entered at higher tier) but if anything they suggest that this trend towards foundation tier has not continued and may have stabilised or even swung back as centres have become more confident about judging the overlap between the two tiers. Awarding body data supports this claim although complex patterns of early entry and retaking make it difficult to see clearly what is happening. For example, it is perhaps that case that if increased numbers of students are entered early at foundation tier, even if they might be entered for higher tier at a later date, this would bias the entry figures towards foundation.

Attitudes towards two tier GCSE mathematics

Centres were asked to compare the two and three tier versions of GCSE mathematics. About 42% of the sample agreed ('strongly agree' or 'agree') with the statement that 'The new two-tier GCSE arrangement is an improvement on the old three-tier

arrangement' whilst 39.5% disagrees, and 17.5% are unsure. Of the 167 school representatives who agreed or strongly agreed that two tier was an improvement over three tier, 15 commented particularly around the increased motivation of lower attainers. In contrast of the 144 who were against two tier, 95 respondents cited reasons including:

- reduced challenge for highest attainers and possible impact on progression;
- difficulties of curriculum coverage, entry decisions and motivation for students likely to get grade B/C.

There are longstanding concerns around the algebra skills developed in school (Sutherland, 1999; Noyes, Murphy et al., 2008; for example Hodgen, Küchemann et al., 2010; Noyes, Wake et al., 2010). A majority of the sample (57%) disagreed with the statement that 'All Higher tier students should be taught the A / A* material'. This is a serious issue for progression if it cannot be assumed that higher tier candidates have been exposed to the full GCSE curriculum. 50% of respondents agreed that 'High attaining students (A* - B) spend enough time studying algebra' but 39% disagreed with this statement. These responses suggest that these concerns are unlikely to dissipate in the near future.

On a more positive note, and in contrast with our findings in the summer of 2009 (Noyes, Wake et al., 2009), 75% of the sample agreed that 'Being able to achieve a grade C at foundation tier has increased the motivation of lower attaining students'.

The majority of respondents agreed with the statement that 'Borderline C/D students should be entered at Foundation tier' (55%) and 40% agreed that 'Borderline C/D students should be entered early so they have opportunities for resitting' (40%).

GCSE 2010

All but two of the respondents were aware of the new GCSE for mathematics starting in September 2010 and 95% think that they know what the main changes are. Around 16% of the centres had, at the time of completing the survey, not done any planning for the new GCSE. Finally, nearly 30% of respondents were not aware of the linked pair pilot that is also due to start in September 2010.

Use of Mathematics survey (see Appendix B)

The survey was conducted in the spring/summer of 2010 and was targeted at all of the students participating in the pilot of the AS/2 Use of Mathematics qualifications. Using entry data provided by AQA we sent surveys to 37 centres and received responses from 27 of these totalling 948 students. Official entry figures showed that 1448 students were entered for AS Use of Mathematics and 368 for A2 (1816 in total, about twice as many being male than female, at each level). The data reported here is from slightly over half (52%) of the whole entry cohort and 58% of the entry in the responding centres.

The sample

The results in this report are based on analysis of these 948 students. From this sample, 777 students (82%) reported that they have moved to a different school/college since completing their GCSEs. Overall, the majority of students (N=610, 65.5%) come from a school described as 'up to 16', and a minority (N=49, 5.3%) had transferred from a

'from 16' institution. The rest of the students (N=273, 29.3%) come from 'through 16' schools. Three analytic categories were created for analysis: Year 12-AS (N=571), Year 13-AS (N=92) and Year 13-A2 (N=217).

The gender split of the sample is in favour of male students with 66.4% (N=570) compared to 289 female. This is very similar to the figure for the official entry figures from AQA (66.5% being male). The sample is 79% White British, 12% Asian and 9% Other (mixed) background.

Concerning students' previous attainment in core subjects, the percentages of students with A and A* are very similar in the three core subjects. However, more than 50% of students achieved a B in GCSE mathematics compared to considerably lower percentages in science (39%) and English (32.7%). This suggests that this is a group of students for whom GCSE mathematics was probably one of their better results.

Reasons for choosing Use of Mathematics

Students' qualitative statements on the open question exploring why they decided to study Use of Mathematics were classified into eight categories: 1) prior attainment, 2) advice/direction, 3) positive disposition, 4) easier than…, 5) negative towards traditional mathematics, 6) use value/applications, 6) future needs, and 8) exchange value [see Appendix B section 1.2]

The most common reason was 'positive disposition', with more than 25% of the students reporting this as the reason for their choice. The second most common reason was 'use value/applications'. The remaining reasons occur with similar popularity (around 10%), with the exception of the 'easier than… (other subjects)' reason which was reported by approximately 5% of the students. This is important given recently expressed concerns (Educators for Reform, 2010) that centres might abandon mathematics for Use of Mathematics. However, as shown below, this 'easier than' reason might be only relevant to those for whom an A level in Mathematics is a possibility, i.e. higher attaining GCSE students who are more actively recruited to A level Mathematics.

There are some striking gender differences in students' reasoning: 'positive disposition' is much more popular for the female group, whereas reasons like 'exchange value', 'use value/applications' and 'prior attainment' are more popular for male students[4]. These reasons are differentiated by prior GCSE mathematics attainment. For students with GCSE grade A 'negative attitudes towards traditional mathematics' and the 'use value/applications' aspect of Use of Mathematics are the main reasons for their choices (these were also reported by them comparatively more frequently than by students with lower grades)[5]. For students with grades B and C the most popular reasons are 'positive dispositions towards mathematics' and 'use value/applications'. As expected, students with lower GCSE grades tend to report 'prior attainment' with higher frequency due to strict entry requirements for traditional mathematics.

Reasons for choosing Use of Mathematics instead of traditional mathematics

Students' qualitative responses to the question about their reasons for choosing Use of Mathematics rather than traditional mathematics were classified using six categories: 1) difficulty, 2) self efficacy, 3) advice/direction/forced, 4) tried AS traditional and it was

[4] Pearson chi-squared=13.826, df=7, p= 0.072

[5] Pearson chi-squared=89.505, df=21, p= <0.001

too hard or failed, 5) use value/applications/interesting, and 6) easier to get grade (on Use of Mathematics).

The most frequent reason for the Y12-AS and Y13-A2 groups was 'directed/advised/forced' and then 'difficulty'. 'Use value/applications/interesting' came next in popularity for both groups, followed by 'tried and failed/too hard'. This last reason is the most popular among the Y13-AS students, followed by 'difficulty'. Given the responses above it is not easy to see from this data the extent to which students perceive Use of Mathematics to be an easier option than traditional A level mathematics

Male students reported that they were 'directed/advised/forced' to the Use of Mathematics course in much higher frequencies than female students. In contrast, 'difficulty' was a more popular reason among female students (Figure 10).

There were some differences based on prior GCSE mathematics attainment. Perceived 'difficulty' is reported more frequently among students with high grades (31.7% of students with an A grade compared to 12% of students with a C). For students with lower GCSE grades, 'directed/advised/forced' was more popular, reaching a very high 70.6% among the students with grade C. In contrast, 'tried and failed' and 'use value…' were more popular amongst students with higher grades (Figure 11). It is not unexpected that lower attaining students would be directed into Use of Mathematics given what we know about the 'clever core' at A level (Matthews and Pepper, 2007).

Advice

According to respondents, the most helpful advice comes from teachers when they register for Y12 and then from school or college at open days. Interestingly advice from family is also considered helpful (by about 40% of the students) but it is unclear as to whether this is regarding mathematics generally, Use of Mathematics specifically or course choices more broadly. The advice from GCSE teachers, careers advisors and websites were rated as overall less helpful.

There was some minor gender difference in perception of the advice received. Female students rated slightly more positively advice from school/college at open day, advice from GCSE teachers and advice from family, compared to male students. In contrast male students were more positive about the advice they got from career advisors. White British students gave the lowest rating to the advice they got from their GCSE teachers compared to students from other ethnic groups.

The quality of advice was perceived differently in the various school types. Satisfaction with advice from GCSE teachers increased as the school type changed from 'up to 16' to 'through 16' and 'from 16'. The opposite trend appeared for advice from teachers when registering for Y12. Students from 'from 16' schools rated more positively advice from family, careers advisors and from websites. This is striking and reinforces the need for an effective communications strategy for 11-16 schools, particularly given the concerns raised in the EMP reports regarding the disparities in student experience between 11-16 and through-16 schools.

Of the students who moved school 48% reported that they received 'no' advice from their GCSE teachers. In comparison, the majority of students who did not move schools rated the advice they received as 'helpful'.

Students' experience with Use of Mathematics:

Use of Mathematics allows students to study two FSMQs during the AS phase of their studies. The most frequently selected FSMQ choices in our sample are Decision Mathematics, Data Analysis and, to a lesser extent, Personal Finance (official data shows that 75%, 96%, 18% of AS student entered these units in 2010). Female students in our sample show preference for Hypothesis Testing (9994) compared with male students who are slightly more in favour of Dynamics and Personal Finance (Figure 16). This matches official cohort figures from AQA. Asian students in the sample appear to prefer Data Analysis less than White British and students of other ethnic backgrounds; the opposite pattern appears for Decision Mathematics (Figure 17).

Students report scoring higher grades at Data Analysis and Decision Mathematics (based on the cumulative percentages of A and B grades). Personal Finance seems to be the most difficult unit with very low percentages of A and B grades and one third of the students failing (Figure 18).

Using students' reported grades we see that, based on the cumulative percentages of A and B grades, overall, male students score more highly in all units. The biggest difference appears to be for Data Analysis. C and D grades are more uniformly distributed among gender groups (with some exceptions). Excluding Dynamics, which has very low frequencies of known grades, it can also be said that the failure rates are similar for male and female students.

The most enjoyable subject based on top rating (5) was Decision Mathematics, and according to the combined percentages of top ratings (4 and 5) Dynamics and Personal Finance were equally enjoyable. Hypothesis Testing appears to be the least popular unit, with the compulsory core unit of USE1-Algebra also not scoring very highly (less than 40% of the students rated it 4 or 5 on the enjoyability scale).

Students considered the most useful subjects, according to the combined percentages of top ratings (4 and 5), to be Personal Finance and Dynamics. Decision Mathematics was considered to be the least useful in students' opinion, with the compulsory core unit of USE1-Algebra also not scoring very highly (only 40% of the students rated it with 4 or 5 in the usefulness scale).

The 'choice' of units available to students is dependent upon the limited options available to students within each centre. It appears that a lot of centres (19) offer only two options to students and these are usually a combination of Data Analysis, Decision Mathematics and Personal Finance (with the first two pairing as the most frequent). This has important implications for developing new Use of Mathematics pathways that cater for the varied mathematics needs of a range of level 3 learners.

Even though the majority (57.2%) reported their perception that Use of Mathematics is easier than GCE mathematics, there is still a very high proportion (35%) who reported that they don't know about the relative difficulty of mathematics and Use of Mathematics.

Future aspirations

The most frequent response to the question 'How likely do you think it is that you will continue to A2 Use of Mathematics?' was 'Likely' (32%) with 'Certain' (24%) coming second.

From the 218 students who reported studying A2 Use of Mathematics, the majority (71%) reported that they plan to go to university. Students who applied to University were asked to list their institutions and courses (with five options). The most popular subjects amongst these students were social science subjects followed by subjects in the Arts and Humanities. Engineering and Life Sciences came next, followed by Computing and Physical Science subjects (Table 27).

The chosen institutions were also categorised based on the four university mission groups. Around two thirds of the course choices were at Million+ and University Alliance institutions, i.e. new universities. Thirty students (out of 176 respondents) reported some problems regarding Use of Mathematics and their applications to university and these were mostly applicants to STEM courses. From the qualitative statements of these students for whom issues have arisen it seems that many university admissions tutors are not aware of the Use of Mathematics qualification. However, anecdotal evidence from centres suggests that when admissions tutors find out more about the programme they are impressed by its content and usefulness.

Case studies

In this section we report on a final group of around 30 case study visits which sought to look back through the Pathways Project to see what had happened over the three years. These comments need to be considered alongside earlier findings from case studies. In the main they strengthen earlier findings, and add a few nuances regarding the ways that centres think that problem solving has been brought out in one of the models for GCSE *Additional* Mathematics. In any future pilots people should be mindful of possible divergences between 'keen' and 'disillusioned' pilot centres (often distinguished on the basis of results, but also related to high staff turnover) which have been apparent through the Pathways Project.

AS and A2 Use of Mathematics

Meeting Student Needs

A Level Use of Mathematics is meeting the needs of students who want to continue with mathematics beyond GCSE and do not have a high enough grade to be permitted to do A Level mathematics. In the past most students who have found the traditional AS course too demanding have stopped studying mathematics completely. There is some evidence that positive feedback received from other students is persuading these potential drop-outs to transfer to Use of Mathematics.

Pathways and progression

There seems to be general consensus from staff and students that Use of Mathematics level 3 meets the needs of students who cannot cope with traditional A Level mathematics but either want or need some kind of mathematics course and qualification. This provides a pathway and combines well with other courses, including the engineering diploma. Use of Mathematics provides a means of enabling students, including those with Grade C GCSE to take mathematics further, e.g. potential primary teachers. However, the relationship between assessment and pedagogy has not yet settled with some unintended consequences, for instance, one centre has reported the perceived lack of basic skills in the students means that teaching has become more traditional over the pilot period, with basic skills being taught separately and not through working in context.

Assessment

Uncertainties have arisen in some centres from unexpectedly poor results, even though students enjoy the courses. There were issues regarding the lack of depth and clarity in the specification for some units and there are few resources published to support the specification. Data sheets distributed in advance were criticised in some cases as not bringing any benefit (c.f. also EMP Interim Report Stage 7). In other centres these were welcomed as a means of settling examination nerves, '*because there isn't that fear of the first question because they have an idea of what they're likely to see, so they're more likely to perform. You don't get that dip you sometimes get with maths exams.'*

Teachers respond differently to different modules because they are not perceived to be of comparable difficulty.

Manageability and Implementation

There needs to be better communication with universities to explain the skills, knowledge and understanding acquired through the Use of Mathematics course. If the A2 qualification is to be extended beyond the pilot phase centres think the following needs to be addressed and we have already made these points repeatedly in our earlier reports.

- Published resources to support most units need to be improved.
- The specifications in all units need to be comprehensive so that there is less room for ambiguity in interpretation.
- There is a need for training and support for centres that have not been involved in the pilot.

GCSE Mathematics and GCSE *Additional* Mathematics

Meeting Student Needs

Students' enjoyment of *Additional* Mathematics is mixed, and the differences between OCR and AQA's construction of GCSE *Additional* Mathematics partly explains some of these differences. The OCR version was one paper with eight or nine ramped questions, not tiered so that all candidates worked through all questions until they get stuck. AQA offered two tiers: Foundation and Higher, each with over 20 questions. The scrutiny of the OCR paper indicates that items require an atypically larger proportion of analytical reasoning than other level 2 examinations. This may of course be at the later stages of questions, which means that lower attaining students will not tackle them.

One centre told us about OCR *Additional* Mathematics: "*our A* kids love it cause it's making them think a little bit more, working their way around a problem. It's more of a paper for the maths/science students."*

Another OCR centre reported:

> *"There doesn't seem to be any pattern of which type of exam suits which children, there seems no logical connection so you can't really say it suits lower ability or girls rather than boys for example. However, because they train them to attempt every question until they get stuck, it improves their confidence (rather than being told they cannot attempt some questions like in the 'old' higher tier GCSE)."*
>
> *"We look for an ability to apply maths in unfamiliar situations and the OCR pilot GCSE is going in the right direction."*

Pathways and progression

Centres feel that students who have done GCSE A*dditional* Mathematics are better prepared for A level mathematics.

The GCSE *Additional* Mathematics pilot was generally seen as being introduced to 'stretch the top end'. One grammar school reports: "*The outcome in terms of performance has been a minor change, but, in terms of learning, the students have to be more versatile with additional mathematics. It is an all-boys' school and the learning advantages seem to be evenly spread across the attainment range".* The perception in

this case is that OCR *additional* mathematics is characterised by questions to which students can apply less formal methods, and make more use of problem-solving strategies, and more than one centre reported that this suits some of their lower-attaining students.

Assessment

Centres are divided about being involved in the GCSE *Additional* Mathematics pilot. Some report benefits in terms of improved grades and, as one told us "the league tables look great". Indirect benefits suggest possible boosting of A level numbers, including more girls. Being involved in the pilot, one department told us, also meant teachers became more aware of how functional skills was being developed in mathematics. Others (AQA) report that GCSE *Additional* mathematics has not worked so well at foundation tier students, as the students do not achieve in the exams and as a result lose motivation, although at higher tier things are much better, with questions challenging students and often generating interesting discussions in the classroom.

There is a clear sense from the pilot that GCSE *Additional* Mathematics has brought benefits to higher attaining students in terms of mathematical experience. One head of mathematics said: "*Although there is no longer GCSE coursework, investigative maths is still part of the schemes of work. The pilot GCSE2 [sic] exam has 'brought it out' and is 'nicer' in this respect."*

Manageability and Implementation

Differences have emerged between involved and disillusioned centres. One centre pulled out of the pilot because results did not improve. One centre was unaware of the linked pair pilot. The system is frail – key people leave and there is little institutional memory. During the pilot, centres have experienced staff changes with different opinions arriving with new staff. This means revisiting themes from earlier in the Pathways Project such as GCSE *Additional* Mathematics assessing the same content as GCSE mathemaitcs. The linked pair addresses this difficulty by having two distinct sets of content, albeit with a substantial overlap.

Other centres feel that the GCSE pilot experience has provided a good preparation for the introduction of the linked pair of GCSEs. Centres have looked at the specifications and are ready to work through sample papers. At the time (Spring 2010) centres foresaw the additional content being familiar topics from the past, and financial applications.

5.Concluding comments and further research

The Pathways Project has been a huge endeavour undertaken by a large and diverse collection of people, organisations and stakeholder groups. Despite disappointments concerning the limited success in transitions from pilot to full implementation there have been important lessons learned about the design, piloting and evaluation of changes in mathematics assessment and the associated support needed for teachers.

In the course of the evaluation we have needed to explore the broader context in which the pilots have been implemented. One of the challenges for policymakers is to understand how curriculum and assessment really work when they are implemented in schools. This requires us to develop complex understandings of the wider context of education, in particular the pressures and constraints that frame teachers' work and capacity to change. Three examples are:

1. The pressure on teachers to meet school targets which encourages them to behave in certain ways in terms of structuring curriculum, timing assessment and framing pedagogy. This includes the tendency to teach to the test, enter students early for qualifications and limit access to more difficult higher tier material. These conditions need to be understood in the planning phase of any new pilot.
2. The difficulties of designing coherent 14-19 curriculum pathways when students may leave, or arrive, at age 16 and when qualifications may have been taken at different times in this age range.
3. The inherent conservatism in the education system, particularly as one reaches the upper age range and when working in a strategically important subject like mathematics, the aims for which continue to be contested (Ernest, 1992; Ernest, 2004). We discuss this issue further below.

Of course these three issues are well known but they are systemic constraints that need very careful consideration in the design phase of a pilot project like Pathways. We have been able to draw on theoretical resources, for example Stephen Ball's (2003) well known critique of 'perfomativity' in education. Designing and understanding complex processes of educational changes, including pilots, needs to draw upon these policy literatures as well as the mathematics education research that we have utilised in various aspects of the work (e.g. that on quantitative literacy, assessment and problem solving approaches)

We make four major recommendations at the close of this project. These are areas that we feel would be worthy of serious consideration and further research:

Recommendation 1:

We strongly recommend that the Use of Mathematics qualifications be adopted post-pilot in order to create new learner pathways that will widen and increase participation and engagement in mathematics.

Given the current Nuffield Foundation study which highlights how poorly we fare in terms of post-16 participation in mathematics internationally, combined with the

inappropriateness of GCE mathematics for the vast majority of learners (Matthews and Pepper, 2007) this approach is necessary.

Recommendation 2:

There needs to be effective CPD for curriculum leaders on how to design learning pathways, relevant curricula and engaging pedagogy, using the available suite of mathematics qualifications. This should also take account of the various school structures as these have been found to make a difference to teachers' understanding of progression issues.

Leaving this to Awarding Bodies is not sufficient as they make different products available to their centres (e.g. Level 3 FSMQ Additional Mathematics (OCR), level 1 to 3 FSMQs (AQA), BTEC level 1 and 2 Mathematical Applications (Edexcel)). A more holistic, impartial set of guidance materials, including case studies already in existence, would be a useful resource here but meetings with teachers would be better still. Given the upheaval in the landscape of mathematics support for schools (e.g. loss of the National Strategies, QCDA, and local cut backs of advisory teachers) it is not clear who is best placed to develop and offer this CPD support.

Recommendation 3

High attaining students need to develop greater facility with algebra by age 16 and assessments should incentivise high quality teaching and learning in this critical area.

Given the central importance of algebra to GCE mathematics programmes and mathematically demanding programmes of higher education it is imperative that high attaining students develop greater algebraic facility by the age of 16. The GCSE A grade descriptor includes the following:

> "Candidates use a wide range of mathematical techniques, terminology, diagrams and symbols consistently, appropriately and accurately. Candidates are able to use different representations effectively and they recognise equivalent representations for example numerical, graphical and algebraic representations. Their numerical skills are sound, they use a calculator effectively and they demonstrate algebraic fluency. They use trigonometry and geometrical properties to solve problems." (Ofqual, 2009)

From our analysis of the complete GCSE assessments of one hundred students attaining grade A in the summer of 2009 we can state with some confidence that the typical student does not 'demonstrate algebraic fluency' at this level.

Given the value of this analysis in explaining what students actually know and can do and how their work gets rewarded in the assessment process we make the following fourth recommendation:

Recommendation 4

There should be further scrutiny of qualifications which combines analyses of assessment design with careful examination of students' responses. This would give a far better indication of the extent to which assessments are measuring what they purport to assess. In turn this would inform future assessment design thereby offering better means of impacting teaching and learning. This would be particularly relevant for the newly introduced problem solving questions at GCSE for example.

Scrutiny and tracking of assessment over time together with analysis of students' responses to assessment items (in GCSE algebra) suggest the need for ongoing analytic work of this type to be carried out. This could ensure that in future we are much better informed about the detail of how assessment interacts with students' experiences of mathematics and how we might improve teaching and learning by intervention in assessment.

Developing appropriate mathematics qualifications

Employer groups and prominent business representatives repeatedly raise concerns about the efficacy of school and university mathematics education. Despite this, GCSE mathematics remains a critical gatekeeper to future educational, employment and, therefore, life opportunities. GCE mathematics is often seen as signaling aptitude for particular ways of thinking rather than specific mathematical competence, and as a means to securing high earning potential (Wolf, 2002), although this latter claim is debatable. All of this helps to reinforce the idea that (success in) mathematics is for the minority (Mendick, 2008), i.e. the 'clever core' (Matthews and Pepper, 2007). Making 14-19 mathematical study attractive and worthwhile for all students is a peculiar challenge in a popular culture in which there is no shame in being innumerate (Gates, 2001).

The EMP data corroborates other research (Jackson, Goldthorpe et al., 2005) that points to the decreasing exchange value in the skilled labour market of qualifications for 16 year olds. It also reinforces earlier research on mathematics at work (Harris, 1991) that claimed workplace mathematics is different from school mathematics, being primarily and effectively learned in situ. Moreover, as suggested by the work of Celia Hoyles and her colleagues, school mathematics might not be the ideal preparation for the world of work anyway, a world which demands greater emphasis on techno-mathematical literacies (Hoyles, Noss et al., 2010). Issues around the role of GCSE mathematics will become more acute as the age for participation in compulsory education increases to 18 by 2015, leaving GCSE qualifications in a rather strange position as no longer being the final exit qualifications.

Making a successful transition to work is important. Being functional with mathematics (what the Americans call quantitative literacy) is an expectation made of many employees at all levels of operation. Efforts to foreground the development of functional mathematics in the school curriculum are therefore welcomed, even though there is still work to do to develop common understandings of what is meant by functionality. Faced with a climate of probable cuts in the funding of training at work (Wolf, Aspin et al.,

2010), and the apparent lack of confidence of employers in lower level school mathematics qualifications as certifying specific mathematical knowledge and skill, it will be important to develop functional mathematics at school that signals key competences, for example in mathematical problem solving. There is an outstanding need to communicate to employers what they can reasonably expect of new employees holding these school mathematics qualifications.

The challenges of curriculum change

It is not unexpected that large and complex education systems should react with inherent 'conservatism' in response to proposals for systemic change. Effecting change in relation to GCSE and AS/A2 was always going to be difficult. This is made even more challenging by the particular status of these qualifications as high stakes hurdles for both students and schools. Moreover, there is not a tradition of 'official' pathways in schools and colleges, due in large part to the historical structure of education in England with its leaving age at 16, marked by the GCSE qualification.

A strength of our system is, arguably, the diversity of possibilities and opportunities that the qualifications market-place provides. On the other hand, for some, this can present considerable challenges and lead to a lack of clear direction. For example, our case study work highlighted the variation in advice that young people might have available as they make crucial decisions at age 16. We found this in terms of the study of mathematics in particular but can generalise this to conclude that advice about transition at age 16 is variable. This suggests a need for more research on advice and choice at transition from compulsory schooling and how this affects students' choices and future participation or otherwise in education. Studies in mathematics explore some of these issues in relation to gender (Mendick, 2005) and social backgrounds more generally (Noyes, 2009). Related studies also explore the impact of schools upon choice to continue with mathematics (Noyes, 2009; Noyes and Sealey, 2010) and how the general attitudes to mathematics frame student choices (Brown, Brown et al., 2008; Hernandez-Martinez, Black et al., 2008). However, most of these studies are focused on choosing (or not choosing) A level mathematics or mathematically demanding higher education programmes. There is a need to expand this research base to consider other choices, including all mathematically related pathways and choices between mathematics and other courses of study.

The aforementioned conservatism acts at two levels: (i) at a structural level meaning that it is difficult to introduce new qualifications (consider for example, the opposition to change that surfaced in the 2009 consultation on changes to GCE mathematics) and (ii) within components of the existing structure meaning that innovation in existing qualifications is difficult to effect.

At a structural level we note the difficulties the new 'Use of Mathematics' qualifications has encountered. The piloted GCSE Use of Mathematics could not be implemented beyond the pilot as a GCSE as it did not comply with regulations that changed during the project. Such regulatory shifts will occasionally coincide with major, long term curriculum and assessment development projects like Pathways and every effort should be made to manage such risks so as to mitigate their effects. That said, the pilot has resulted in a successful case being made for the new AQA level 1/2 Certificate in Use of Mathematics. This situation means that establishing parity of esteem with GCSE is compromised from the outset, although this might have been the intention, i.e. not to

risk undermining the most important education 'gatekeeper' (Volmink, 1994), namely GCSE mathematics. It is certainly the case that mathematics qualifications in upper secondary school are quietly contested and political (Schoenfeld, 2004; Restivo and Sloan, 2007; Gutstein, 2009; Noyes, 2009) although here in England we have not gone as far as the 'maths wars' in the US.

The evaluation of both the assessment and teachers' responses to the piloted GCSE in Use of Mathematics suggests it forms a valuable and motivating experience for students with outcomes that match those of GCSE. Equally, we note the opposition to the GCE Use of Mathematics that surfaced in Summer 2009 and which we deconstructed in our Stage 6 Report. These responses of 'the system', including powerful stakeholder groups and individuals - those Ball and Exley (2010) describe as policy 'interlockers' - signal the hold that the mainstream GCSE and GCE have over innovation and change. These conservative reactions to proposed changes occurred even in a climate of development. They raise important issues that need to be considered in any future development work. How realistic is it to expect that structural changes be implemented in such a climate?

It might be argued that an alternative to changing structures is to work within those that currently exist. However, our evidence is that such changes are also difficult to achieve. For example, we draw attention to the lack of development at A Level. Perhaps most disappointing when we look back at the criteria that the Smith Inquiry laid down for pathways development is that in almost all respects expectations about new approaches to pedagogy and use of ICT have not materialised at GCE level. Our scrutiny of assessment and case study work in schools and colleges suggests that student experiences in studying towards mainstream qualifications are likely to be little different now from before the Pathways Project. In this case we reassert that the whole process of pathways development was too narrowly focused on assessment and qualifications and was not conceptualised broadly enough at the outset. Most certainly support for pedagogic development should have been built into the overall strategy.

These observations lead us to conclude that endeavours such as those undertaken by the pathways development projects are particularly complex and aim for change in a climate of conservatism. The importance of this conservatism needs to be recognised and valued from the outset. It is, after all, what ensures status and value for qualifications that are important as gateways and gatekeepers in our education system. Strategic planning for change needs to remain keenly aware of such issues, in addition to, for example, the performativity and structural constraints highlighted at the start of this section. In turn, this requires that any proposed change is informed by a wide range of background evidence drawing on a substantial research base. There is a wide range of appropriate research already available and underway, for example, in relation to the use of ICT in teaching and learning at A Level. Also the pathways developments were informed by well-recognised research teams in phase 1. It seems reasonable to suggest that the projects' implementation might have been more successful if greater attention to 'what we know' had been strategically built into the ongoing remit for Phase II. For this reason a strong case can be made for evaluators to be those with expertise not only in the effective management of research and evaluation methods but also those with comprehensive insights into the extant research literatures in areas broadly relevant to the field of study.

Reflections on the EMP project

The evaluation has faced a considerable number of challenges throughout the last three years, largely as a result of the ever changing political context. This has made it very difficult to ascertain the long term impact of any of the pilot qualifications. In spite of this we have been able to offer a critical review of the processes of piloting and the reports from the evaluation offer a comprehensive resource that explores a range of issues pertinent to the ongoing improvement of mathematics education in England.

Throughout the project we have engaged with a wide range of stakeholders and are grateful for the support of all concerned, from teachers who have taken the time to complete questionnaires or arrange case study visits, to organisations that have created the opportunities for us to consult them. Working across these levels has enabled us to connect three domains: classrooms/schools, awarding bodies and curriculum development/policymaking. The pilot awarding bodies and our contacts at QCDA have been both supportive and at times critical of our work which has served to improve the professional dialogue and enhance the contribution of the EMP project.

We conclude this project recognising that although there has been some important progress made in the last six years there remains a great deal to be done to improve the quality of mathematics education experienced by a very large number of 14-19 year olds. The underpinning problem which motivated the 2004 Smith Report (following Roberts, 2002) regarding the relatively low levels of participation in post-16 mathematics has not been ameliorated to bring us in line with international competitors. Indeed it would have been naive to think that there would be quick fixes to this issue; a problem which has been decades in the making arguably needs longer term planning than the political timescales of education permit. A longer term view of education planning, curriculum and assessment development is essential if substantial progress is to be made. It is not clear how this will happen with the forthcoming demise of QCDA but serious consideration needs to be given to the complex challenges of educational change, in particular ongoing improvements in 14-19 mathematics *engagement*, *attainment*, *progression* and *participation*; issues which readers of this report will no doubt all agree are of the utmost importance.

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Evaluating Mathematics Pathways

Final Report - Appendices

Appendix A: GCSE Survey Technical Report

List of Tables

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Part A: Characteristics of Participating Centres

The results presented in this report are based on 368 responses from centres. In Appendix I we briefly discuss the representativeness of the sample and conclude that there is reasonable evidence to say that the students represented by these schools are representative of the national cohort. There is a slight bias to responses from independent schools but this is not large. Our estimates of the proportion of students in these schools achieving A*-C in mathematics in our sample (61.4%) is very similar to the official figures for 2009 (61.7%)

A1. Who completed the survey?

Respondents to the survey were asked to report their role within the centre. There were two relevant questions for this purpose:

(1) Question 7: 'I am completing this questionnaire as the main representative of my school' (292 responded 'Yes', 75 responded 'No', 1 missing response)

(2) Question 8: 'I am…' (272 responded 'Head of Department', and 95 responded 'other')

Table 1: Role of respondent within School and Mathematics Department

Main representative of school?	I am…		
	Head of Department	Other	Total
Yes	239	53	292
No	32	42	74
Total	271	95	366

Even though the majority of the responses (N=271, 74%) are from the Head of the Mathematics department, there are responses from other members of staff, who aren't necessarily the main school representative. Table 2 summarises the other roles of the survey respondents.

Table 2: Other roles of survey respondents

	Main school representative (Frequency)	
Role	Yes	No
2IC/2nd in department	10	16
KS4 (Mathematics) Coordinator/Leader	14	
Assistant Head	7	4
Head teacher/ Principal	3	
Mathematics Teacher, Excellent teacher status, teacher in charge, Lecturer	9	9
GCSE coordinator	3	1
Was head of mathematics	2	1
Acting Head of Department	1	
Centre manager	1	
Teaching Assistant	1	
Assessment in mathematics	1	
Team/course leader, assistant for mathematics		3
Head of year/mathematics teacher		1
Total (missing)	53 (1)	42 (2)

The following section includes respondents' schools' demographic characteristics that could be used as explanatory variables in subsequent analysis.

A2. Description of participating schools

Respondents were asked to indicate the age range of students at their schools. Table 3 shows the distribution of their responses. The majority of schools (66%) are described as 'Through

16' which includes 11-18, 14-19 or 13-18. 30% of the schools are for age 'up to 16', and only a small number (N=15, 4%) are described as 'post 16 schools'.

Table 3: Distribution of participating schools by age range of their students

Age range of Students	Frequency	Percent	Cumulative Percent
Up to 16 (for example, 11 - 16, 12 - 16)	110	29.9	29.9
Through 16 (for example, 11 - 18, 14 - 19, 13 - 18)	243	66	95.9
From 16 (for example, 16 - 18)	15	4.1	100.0
Total	368	100	

The distribution of the schools according to their 'type' (State, independent sector, other) is presented in Table 4. The vast majority of schools (80%) are described as 'state'. The 26 schools which were described as 'other' gave the following descriptions for their 'type' (Table 5):

Table 4: Distribution of participating schools by 'type' of school

School Type	Frequency	Percent
State sector	296	80.4
Independent sector	46	12.5
Other (for example, PRU, Special, Academy)	26	7.1
Total	368	100

Table 5: Other 'types' of schools

Type	Frequency
PRU	8
Academy	4
FE College	2
Special Schools	2
State Sixth Form College	1
Private Business (international British school in Houston Texas)	1
Home and Hospital Teaching Service	1
Alternative provision for young people who are 14 to 16	1
Selective Grammar	1
Missing	5
Total	26

A cross-tabulation of school type with students' age range is presented in Table 6, and Figure 1 illustrates this classification.

Table 6: Cross-tabulation of School 'type' by students' age range

	School Type			
Students' age range	State Sector	Independent Sector	Other	Total
Up to 16	87	9	14	110
Through 16	198	36	9	243
From 16	11	1	3	15
Total	296	46	26	368

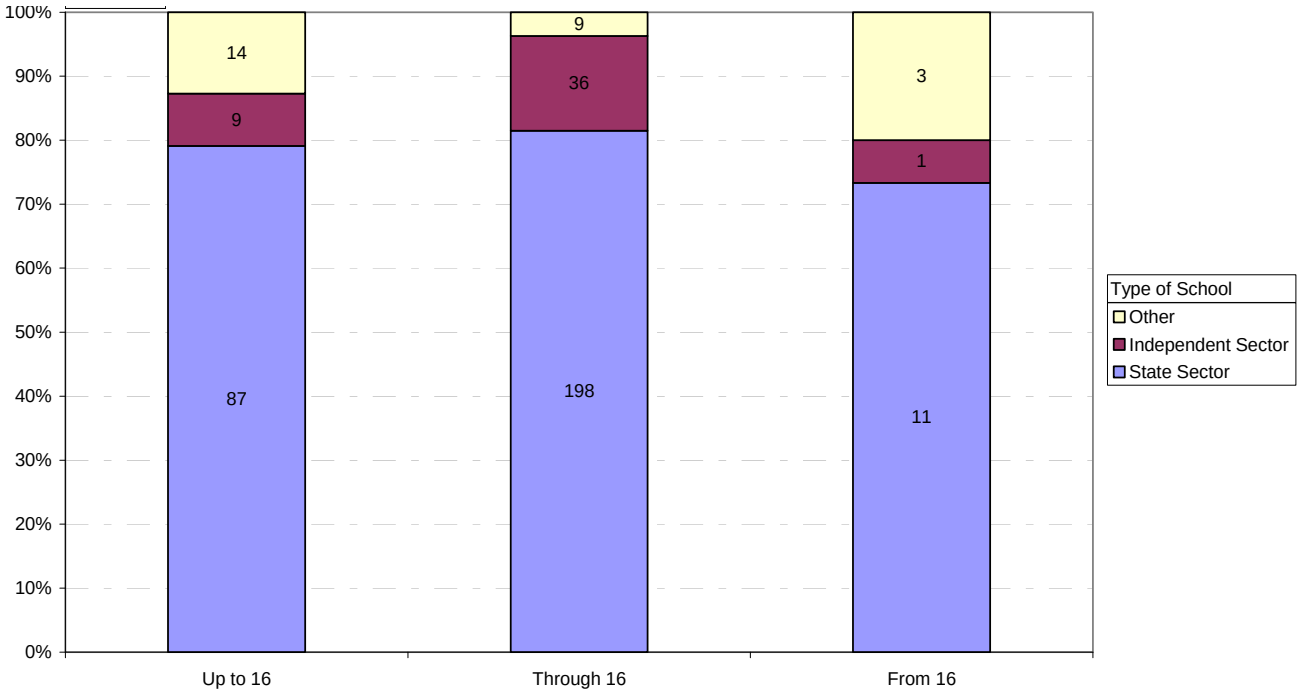


Figure 1: Type of School by students' age range

Respondents were also asked whether their school is co-educational or single sex (Question 3). As shown in Table 7, the majority of responses came from mixed schools (82%). The sample includes more girls' schools (46) than boys' schools (20).

Table 7: Distribution of participating schools by gender 'type'

Gender 'type' of school	Frequency	Percent
Co-educational (mixed)	302	82.1
Single sex – boys	20	5.4
Single sex – girls	46	12.5
Total	368	100

With Question 4, respondents were asked to report the percentage of students at their school who attained grades A* to C in mathematics in 2009. Table 8 shows the distribution of the sample responses, with the majority reporting that more than 70% of their students attained A* to C.

Table 8: Distribution of participating schools by percentage of students who attained grades A*-C in mathematics in 2009

Percentage of students who attained grades A*-C in mathematics in 2009	Frequency	Percent
Less than 30%	40	10.9
30% - 50%	66	17.9
51% - 70%	114	31.0
More than 70%	148	40.2
Total	368	100.0

Figure 2 shows how these percentages differ by 'type' of school.

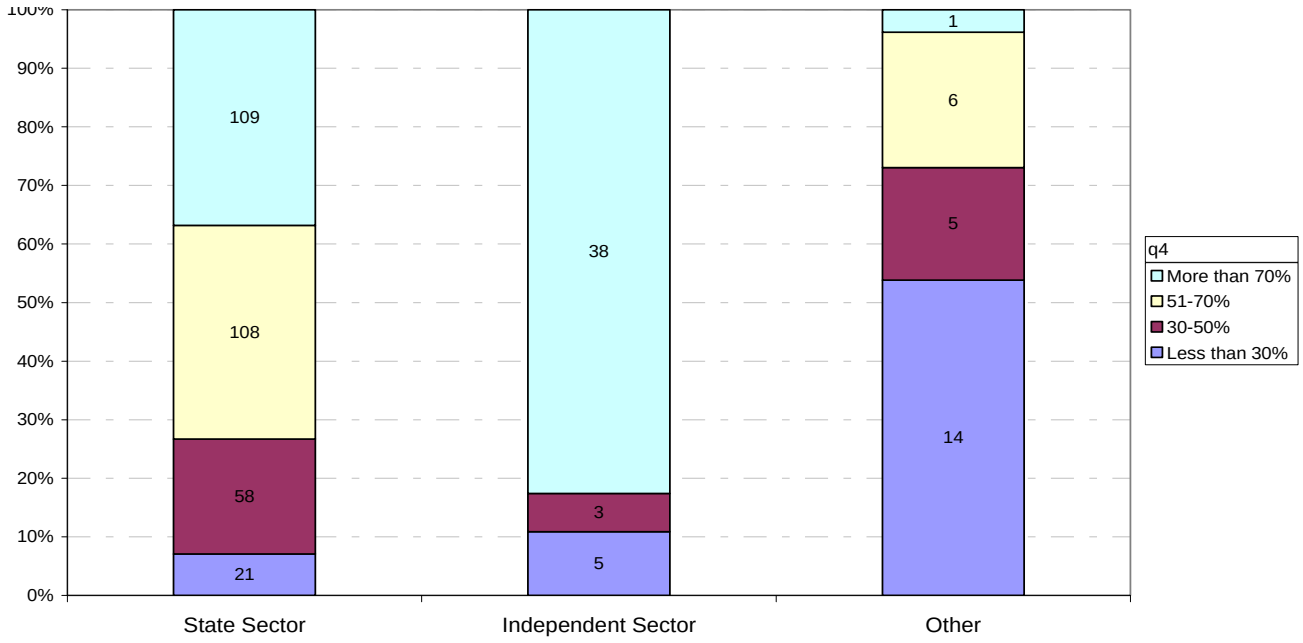


Figure 2: % of A*-C in GCSE mathematics by type of school

Schools in the 'independent sector' report better results in mathematics GCSE grades (the vast majority of them report that more than 70% of their students got A* to C grade). Schools in the state sector report equally, percentages more than 70% and between 50 and 70%. Schools described as 'other type' seem to have worse results in mathematics since the majority reported low percentages of A* to C grades The official figures for the percentages of students obtaining 5A*-C including English and mathematics show that maintained schools achieve slightly higher (50.7%) than independent school (48.4%) although there is such variation in each of these groups it is hard to use these figures to make comparisons. It does seem that the independent schools in the sample are generally higher attaining than typical independent schools.

Some differences are shown in Figure 3 regarding the school type as defined by their students' age range. Schools described as 'Through 16' appear to have better results in GCSE mathematics, followed by 'Up to 16' schools. Overall, the 'from 16' schools have the worst results (even though it should be noted that they comprise a very small part of the sample (15 out of 368)). This is to be expected as these centres are likely to consist largely of retaking GCSE students.

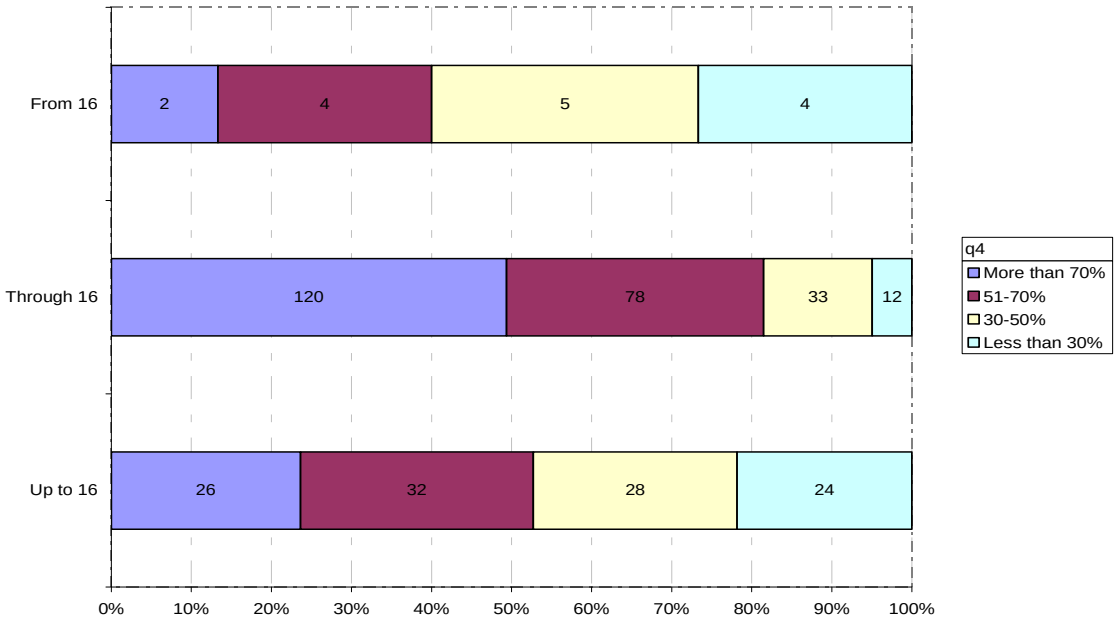


Figure 3: % of A*-C in Mathematics by centre 'type' (age range)

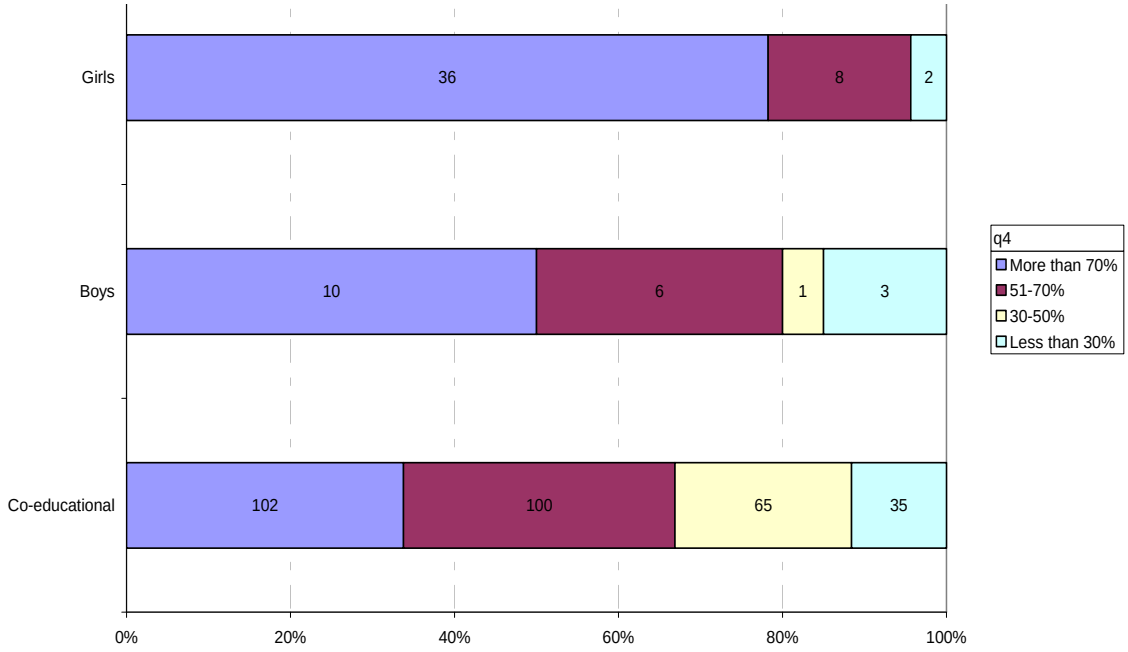


Figure 4: % of A*-C in Mathematics by 'type' of School (gender)

Figure 4 presents the differences in students' mathematical GCSE attainment in 2009, based on the schools 'gender' context. Co-educational schools reported lower attainment overall. From the single-sex schools, the vast majority of girls' schools reported over 70% of students achieved a grade between A* and C.

Part B: GCSE Entry in Mathematics

The number of students in the current Year 11 cohort (2009-10) varied considerably (Question 9). The mean number of students was 172 (with SD=134). The histogram in Figure 5 shows the distribution of these responses, which is roughly normal with some outliers, i.e. schools with more than 2000 students in their Y11 cohort.

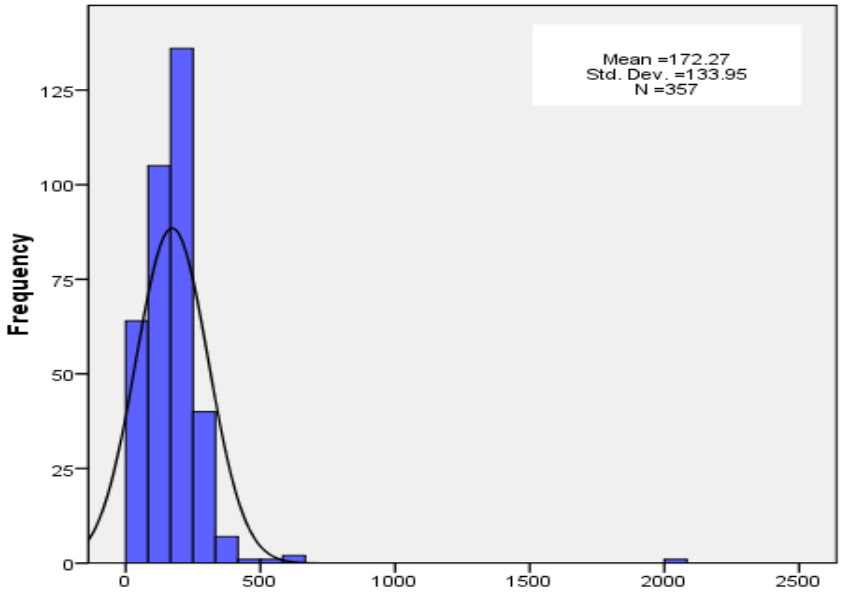


Figure 5: Histogram of the number of students in current Y11

B1. Awarding Bodies

Tables 9 and 10 show how respondents entered different students for different modes of GCSEs with different awarding bodies this academic year[6]. It can be seen that many more of the survey respondents were Edexcel centre. It is also notable that from responding AQA centres there are more using modular specifications than linear and this is the opposite way around for Edexcel. We divide the grade range between what we call high attainers (those expected to achieve to achieve A*-B), middle attainers (those around the C/D borderline) and low attainers (those not expected to get near grade C, i.e. grades E-G)

Table 9: Awarding bodies used for modular mathematics based on student attainment

	AQA	Edexcel	OCR	WJEC
High Attainers (GCSE A*-B)	55	82	19	0
Middle Attainers (GCSE C/D)	59	103	20	0
Low Attainers (GCSE E-G)	52	101	15	0

Table 10: Awarding bodies for linear mathematics based on student attainment

	AQA	Edexcel	OCR	WJEC
High Attainers (GCSE A*-B)	11	217	9	1
Middle Attainers (GCSE C/D)	19	209	21	1
Low Attainers (GCSE E-G)	16	163	12	2

[6] It should be noted that almost all centres use only one awarding body. The only exceptions were three schools for modular [one using both AQA and Edexcel for middle and low attainers, one using Edexcel and OCR for middle attainers and one using Edexcel and AQA for low attainers] and three different schools for linear [two using Edexcel and OCR for middle and low attainers and one using AQA and OCR for middle and low attainers]

B2. Timing for completion of GCSE for current Y11 cohort

The majority of schools reported that the students first completed a GCSE mathematics qualification at the end of Y11. The distribution of responses for earlier entry seems to differ depending on students' level of attainment. High attainers appear to have completed a GCSE during Y10 more frequently than middle and lower attainers. Middle attainers also appear to have completed a GCSE during Y11 more frequently than the higher and lower attainers. Figure 6 illustrates the distribution of 'timing' within each attainment level.

Table 11: Timing of first completion of a GCSE qualification by attainment

	Before Y10	During Y10	During Y11	At the end of Y11
High Attainers (GCSE A*-B) (N=344)	5	60	51	228
Middle Attainers (GCSE C/D) (N=327)	4	27	71	225
Low Attainers (GCSE E-G) (N=296)	3	32	36	225

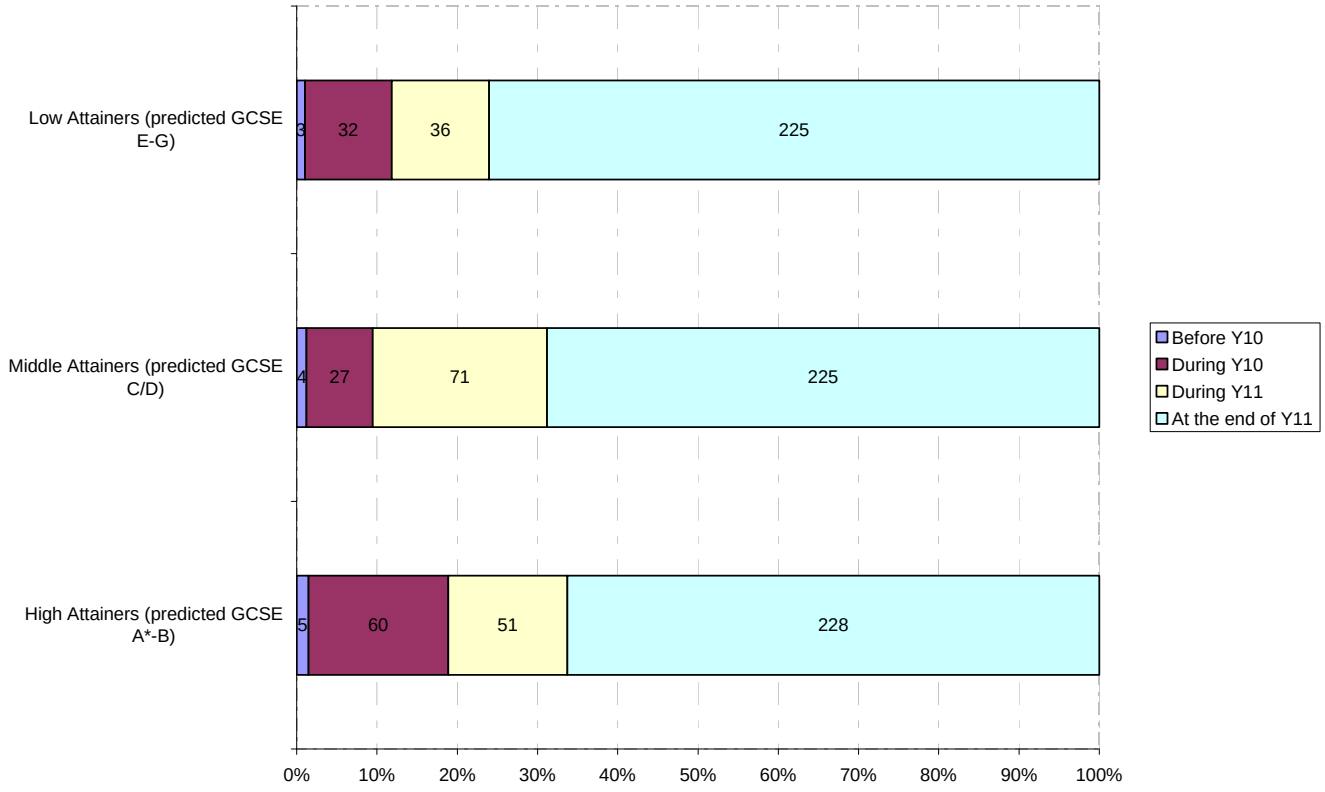
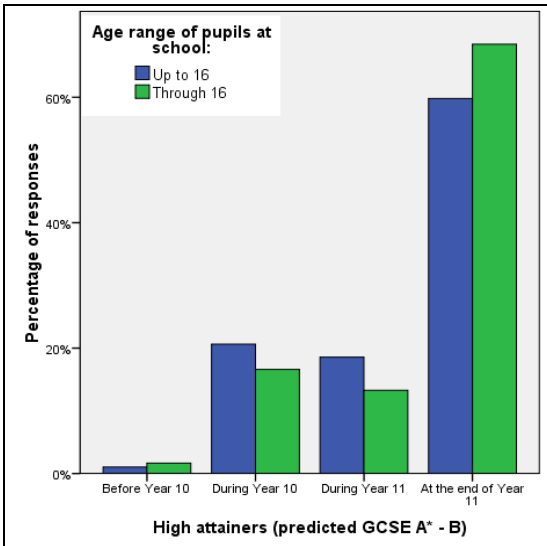
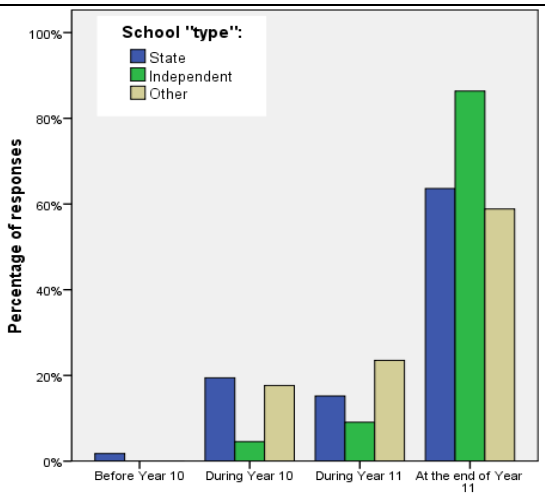


Figure 6: First completion of a GCSE qualification based on students' attainment

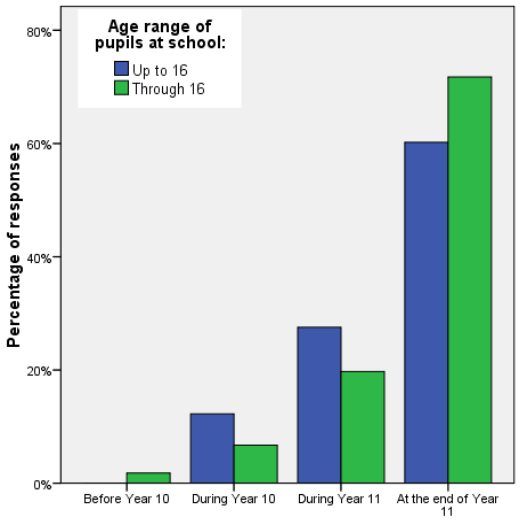
Nearly 20% of high attaining students have completed their GCSE by the end of year 10 and a third of higher and middle attaining student have completed their GCSE mathematics before the normal examination period at the end of year 11. It should be noted that these data are for students who were completing their compulsory schooling in 2010. That was the final cohort to have completed National Curriculum Tests in year 9 and our evidence suggests that the removal of those tests encouraged many more schools to consider early entry. So we would imagine the figure for the 2011 year 11 cohort to be higher still. Further analysis of first completion of a mathematics GCSE with respect to type of school can be seen in the charts of Figure 7. Figure 8 shows how first completion differs by the 'gender' type of school. Given that the middle and low attaining students first entry point are similarly distributed the early entry of high attaining boys (in boys' schools) is striking.



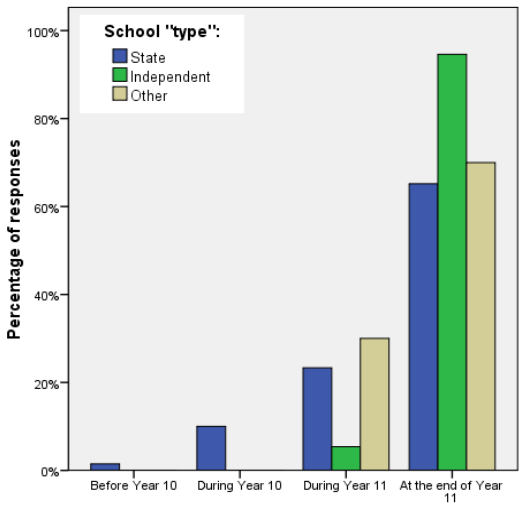
High attainers (predicted GCSE A* - B)



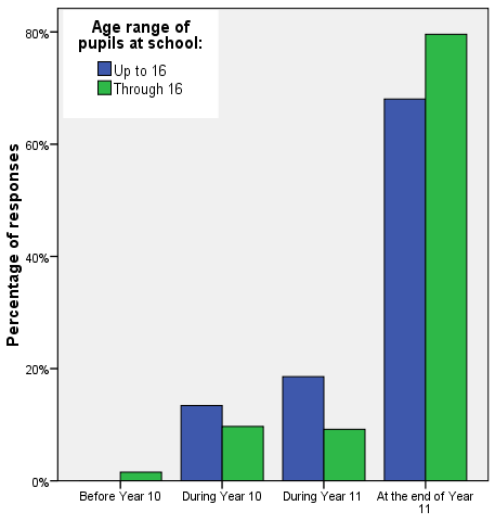
High attainers (predicted GCSE A* - B)



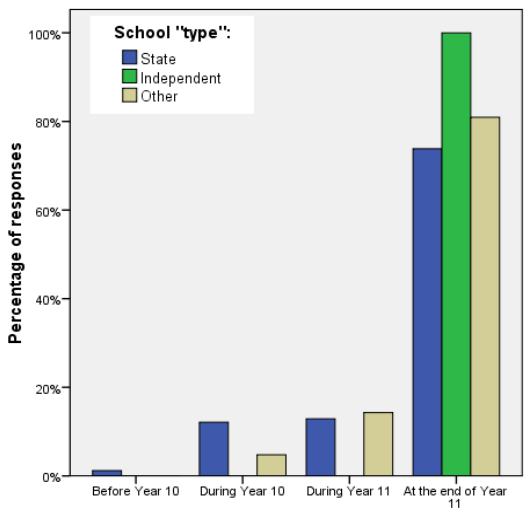
Middle attainers (predicted GCSE C/D)



Middle attainers (predicted GCSE C/D)



Low attainers (predicted GCSE E - G)



Low attainers (predicted GCSE E - G)

Figure 7: First completion of a GCSE qualification based on students' attainment by age range of students (left) and type of school (right)

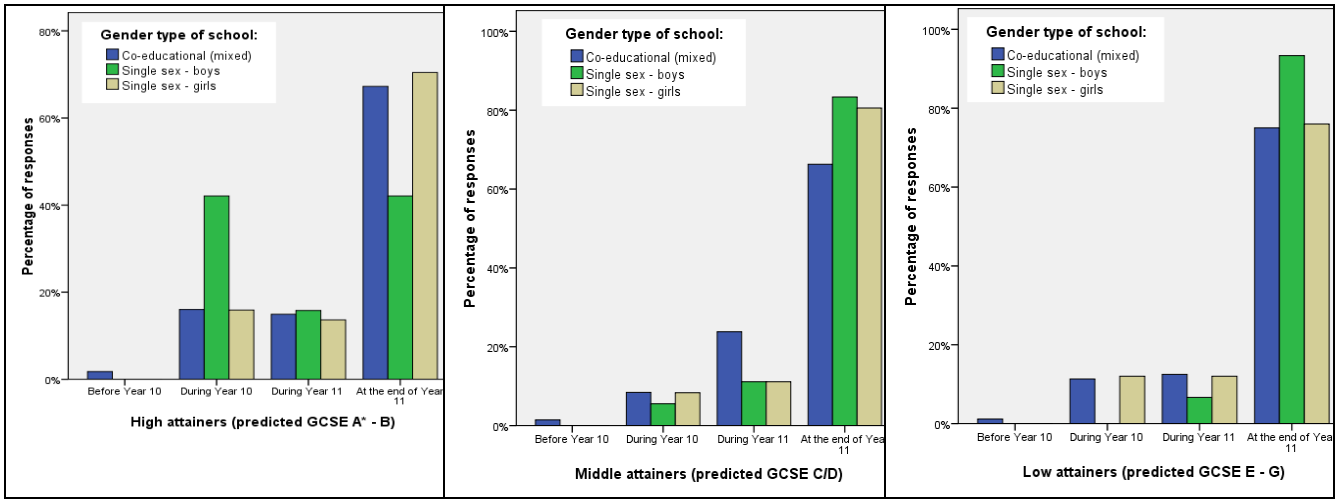


Figure 8: First completion of a GCSE qualification based on students' attainment by gender type of school

Before proceeding to consider what students do next when they have been entered early we want to explore whether schools have a blanket early entry policy or whether their strategies are differentiated by attainment level. Table 12 identifies the numbers of schools which have common entry policies for all levels (i.e. high, middle, low) or for two of the three levels. It suggests that about half of the schools in our sample (49%) have a 'one size fits all' policy for the timing of their students' initial sitting of the GCSE mathematics qualifications. This is not particularly striking given that the vast majority of these are schools in which all students are entered at the end of Year 11. The remaining centres have a more differentiated entry policy, sometimes based on common policy for middle and low attainers (14%) or on the other combinations, as shown below.

Table 12: Numbers of schools adopting blanket early entry approaches

	Common policy for …			
Response:	All levels	Low and Middle only	High and Middle only	High and Low only
Before Y10	3			
During Y10	17	4	4	1
During Y11	17	10	4	
At the end of Y11	140	36	7	25
Total	177	50	15	26
Proportion from available responses (N=284)	62%	18%	5%	9%
Proportion from total schools (N=368)	49%	14%	4%	7%

B3. Early entry to GCSE

Question 13 was about the current Year 11 cohort and asked: 'If students first completed a GCSE in mathematics before the end of Year 11, roughly what proportion will have retaken that GCSE by the end of Year 11?' Table 13 presents the distribution of responses to this question, which is also illustrated graphically in Figure 9. What is most striking is the number of schools in which students are not re- entered which raises the question of what mathematics they are doing.

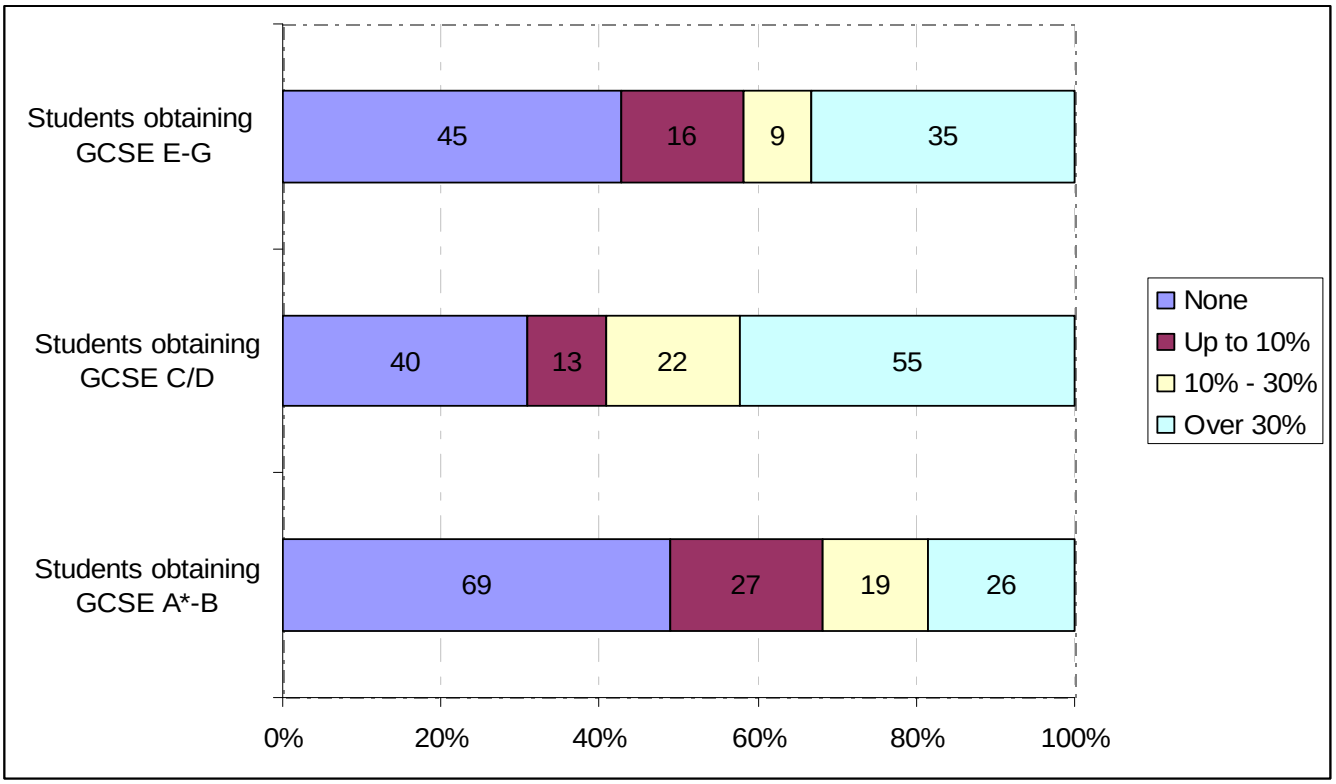


Figure 9: Proportion of students who completed GCSE before Y11 and retake by the end of Y11

Table 13: Proportion of students who completed GCSE before Y11 and retake by the end of Y11

	Percentage			
	None	Up to 10%	10% - 30%	Over 30%
Students obtaining GCSE A*-B [N=141]	69 (49%)	27 (19%)	19 (13%)	26 (18%)
Students obtaining GCSE C/D [N=130]	40 (31%)	13 (10%)	22 (17%)	55 (42%)
Students obtaining GCSE E-G [N=105]	45 (43%)	16 (15%)	9 (8.5%)	35 (33.5%)

Question 15 asked what mathematics most of the students who enter GCSE mathematics before the end of year 11 do afterwards. Their responses, based on the obtained grade are presented in Table 14. So, for example, 11 heads of department reported that their early entered students who had obtained a GCSE grade A would do no more mathematics. This is around 10% of schools reporting for A grade students. We are pleased to see that the vast majority of schools offer more mathematics to their students who have achieved a grade A early. Such further opportunities are not so readily available as the attainment in early entered GCSE decreases and, strikingly, students in 25 centres (23.1% of respondents to this item) would expect the students to do no further mathematics if they achieved a grade C. Similarly a large proportion of those achieving a D early simply repeat the same mathematics.

Table 14: What mathematics students do after early GCSE entry

	No Mathematics	Same Mathematics	More mathematics at similar level	More mathematics at a higher level
Grade A	11 (9.7%)	5 (4.4%	19 (16.8%)	78 (69.0%)
Grade B	11 (13.1%)	13 (15.5%)	23 (27.4%)	37 (44.0%)
Grade C	25 (23.1%)	23 (21.3%)	27 (25.0%)	33 (30.6%)
Grade D	6 (6.5%)	47 (51.1%)	34 (37.0%)	5 (5.4%)
Grade E	6 (7.6%)	36 (45.6%)	33 (41.8%)	4 (5.1%)

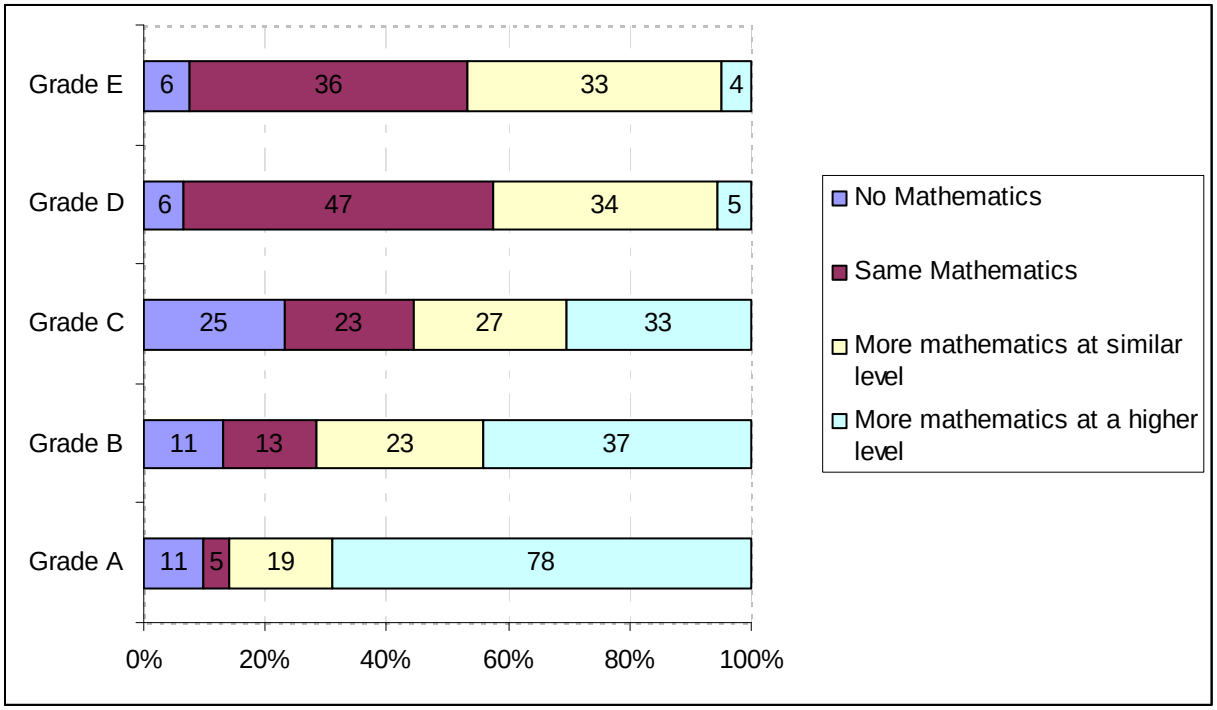


Figure 10: Mathematical provision for students who take GCSE early by achieved grade

Figure 10 shows that students who achieve GCSE grade A are very likely to continue with more mathematics at a higher level. Students who achieve a Grade B are also very likely to be doing more mathematics at either the same or a higher level. For students who achieve grade C the provision is very variable with almost one in four schools no longer expecting students to study mathematics. For Grade D and E students, the picture changes and most schools do the same mathematics or more mathematics at similar level.

Participants were invited with Question 16 (open ended) to give any additional comments on any issue of early entry. A brief analysis of these responses from 90 schools suggests a number of general categories of statements that are listed below. The comprehensive list of these responses, under each category, is attached as Appendix 2.

- Timetabling problems [N=3]
- Early entry only for high attainers [N=12]
- Options - more mathematics for high attainers [N=16]
- Options - other subjects [N=5]
- Options - time for resits [N=8]
- No longer / no in principle [N=8]

- No (extend, enrich, breadth) [N=12]
- Motivation positive [N=4]
- Motivation negative [N=6]
- General/commentary [N=16]

B4. Introduction of strategies for KS4

Schools were asked to report whether they had recently introduced any of three strategies for students at Key Stage 4 (KS4). The frequencies of their responses are presented in Table 15.

Table 15: Strategies introduced by schools for KS4

Strategies	Yes	No	Missing
Increased curriculum time for mathematics	72	243	53
Other time / support for mathematics, for example, lunchtimes or after school	227	106	35
Target staffing to support C/D borderline students	227	100	41

As can be seen the less frequently adopted strategy is 'increased curriculum time for mathematics' which was introduced by 72 schools. The other two were introduced by about two thirds of the schools in the sample (N=227).

The following figures show possible differences in the distribution of schools' responses in regards to introduced strategies based on various schools' characteristics.

Figure 11, first, shows how these responses are differentiated based on the age range of students at the school. As can be seen, 'up to 16' schools are more likely to adopt these strategies that 'through 16' schools.

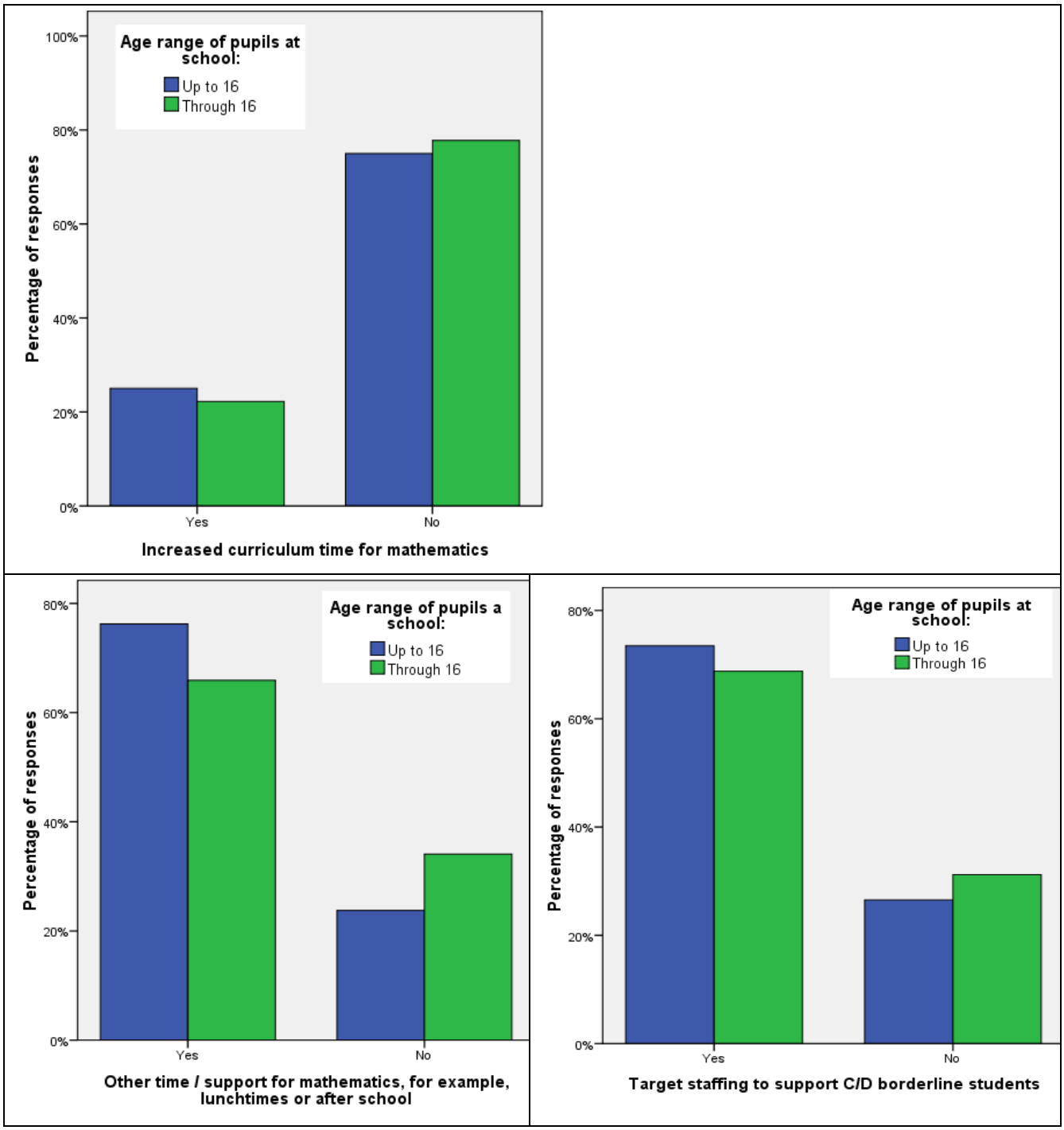


Figure 11: Strategies introduced by schools based on students' age range in school

Figure 12 shows how the use of the three strategies is differentiated based on the 'type' of school (i.e. state or independent). State schools are more likely to adopt these strategies and particularly striking is the focussed support for C/D borderline students. This strategy is much more likely to be adopted by state schools although this might be largely explained by the higher attainment in those schools; C/D borderline is less critical due to the attainment profile of the students.

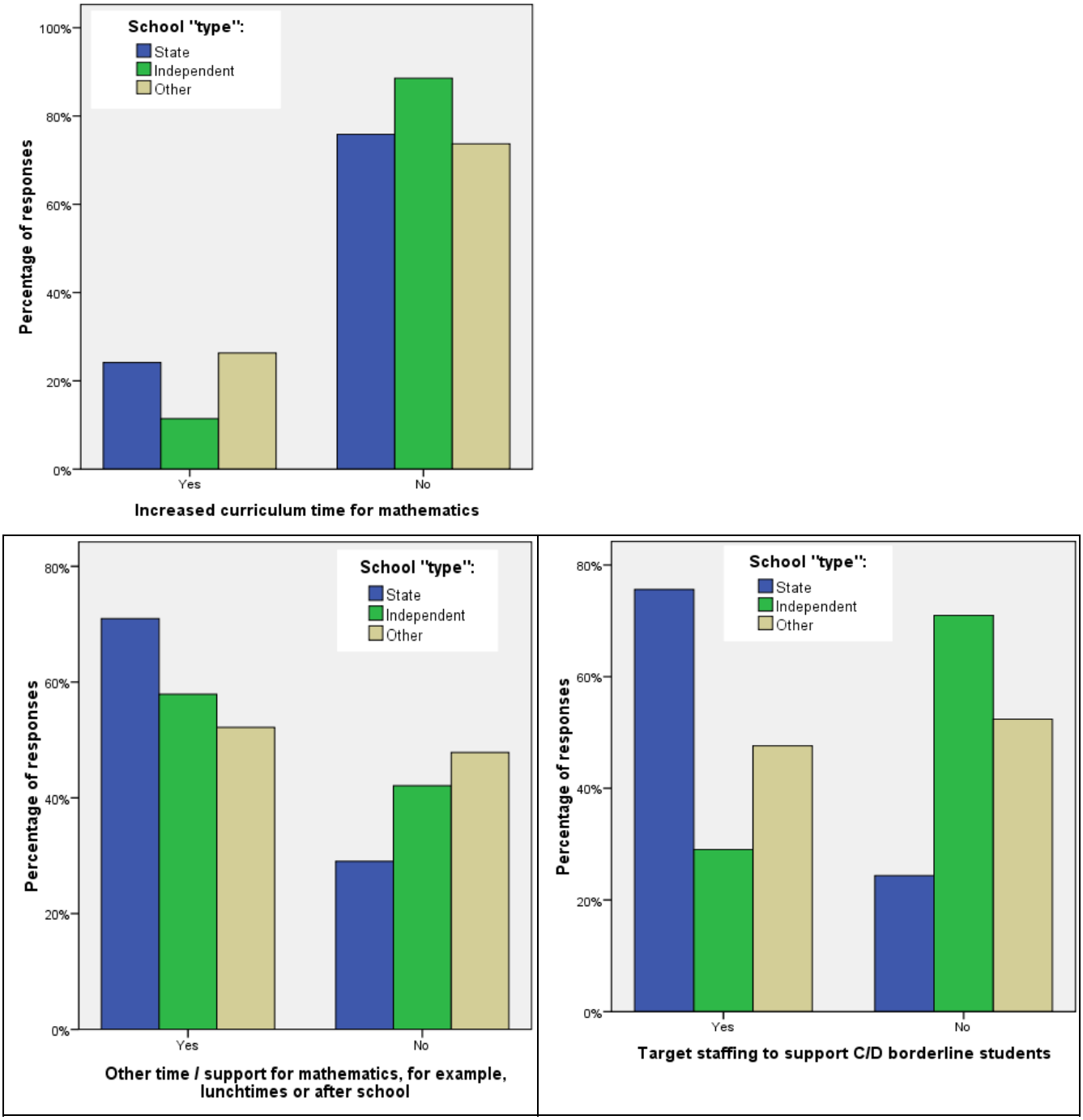


Figure 12: Strategies introduced by schools based on School 'type' (i.e. state, independent)

Figure 13 shows how the use of the three strategies is differentiated based on the 'gender type' of school. Overall, it can be seen that co-educational schools use the strategies more frequently than single sex schools. The largest difference between single-sex and coeducational schools appears for the 'increased curriculum time for mathematics'. As far as differences between the single-sex schools it appears that girls' schools make more use of 'increased curriculum time for mathematics', whereas schools for boys make more use of strategies like 'other time /support for mathematics' and 'target staffing to support C/D borderline students'.

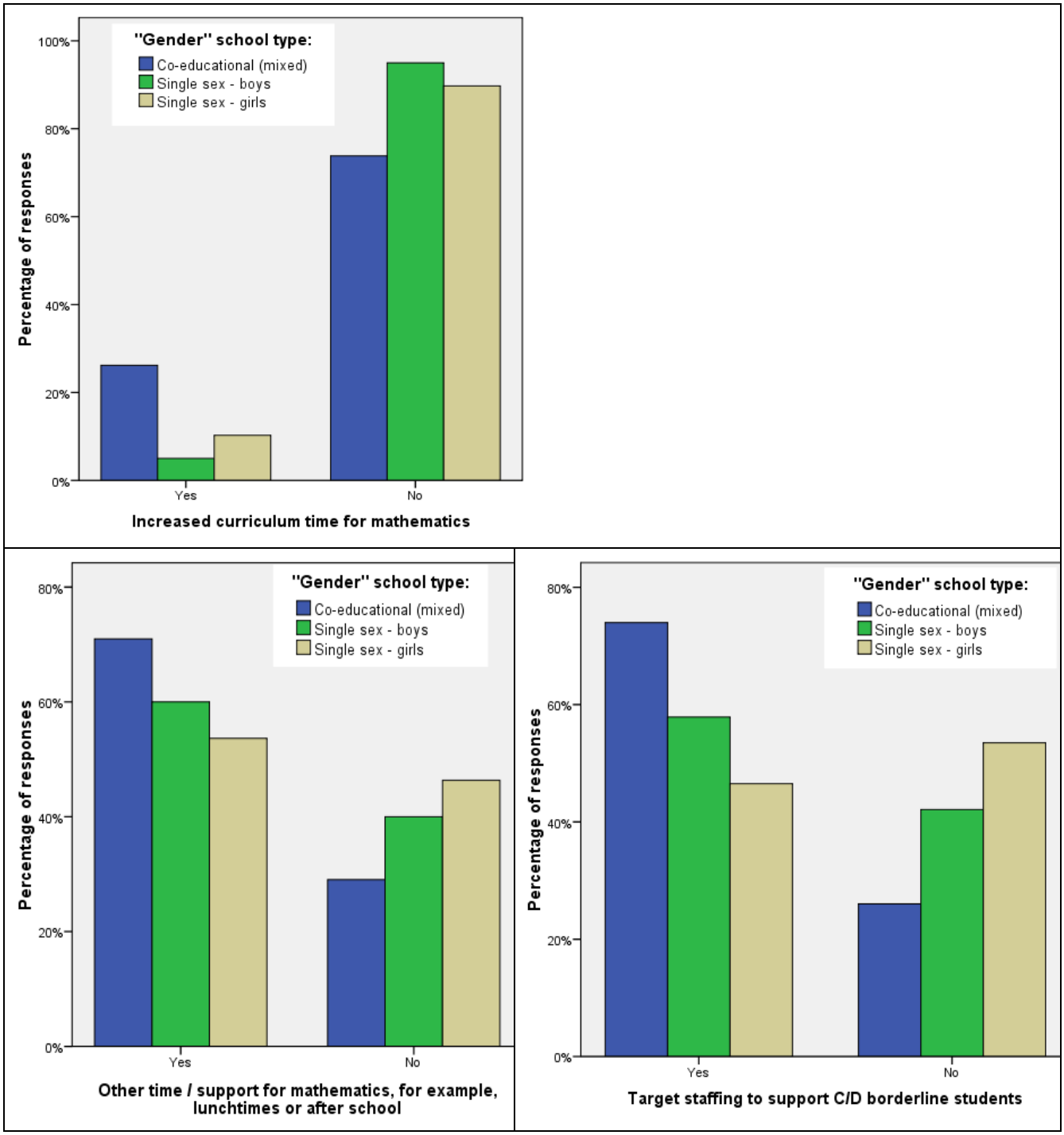


Figure 13: Strategies introduced by schools based on school's 'gender' type

As far as differences based on students' attainment in schools (Figure 14), it seems that schools with between 30 to 70% students gaining A* to C grades are making more use of these strategies than schools with higher or lower mathematical attainment. This is to be expected.

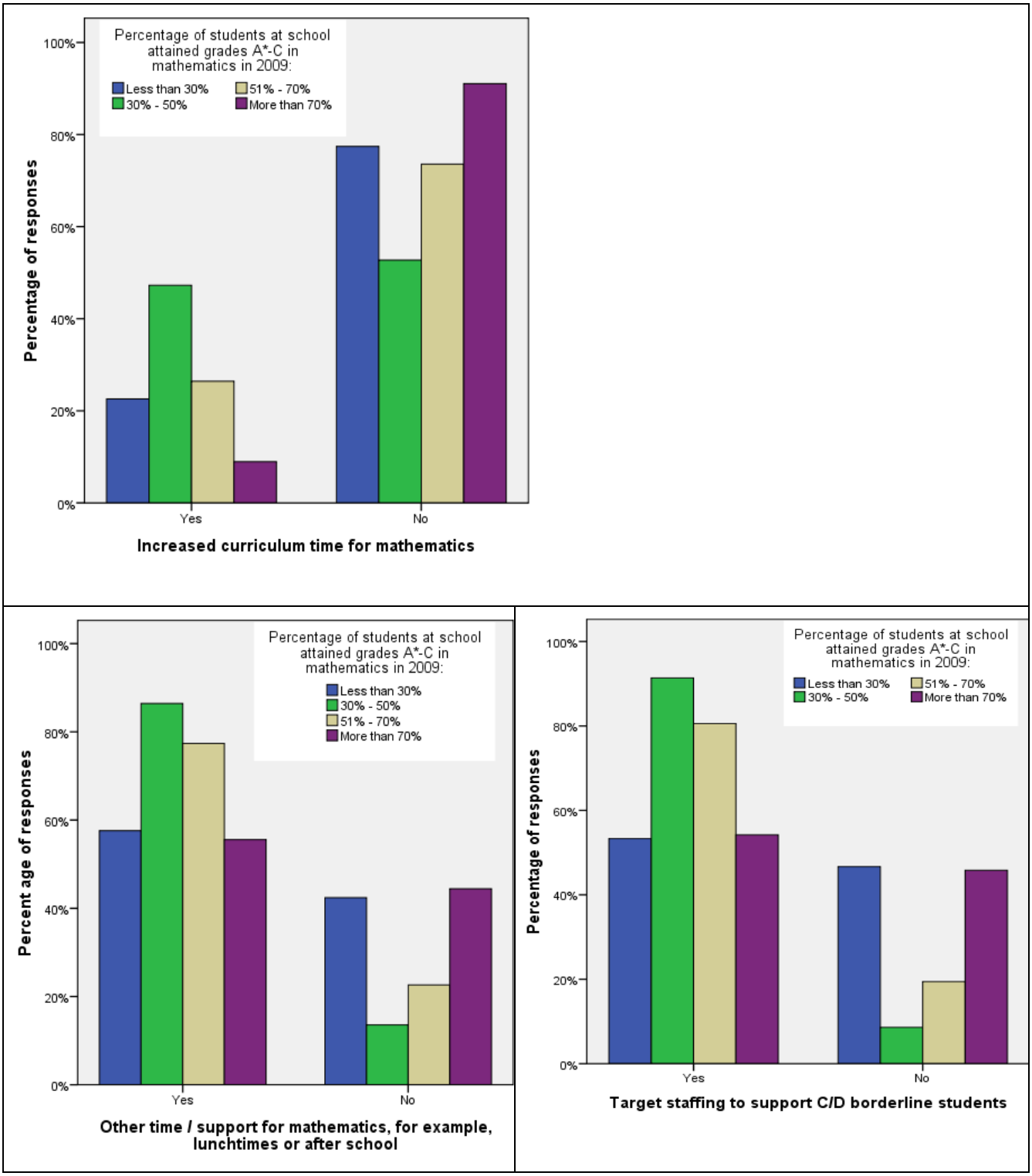


Figure 14: Strategies introduced by schools based on students' GCSE mathematical attainment

We also explored whether schools were using these strategies in conjunction with one another. Cross-tabulations of data from schools that responded to all three of these categories (N=297) indicate that:

- Around 20% of centres have used all three of these strategies together;
- A larger group of centres (40%) has combined 'other time/support' with 'targeted staffing' but has not increased the overall curriculum time for mathematics;

- Of the centres who have increased curriculum time for mathematics, around 90% of these are also employing other strategies;
- 25% of centres are using none of the strategies;
- The remaining centres are divided across the remaining combinations of these strategies;
- Schools tend to either combine strategies or use none at all.

Respondents were invited to give more details of any other strategy used. A summary of their responses is given in the list below:

Curriculum and assessment:

- Extra hour for GCSE statistics to be incorporated into the higher attainers' timetable
- Additional Mathematics FSMQ to extend 'most able'.
- Introduction of Edexcel ALAN L2 course for students targeted at grades E to G
- Starting GCSE in Y9 to give 3 years to complete the course.
- Early entry (November of Y11)

Extra sessions and revision:

- After school sessions/support (and half terms), breakfast club
- Holiday sessions
- Targeted revision sessions for six weeks before the exam
- Sunday revision sessions before exam
- Structured Revision programme
- Super learning day C/D borderline, Super learning day - all year 11
- Whole day sessions pre-exams

Resources and staffing:

- Promoting additional resources - i.e. Mathswatch
- Mathematics conferences, ENGMA project
- Staffing support for Y11
- Employed a mathematics teacher from outside to work with small groups of C/D borderline students in school
- Smaller class sizes (for C/D borderline)

Targeted interventions:

- Item level analysis of exams
- Withdrawal groups from other subjects to do mathematics in curriculum time.
- One to one tuition for targeted students
- 1 to 1, volunteer mentoring,

Other:

- Strong use of specialist Learning Development Department
- Parental engagement evenings informing them how they can work with their child to raise attainment in mathematics

Part C: Two tier GCSE Mathematics

C1. Change in number of students entered at Higher tier

In order to check for possible increase or decrease of the number of students being entered at Higher tier schools were asked to indicate the approximate proportion of GCSE students in each Year 11 cohort who were entered at Higher tier in the last three years. The frequencies of their responses are shown in Table 16 (for years 2008, 2009 and 2010).

Table 16: Proportion of GCSE students in the Year 11 cohort who were entered at Higher Tier over the last three years

	School Frequency (%)		
% of Higher tier entry	2008	2009	2010
up to 30%	62 (19.3)	58 (17.6)	52 (15.3)
31% to 50%	79 (24.5)	67 (20.3)	67 (19.7)
51% to 70%	82 (25.5)	100 (30.3)	102 (30)
over 70%	99 (30.7)	105 (31.8)	119 (35)
Missing	46	38	28

To capture the 'change' in these proportions, a new variable was created based on individual observation of the three corresponding columns. The new variable was indicating increase, decrease or no change on proportions. The 'no change' centres entered the same proportion of students at Higher tier in each of the three years. The distribution of schools' based on this new variable is presented in Table 17, split by school type.

Table 17: Change in proportion of Higher Tier by school type (students' age range)

	Change in proportion of Higher Tier			
School type	Decrease	No change	Increase	Total
Up to 16	16	37	44	97
Through 16	32	111	87	230
From 16	4	1	3	8
Total	52	149	134	335

Figure 15 shows how the 'change' was differentiated based on the proportion of students entered during 2008. As expected (and seen), increase is more frequent in schools with reported initially low proportion of Higher tier (at 2008).

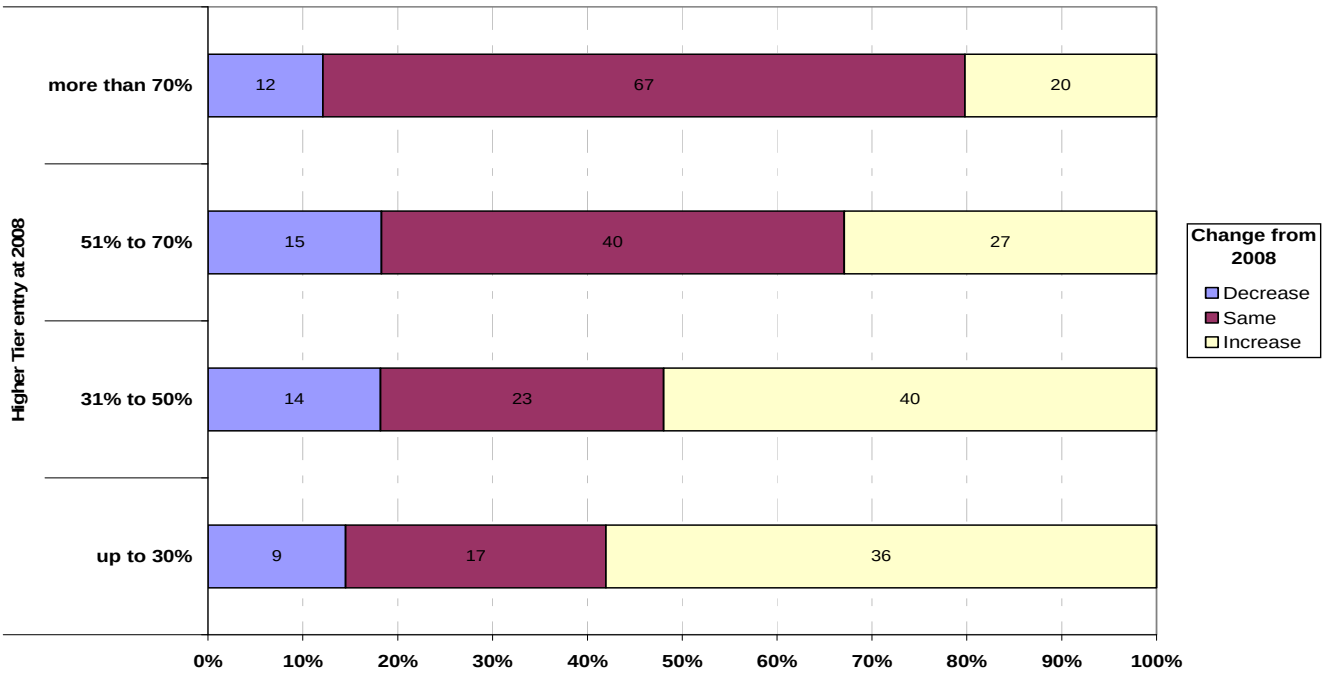


Figure 15: Change in proportion of Higher tier based on proportion entered during 2008

C2. Attitudes towards two-tier GCSE mathematics

The respondents were also asked to report their degree of their agreement to a series of statements about the new two-tier GCSE. The distribution of their responses is presented in Table 18 (frequencies and percentages).

Table 18: Summary (Frequencies and percentages) of schools' attitudes on two-tier GCSE

Statement	Response Freq (%)				
	Strongly agree	Agree	Not sure	Disagree	Strongly disagree
The new two - tier GCSE arrangement is an improvement on the old three - tier arrangement	44 (12.1)	113 (31)	64 (17.5)	74 (20.3)	70 (19.2)
All Higher tier students should be taught the A / A* material	33 (9)	93 (25.4)	31 (8.5)	171 (46.7)	38 (10.4)
High attaining students (A* - B) spend enough time studying algebra	17 (4.7)	163 (44.9)	43 (11.8)	124 (34.2)	16 (4.4)
Higher tier GCSE is a good preparation for AS mathematics	25 (6.8)	138 (37.7)	77 (21)	94 (25.7)	32 (8.7)
Being able to achieve a grade C at Foundation tier has increased the motivation of lower attaining students	124 (34.3)	146 (40.4)	49 (13.6)	33 (9.1)	9 (2.5)
Borderline C / D students should be entered at Foundation tier	76 (21)	122 (33.7)	78 (21.5)	77 (21.3)	9 (2.5)
Borderline C / D students should be entered early so they have opportunities for resitting	37 (10.3)	106 (29.5)	96 (26.7)	100 (27.9)	20 (5.6)
Borderline C / D students should be entered early because they do better the earlier they complete the qualification	6 (1.7)	56 (15.6)	151 (42.2)	111 (31)	34 (9.5)

Several of the items in Table 18 were used one year previously with a sample of pilot centres from the Mathematics Pathways project. The support for the two-tier GCSE has declined from 47.7% agree/ strongly agree in 2009 to 43.1% in 2010; those disagreeing or strongly disagreeing with the same statement has risen from 30% to 39.5%. There is also more disagreement with the statement that 'all higher tier students should be taught the A*/A

material' (33.3% in 2009 to 57.1% in 2010). It is difficult to say whether these differences are genuine changes over time or reflect different cohorts; the pilot cohort being more enthusiastic about embracing change. However, if these changes do reflect genuine changes in attitude to the two-tier GCSE this would be cause for concern. On a more positive note there has been a significant improvement in the view that being able to access grade C at foundation tier has increased motivation (from 8% to 75% agree or strongly agree).

Figure 16 also shows the distribution of responses to the first item: 'The new two-tier GCSE arrangement is an improvement on the old three-tier arrangement', based on overall school mathematical attainment.

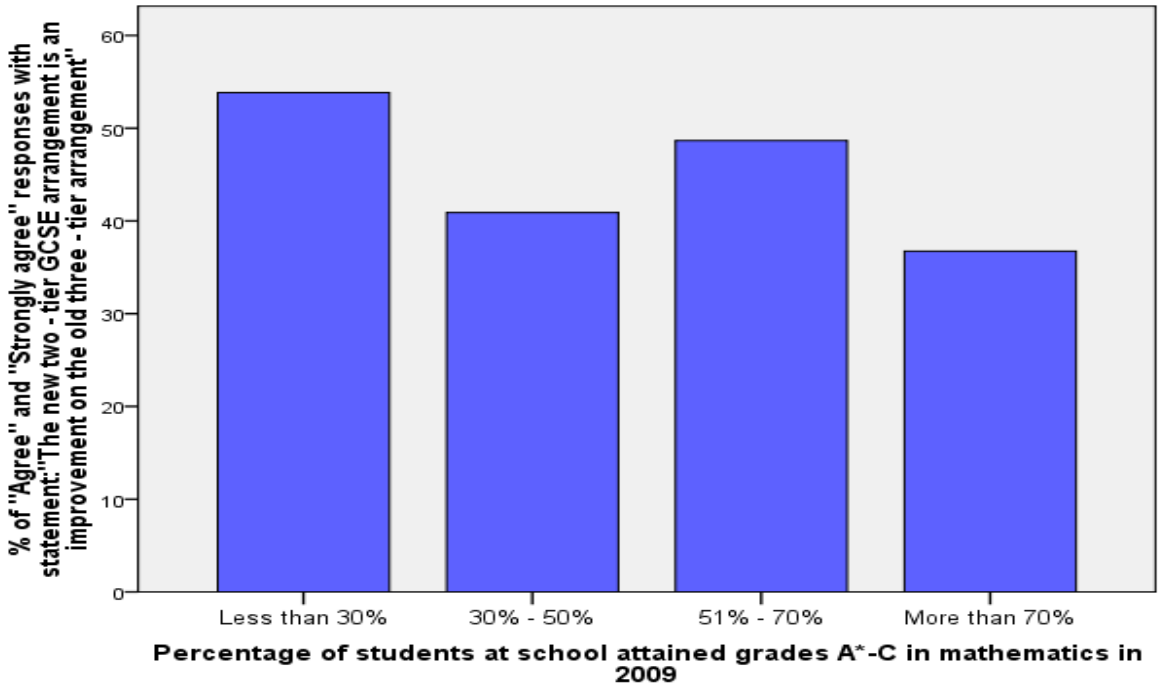


Figure 16: Distribution of responses to Statement 'The new two - tier GCSE arrangement is an improvement on the old three - tier arrangement' based on schools' mathematical attainment in 2009

For the following figures the accumulated percentage of agreement (A and SA) with a statement is presented and in both figures the chart is presented by the school's mathematics attainment. It is not clear why these differences appear across the school attainment types. It does seem important that only half of respondents can agree that higher tier students spend enough time studying algebra.

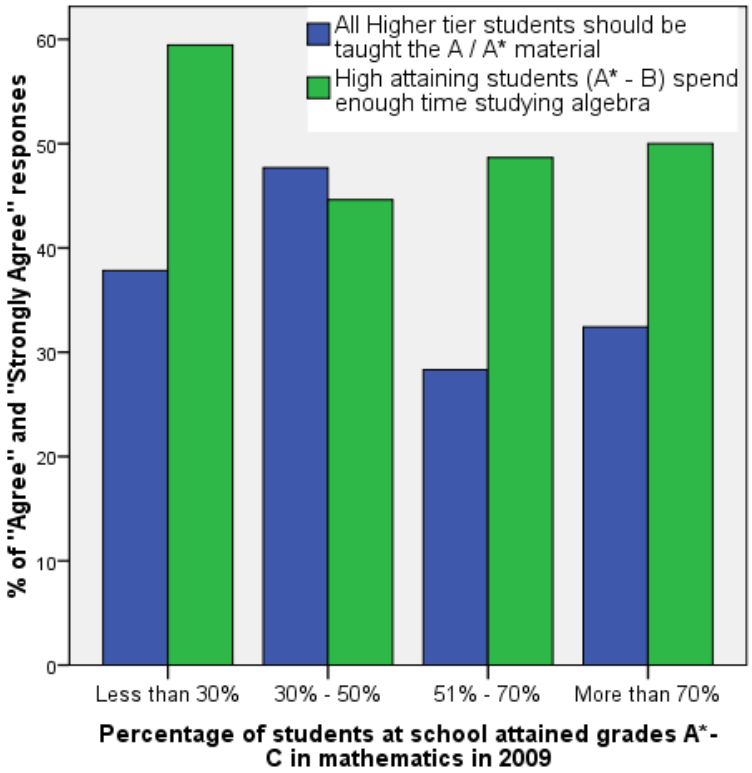


Figure 17: Percentage who agree that high attaining students spend long enough studying algebra, and that they should be taught the A/A* material based on schools' overall mathematical attainment

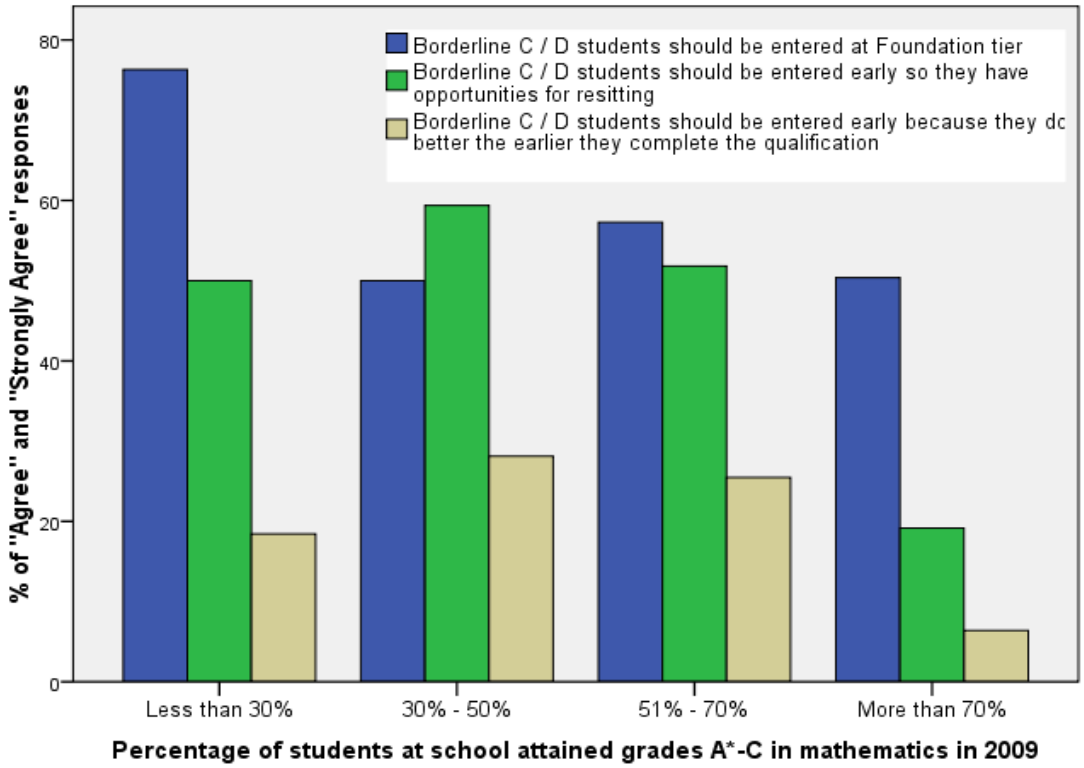


Figure 18: Percentage who agree that borderline C/D students should be entered at foundation, and early for various reasons, based on schools' overall mathematical attainment

Figure 18 highlights different strategies for maximizing the attainment of C/D borderline student. In high attaining schools where the vast majority achieve a grade C or above there is less pressure for early entry.

The final question of this section (Question 19) invited respondents to comment on the two-tier GCSE, comparing it with the previous three tier arrangement. The 132 comments of the respondents to this question were categorized based on 4 broad categories listed below [with the frequencies of each group of comments]:

- In favour of 2 tiers [N=15]
- Several mixed points [N=12]
- Other [N=10]
- Against [N=95]
- awkward for placing B/C/D students [N=25]
- demotivating/disadvantaging B/C students [N=23]
- general call to go back to 3 tiers (with C at foundation) [N=13]
- lack of A/A* content in exams, problems for progression to AS/A-Levels [N=20]
- multiple points from the above [N=5]
- other/general [N=9]

As can be seen in the above list, the majority of respondents to question 19 were against the two-tier arrangement and stated their preference for the previous three-tier arrangement. Their main reasoning is also shown through the sub-categories of the against-statements. The comprehensive list of these 132 comments is presented in Appendix 3 based on the classification presented here. The trend presented here, with the majority being against the two tier, seems to contradict the responses to the first statement in Table 18, where about 43% agree that “the new two - tier GCSE arrangement is an improvement on the old three - tier arrangement”, and only 39% disagree. It seems that those who disagree are more vocal about their reasons.

It is worth cross-tabulating these categorized comments, with the responses of this statement and also consider the high number of schools (N=233) which did not provide a response to this open-ended question. Figure 19 shows how responses are distributed based on this classification, and indicates that the majority of negative comments actually come from the schools which initially disagreed with Q18-first statement:

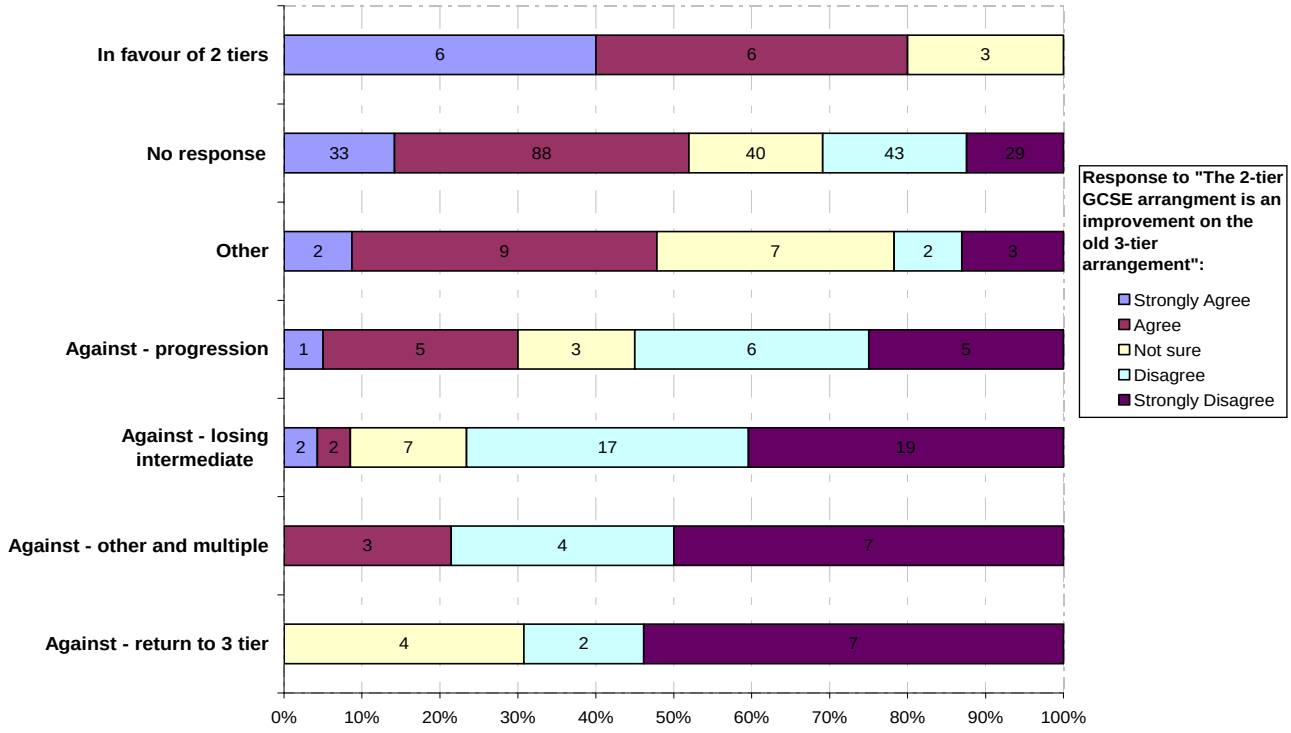


Figure 19: Distribution of open ended comments group by responses to first statement of Question 18

Part D: Thinking Ahead to the next academic year

Table 19: Frequencies of responses to Questions 20 to 24

Questions:	Yes	No
Are you aware that the new GCSE mathematics will start from September 2010?	366 (99.5%)	2 (0.5%)
Do you think you know what the main changes are?	346 (95%)	19 (5%)
Have you done any planning for the new GCSE mathematics?	308 (84%)	58 (16%)
Are you aware that a new pilot of a linked pair of GCSEs will start in September 2010?	265 (72%)	103 (28%)
Are you intending to be a pilot centre for the linked pair of GCSEs? (Missing=105)	31 (12%)	232 (88%)

Those who reported that they intend to be a pilot centre, were also asked to report which groups of students they expect to enter to the linked pair. The responses from the 31 centres are summarized below and suggest that there is a bias towards entering middle and high attainers. This might be as a result of the sample of responding centres or could signal that the pilot centres do not see the new linked pair as suited for all learners. Figure 21 shows how these responses are distributed based on the mathematical attainment of students in these schools.

High attainers (A*-B): N= 26

Middle attainers (C/D): N=24

Low attainers (E-G): N=12

The final question of the survey (Question 26) asked about reasons that influenced the decision to take part in the pilot of the linked pair. These are presented in Appendix 4, organized by whether or not the school intends to take part.

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Hodgen, J., Küchemann, D., Brown, M., & Coe, R. (2010). Multiplicative Reasoning, Ratio and Decimals: A 30-Year Comparison of Lower Secondary Students' Understandings. Paper presented at the International Group for the Psychology of Mathematics, Belo Horizonte, Brazil.

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APPENDIX A1: Sample representativeness

The survey was aimed at heads of department and there were responses from around 10% of the secondary schools in England (there were about 3000 maintained secondary school in 2008/9). In the absence of figures for the numbers of schools of different types in England we have made comparison using provided DfE performance data of students from 2009. That provides a national picture of student attainment, by gender and school type.

Three measures are used to estimate the representativeness of the sample, or more particularly the representativeness of the sample of students represented by this sample of teachers. Respondents indicated the size of the year 11 cohort to the nearest 10. They also indicated the proportion of the 2009 cohort that achieved grade A*-C in mathematics.

In the table below we chose 'mid points' for each of the four response ranges, limiting the extent of the range at the higher and lower ends. From there we calculate an estimate of the number of students represented in the sample schools who attained a grade A*-C in mathematics in the 2009 Y11 cohort. It needs to be emphasized that this is only an estimate.

Response range	'Mid point'	Number of schools	Estimated total students	Estimated A*-C students
Less than 30%	20%	36	2812	562
30% - 50%	40%	65	12498	4999
51% - 70%	60%	112	22719	13631
More than 70%	80%	144	23471	18777
	Total	357	61500	37970

Estimated numbers of students (represented by survey respondents) who attained grades A*-C in mathematics in 2009

So, in our sample an estimated 61.4% of those students in the responding schools achieved C or above in mathematics. This is compared to a figure of 61.7% as based on the Office for National Statistics data.

Similar estimations can be made by school types to show a) the number of students represented by the survey respondents and b) the proportions obtaining C or above in mathematics. Estimates of the represented sample populations are shown by school type

Type of school	Estimated total students represented in survey	Estimated % of sample cohort	Estimate % of students attaining C or above	Official % of cohort
Maintained	54524	89%	62%	94%
Independent	3196	5%	78%	4%
Other	3780	6%	41%	2%
Mixed	52817	86%	60%	
Boys	2637	4%	65%	
Girls	6046	10%	74%	
Up to 16	16452	27%	54%	
Through 16	44138	72%	65%	
From 16	910	2%	56%	

Estimated numbers of students represented in survey sample (by school type) and proportions obtaining A*-C in mathematics

We conclude that although the sample might be slightly biased to independent school respondents this is not markedly so, and given the estimated percentage of represented students obtaining grades A*-C it is reasonable to claim representativeness for this sample.

APPENDIX A2: Additional comments on early entry

Timetabling problems

- We run Additional mathematics as an after school option. We feel most pupils benefit from greater maturity in year 11
- Would like to but timetable restrictions
- Yr group split into two 'Band's', therefore about 13 to 18 'G and T' students in each band. Have requested a set of their own at the top of each band so they do IGCSE at the end of yr10 and are taught Additional Mathematics in yr11. This has been put to SLT for the last four years for timetabling but we have been asked to give after school lessons as there is no funding for staffing these groups. This does not give teacher's the incentive to enter students early for GCSE as it means teaching 'parallel' groups in the top set in yr 10 and than having to teach successful students Additional Mathematics after school in yr11.

Early entry only for high attainers

- All our students gain A*-B, top set (30) do it in yr 10, rest at end yr11, none resit
- Early entry at our school is only for A or A* students. All rest entered at end Y11
- I do not support early entry unless pupils will get A*/A
- I found that entering the students for Nov exams useful because they concentrated on mathematics alone and students who did not get A* are repeating to get it.
- I think early entry should result in A* or A. More early entries encourages exam cramming as well as encouraging schools to give an inaccurate picture due to constant repetition; are the exams designed for this approach?
- Inappropriate for any students unless they will achieve an A* on early entry. Universities look for A* and this could go against able mathematicians who haven't had enough time to prepare thoroughly.
- only do it if A/A* is guaranteed
- Our top two sets (approx half the year group, i.e. just under 60 students) take GCSE Mathematics at the end of Y10, retaking in Nov of Y11 if they do not get an A*. The rest take it at the end of Y11. There is no possibility in question 12 for giving more than one response. Almost all our students get A*-B with just one or two expected to get C this year. Those who take GCSE early then go on to study Additional Mathematics, which we regard as a preparation for A level mathematics. Last year our Y11 top set took Additional Mathematics at the same time as GCSE and this has had a positive impact on their achievement in Y12.

- We are currently considering Early Entry for our highest achieving pupils, who would then go on to target the higher Statistics and the upper grades in Statistics. This is only on the thought process at the moment but could be implemented next year
- We enter a 'fast track' group of 25 students in Nov of Year 11. All achieved A or A*, with the majority gaining the higher grade. They have then gone on to study Additional Mathematics in preparation for A-level. We expect all of them to continue with mathematics in the sixth form
- We entered 35 students for early entry. 33 got A* and the 2 who got A resat. They now have A*. All are now doing the OCR FSMQ.
- We may consider entering high attainers for the linear course in the Nov or March sittings of yr 11, certainly not earlier. They then sit Add Mathematics FSMQ.

Options - more mathematics for high attainers

- + AS CORE 1
- 10 got A or A* in yr 10 so they are now doing AS level C1,2 and S1
- All pupils who took mathematics at the end of year 10 then sat either the Additional mathematics FSMQ or the AS level exams.
- First attempt by the school in November of year 11 for early entry. Difficulty for the mathematics department was whether to continue as most of the cohort would not be taking mathematics further upon leaving school. Most of the early entry cohort had taken GCSE Stats in year 10. With the results of November not out until January it was a case of retrying or to push for a higher level grade due to time remaining. As a consequence of this there will be a cohort of year 10s taking early entry and those successful in achieving A*- C will study for Stats, A/S transition or a finance based course.
- FSMQ Managing Money for weakest students who sat GCSE in November
- GCSE Statistics for 2 classes that got grade B+ at end of yr 10
- Given an option of A level, GCSE Statistics or Financial GCSE
- Ours followed the additional mathematics course in year 11 and took a retake if they did not attain an A* in year 10.
- Summer 2009 GCSE results: 5A*-C: 64% with only 1 A*. However, we decided to enter the whole of our current year 11 cohort for GCSE Mathematics in November 2009. 5A*-C was :54% with 3 A* grades. Our top two groups (Higher Tier) then went on to do GCSE Statistics with a small number resitting Higher tier this June. Of our third set of 7 sets, the majority gained a C at Foundation Tier and have now gone on to Higher Tier. The early entry using Edexcel has enabled us to use results plus to help borderline grade C students to identify areas of weakness. We have been pleasantly surprised with our early entry for the first time and it is something we will continue to do.
- the majority of early entry pupils entered in Nov year 11 - those that got a C or better then studied stats only - those who did not retook mathematics only - the top 30 pupils will take mathematics and stats at the end of year 11
- The only ones who didn't retake were those getting an A* in Nov who went on to do C1 in May.

- The students who have passed mathematics early are completing their GCSE Statistics course
- There is a fast track group in the current year 9 group and they will be do additional mathematics when they complete their GCSE in year 10.
- They did AS Mathematics in Y11 (C1, C2 , M1)
- We use GCSE Statistics at the end of Year 10 as enrichment for the top end. We also feel that because of the relational, sequential learning nature of mathematics, that students are best prepared at the end of year 11...and don't have any below par modules putting them off.
- We were concerned with the issue of high attainers doing very little mathematics in Y11 if they passed in November of Y11. Our fast track students went on to do Foundations of Advanced Mathematics as they had completed GCSE Statistics in either Y9 or Y10

Options - other subjects

- Also a high proportion who got Grade C and didn't want to continue to Grade B then did extra English and catch-up coursework for other subjects
- Few students have been able to attain a grade higher than a C as a result of early entry. We have used the time in some cases to improve the English results, where this was identified as a weak area.
- Some grade C students have gone on to study at Higher level in order to try to get a B grade, however the majority decided to use the time to concentrate on other subjects. They did not get their results until the end of January and were given the choice. Our A*/A grade students (end of Yr 10) have been studying at AS level. The B and D grade students are retaking. For the future we intend to only accelerate the A* students and will use 'Use of Mathematics' at AS level rather than the traditional AS. We have changed this due to the University stance on retake at A level, not wishing to disadvantage our most able students. We intend to extend the early entry of C/D borderline students as it has been a success this year and has offered a safety net for students wishing to take Higher for a B grade (as in the past we have had a few who fell short and ended with a D grade from Higher tier but when retaking at Foundation were easily able to attain a C grade). The removal of the intermediate tier has affected B grades significantly.
- We only enter 15 students that are C grade mathematics but low English, so they can achieve a C grade in mathematics then concentrate on English GCSE afterwards. In the future we are intending to enter some bright year 9 students for unit 1, and then finish units 2 and 3 in year 10 followed by GCSE statistics or FSMQ Mathematics in year 11.
- When possible, we like to enter students for GCSE in year 10 so that they can do work experience in year 11.

Options - time for resits

- Any students who carry on with mathematics are either resitting to gain C grade or wanting to carry on with mathematics in Year 12
- The school uses early entry as an intervention tool. Students take the GCSE in November and when the results are available in January are re-set in an attempt to maximise the number of grade C passes. This has a detrimental affect on potentially higher achieving students. Many are happy to have achieved a C or B and don't put in the effort to study

for higher grades. Some just opt out of mathematics, but nothing else is offered to them in a structured way, due to lack of staffing. Siege mentality.

- This year all early entry candidates achieved a C. 2 students then discovered they needed a B to study sciences at college and are resitting at higher tier this week.
- Trialling early Nov Y11 entry in 2010 for our best foundation students aiming for an early C then to be targeted at higher tier B in summer 2011
- We entered our more able pupils in year 10 to see if they were capable of obtaining a C grade (four did and one got a high D) to keep the group together we moved them on to the higher paper
- We found early entry allowed our pupils greater flexibility as those with a grade C often had the confidence to attempt the higher level secure in the knowledge that they had the required grade C already
- We have used the Additional Mathematics as an early entry for some high attainers and our lowest attainers. Some of the lower attainers can then be reluctant to continue, but we try to encourage them to go for a higher grade.
- we only enter pupils who would have traditionally been entered for intermediate tier who have target grades of C-E. Pupils who pass the foundation tier at a C at the end of year 10 have the option of taking higher tier to improve their grade or use the freed up time to help improve their English or any other subjects. Pupils who narrowly miss may resit in January and others resit at the end of year 11.

No longer / no in principle

- Pupil are best advised not to enter early!
- We are opposed to early entry in principle.
- We do no early entry.
- We don't do early entry for GCSE mathematics
- We have now adopted a linear approach that sees students entered for examinations only when they have demonstrated that they are able to achieve their appropriate grade. This could be any time from June of Y10, November of Y11 or June of Y11.
- We have stopped doing early entry because it affected our A* grades and we felt there was enough breadth in the GCSE course for early entry not to be necessary.
- We have tried it in the past but it has limited success - it ends up being a series of re-takes!
- We no longer enter any for early entry. Instead our top two sets take IGCSE (Edexcel) and Add Mathematics (OCR) at the end of year 11. Results are much better this way (no need for retakes) and teaching time is not lost in year 10.

No (extend, enrich, breadth)

- Currently, we do not enter early, as we prefer to enrich the GCSE curriculum in preparation for A level
- Do not believe in early entry. We do fast track our students however, two year KS3, two year GCSE then in year 11 they do an Additional Mathematics qualification by OCR but they take GCSE paper still at end of year 11.

- Don't believe in acceleration, colleges don't like us interfering with A-level courses, did the OU course the Story of Mathematics with 5 Y11 pupils, we do GCSE Stats in Y10
- I do not agree with early entry. We should be trying to broaden the students' experience. we have offered GCSE Stats to top sets as an option for many years now, and for two years we have been trying Add Mathematics. LSA's are used to support weaker students and the weakest 3 or 4 also do Entry Level as well as GCSE.
- I do not see the point of early entry. I believe in giving our students a broad breadth of mathematics education. Our top two sets are offered an extra GCSE in Statistics, voluntary, lunchtime lessons. Our top set (students achieving Level 8 at KS3) have been entered for FSMQ Additional Mathematics as well as GCSE Mathematics (some do Stats as well). Mixed results but we are working on it.
- If students do not get individual potential grades in early entry then they will want to resit - which is a waste of time and energy. Much better to offer able students a BREADTH of study and enter first time at end of Year 11.
- The school's general policy does not favour early entry at GCSE, but to extend students with the use of Statistics GCSE which is examined alongside the GCSE in June. Due to pressures of exam leave and its impact on other examined subjects.
- We did enter one student for GCSE Mathematics Higher last year. He got an A*. He is doing his final AS module this year - predicted A. Outstanding students like him can rightly be entered early and accelerated - we couldn't hold him back. With the rest, there is plenty to extend the gifted in the ordinary GCSE syllabus eg we do coordinate geometry and trig to AS level with our top set - which is just GCSE but more rigorous.
- We do not enter early, but we do go into greater depth with specific algebra topics which will be needed at AS level
- We have continued to enter students for mathematics at the end of Y11 as we firmly believe that they will have the best opportunity of achieving the highest possible grade through this route. In particular we place strong emphasis on rigorous algebra skills and make every attempt to open our students to wider opportunities in mathematics. We also find that students who enter our 6th form from other schools to study mathematics are, on the whole, less well prepared for study at advanced level. Modular courses do not allow students to develop an appreciation of the inter-connectedness of mathematical ideas, and those who have been entered early (and then not continued with their studies in mathematics) often lose many of those basic skills which are essential for study at AS/A2 level. Furthermore, they have no appreciation of the beauty of mathematics as a subject in its own right. The subject is - sadly - being reduced to rules and algorithms and criteria which simply have to be learnt, not understood.
- We no longer will complete the GCSE early as we have been told that Universities want them to do an A level over 2 years with no resits. We now enrich with GCSE Stats and OCR additional mathematics instead of finishing GCSE early.
- we prefer to challenge able students during the GCSE course by extending and enriching rather than rushing GCSE. Most able students do FSMQ additional alongside GCSE

Motivation positive

- Great motivator - students worked really hard and generally liked it. One student did then choose to carry on and enter at higher level in summer. Remainder had extra time

for science, ICT and coursework in general. Current year 10 C/D students want to have chance at doing November exam.

- It worked well with certain 'types' of students - i.e. those who had started to lose motivation, those who were capable of sitting higher but had got D or E in the mock.
- Our students have been very positive about it. I was concerned about students not wanting to sit the higher if they had achieved a C but this was not the case.
- We found that the C/D students entering early ie November were more motivated and generally performed better.

Motivation negative

- Early entry allows students to lose focus therefore we combine the GCSE and AS-level courses to take each topic further and the students complete both courses at the same time.
- Early entry for A and B grade students (eg at the end of Year 10) is demotivating when it comes to carrying on with mathematics in Year 11; and they were not too keen on Statistics GCSE either!
- Early entry was trialled for this academic year 2009/10 for our set 2 students (target grades B and C). All were entered for Foundation tier to 'secure' a grade C. In future we would consider entering some for Higher tier to secure a B then target intervention to raise attainment at B/A borderline. For a minority, early entry was demotivating as students felt they had secured their grade C so preferred to dedicate their time to revising for other subjects and became disaffected in their mathematics lessons. We need to put in to place intervention strategies for disaffected students to avoid this happening again.
- In my opinion early entry is a vital tool to improving mathematics results, however, it hasn't worked in some cases. For example, with the higher students who have already got their GCSE grade C (in November) but have been targeted a higher grade, we have found that they were switched off and didn't want to progress to a higher grade. In future, we won't be entering the higher students for early entry in the November of year 11.
- It can demotivate some students
- Not keen on early entry but pressured by school to do it. Trialled it with set 2 and 3 taking the Foundation paper in November 2009 with 2 extremely experienced teachers. Results were encouraging but getting them back on task in mathematics to take the higher paper is an issue.

General/commentary

- Although early entry suits some stronger candidates, there is little choice of additional qualifications to be taken in year 11.
- I have considered early entry and in a school like ours found it heavily dependent suitability of staff and having one solid class to take through
- If the GCSE's weren't getting so ridiculously easy the majority of students wouldn't be able to take them early
- Limited to D to C students.

- No students got below a C who early entered
- Our early entry was for a pilot GCSE for OCR and we felt we needed to provide some data for an exam which looked dead in the water at the meeting in October. We enter potential failing pupils early to increase their chances of a qualification before they are excluded or leave for health reasons.
- Our students did early entry at the end of Year 10 in GCSE Statistics
- Previous cohort attempted for some 'traditional 'foundation candidates in November 2008 with poor success but many of those achieved grade C in Summer 2009
- Results have not reflected students' ability.
- The possibility of beginning GCSE in what was KS3 has largely undermined the explorative and playful aspect of mathematics in the middle school.
- Very difficult for us as students come to us at any time during year 10 and year 11, most having missed huge chunks of schooling.
- We have toyed with the idea on and off for years but have always found that our Year 9 and 10 pupils lack the maturity to achieve their full potential on Module exams taken early, resulting in re-entries and delaying the end of the course until the end of Year 11. We have also never found a satisfactory programme to fill the time after the completion of the GCCSE course. It is highly likely that early entry will disappear off the map when the full extent of spending cuts becomes apparent - schools are going to struggle to justify 60 pounds per child per qualification?
- We now start our GCSE course in year 9 for all students.
- When we did the early entry for the Mathematics GCSE the students performed no better than in previous years
- Will try early entry for a pilot of about 20 students on the C/D border next year
- year 9 taking unit 1 are not mature enough to understand some of the contexts, likewise the accelerated year 9 students taking unit 2 - this can only get worse with functional elements coming into play

APPENDIX A3: Additional comments on two-tier GCSE

Total number of comments: 132

In favour of two tier (15)

- Better because all students have access to grade C
- Brought us in line with other GCSE's so parents and pupils understood it more easily. Students are more motivated if they think they can achieve a C since this is an entry requirement for courses they want to do after GCSE
- Difficult to be sure of level of entry for B/C students - many lack confidence and find the A/A* questions daunting - need a lot of reassurance otherwise they may panic. Good that the weaker students now feel that they have access to grade C even if the chances are very low.
- For a PRU, we find it much more valuable to spend time on GCSE Exam accreditation without coursework time constraints. We like the functional skills questions too.
- For the students at the PRU I work in it has motivated them more, now they are able to achieve a grade C at GCSE
- Foundation level is so much better now the students have a C to aim at but it seems easier to get a c at higher level It seems wrong educationally to make students sit an exam that they will only ever be able to do half of.
- From our analysis it is significantly easier for students to get a C if entered at foundation, especially with the modular. Slightly more able students who take higher often get worse results in terms of UMS marks
- Girls' attainment at Foundation is markedly improved compared to their performance on the old Intermediate tier.
- Improved issue of which tier to enter for, as we used to enter a small number for the intermediate tier, we now enter all students for the higher tier. However, we do have C/D borderline and I am not convinced on which is the best paper for them. Apparently, the new scheme will allow entry at any level and mixed entry with the UMS result allowing all grades which sounds like a good idea.
- It is hugely significant that all students can now aim to achieve a C pass, and that more able students can attempt the A and A* grades.
- Moving the C grade into the foundation tier has made the motivational aspect of teaching special needs pupils a lot better as they know what they do on the 'day' counts.
- Parents are now wanting students to gain a B rather than a C, so they are asking for students who are plainly not capable of it, to do the higher papers. Still, it's better than it was.
- The 3 tier system meant that the Foundation students had no way of achieving a C grade and this is de-motivating.
- The old 3 tier system was very de-motivating for low attainers - great that it's gone. The new system would be ok if it was more demanding at higher level. The exam boards (Edexcel in particular) seem to have used it as an opportunity to lower the standard

- We give a Foundation paper as end of year test to all our students. Foundation students are usually encouraged that they can achieve grade D then and it motivates most of them to push for grade C in Year 11.

Against – losing intermediate (47)

- As an FE college, we only have students with a grade D who are aiming for a C. The 3 tier system was perfect for us and allowed students to aim for a B.
- As per usual, the majority of students in the middle have lost out under the 2 tier system. There was nothing wrong with the intermediate tier. Students who were entered for the old Foundation tier had absolutely no chance of getting a grade C so the new Foundation only gives them false hope and unrealistic expectations of what they can achieve. Two-tier has been an abject failure.
- Can't answer Q17 as it only came to the school Sept 2009. Did prefer the 3 tier as pupil who were C / B the Intermediate tier was more suited and was able to give them a good experience of mathematics, rather than any C / B candidate now feels very deflated when they can't answer the last third of the paper.
- Every student should have the opportunity to achieve their potential...B grade students suffer under this system as much Higher material daunts them and they end up taking an exam they are not confident in. C grade students should do foundation as they then achieve their grade by succeeding in an exam rather than by aiming for 35% and not worrying about the rest.
- Good grade B students find the Higher tier material challenging and often 'give up'. The Intermediate tier catered for them much better than the present Higher tier.
- Grade B/C students are hugely disadvantaged by the 2-tier model. Foundation is nowhere near stretching enough and rewards 'accuracy on easy mathematics' rather than any real 'grade C/D' ability. To put them into higher tier you have to admit that you will not teach them big chunks of the syllabus (and get parental complaints) as they are not ready mathematically or 'drill' them in answering harder topics without any real understanding. The 2-tier move has been a catastrophe - and the worse thing is that most people said it would be!
- Grade C students can be de-motivated by the higher level paper, the old intermediate tier was very motivational for grade C, D and borderline B students.
- Higher tier is too difficult for C/B pupils who would have done the intermediate tier. There is too big a divide between higher and foundation tier and it really disadvantages c/b pupils.
- I still feel there is a place for the three tier arrangement. There is more discussion related to C/D border students and their choice of paper than any other topic. With a school of very middle ability students the evidence so far of students achieving a C at foundation is very small (<4%). It may have a motivating factor but is very rarely achieved by this school's students. The evidence I have found is that the C/D grade students mess up the G and F grade questions and therefore do not achieve sufficient marks to be awarded the C. Put these students in for the higher and they finish the exam in 30 minutes.
- I would like 3 tiers but pupils need to be able to achieve a C on the lowest tier. The problem now lies with B/C candidates.

- Intermediate was well suited to middle sets who could achieve a B but not have to study the A and A* topics.
- It compromises the potential grade B students who often cannot cope with the Higher grade material and so struggle to achieve B at Higher. The increased difficulty of the content also reduces the revision preparation time. An Intermediate Tier which focuses on B as its top tier but where C is also more achievable would be welcome.
- It has been difficult to convince borderline (and D/E) students that we probably know best as to what tier of entry they should be entered for and they often want to be entered for higher when they are struggling with C/D grade concepts.
- It has made it extremely difficult for us to choose the tier of entry for C/D borderline pupils. With such a group I have taught all topics to grade B but then there are A and A* topics on their exam that they cannot access and I have delivered these after school for pupils to attend if they wish. Trying to teach the more challenging topics to C/D borderlines can panic them and they switch off!
- It is difficult to know where to enter the C/D boarder-line students. It is really hard to get a C on Foundation, yet it is an emotionally crippling experience to go through the higher with these students
- It is rubbish - the higher tier is too hard for the middle ability students. How can we put students in for a paper when they can't access 50% of the paper? Criminal. We need intermediate back for the middle ability students. Just make C grade available on foundation at around 90%.
- It is very difficult to decide on the tier of entry. Teaching students in a C/B set is difficult as have to try to accommodate Higher and Foundation content. Has been a major problem in our school.
- It was easier to persuade parents that they should do Intermediate rather than foundation.
- Majority of students fall in old Intermediate band. Decision re entry level very difficult - parental view often at odds with that of the school.
- Many of our students find the two tier GCSE harder to start with in the higher tier but the foundation tier is easy and they make silly mistakes. The intermediate tier was just right for the C/D borderline students.
- Middle groups miss the intermediate tier. We end up teaching a similar structure to the intermediate but encounter some conflict from students and/or parents who feel every topic should be covered by all entrants at higher tier. I do feel that you can achieve a B grade but not really be a suitable candidate for AS. I'd be interested to know if there is any collation of statistics of time allocation for KS4 mathematics between schools.
- More difficult for pupils to attain a grade C on foundation due to level of accuracy needed. B grade topics such as cumulative frequency, tree diagrams made intermediate tier more accessible and satisfying to teach.
- Often difficult to decide tier of entry for C/D borderline pupils. Early entry allows change of tier if necessary, e.g. C grade achieved at foundation so pupils move on to higher. Higher tier does not extend or challenge the most able, and does not always prepare pupils well for A-level.

- Our students arrive with a D or below - the 3-tier system was far easier for us to administer where we could enter everyone for Intermediate. We used to get some students with a B and the majority with a C - now the higher tier is too difficult and although some do try it, it is less likely that we can get students to achieve a B. The students arriving from school having studied Higher level are generally OK if they have an A* but otherwise have problems with algebra. Grade Bs struggle and we don't allow Cs to start AS Mathematics.
- Personally I do not like the two tier system. Pupils who are achieving B grades find that a lot of the exam paper is too difficult for them, and they are sitting in an exam Hall for 1hr 45min only able to complete 50-60% of the paper. The three tier system was much better and should of simply of been adjusted to include C grade on the Foundation paper.
- Pupils who are level 6 at the end of KS3 find it very hard to access all the higher tier material. They should be 'good enough' to get Bs, but many don't make it as they get turned off by how difficult most of the mathematics topics appear to be. There is no
- Removal of intermediate level means that B/C students are taking papers in which they cannot answer a lot of questions - not a positive experience. Mathematics has so much negative press and I feel that the nature of the tier system contributes to this. There is too much of a resit culture. It might be good for exam board finances but bad for pupils as they enter in the expectation of not doing well enough. It is important for them to do as well as they can first time around. It is up to staff to enter them when they are ready, not just to have a go for the sake of it.
- Some students find the idea of the Higher tier intimidating, whereas before the "middle" tier encouraged them to really aim at a possible B with a "safety net" of the C. Made it easier for me to decide levels.
- Students previously suited to intermediate for 'B' grade not so easily matched to higher
- Students who are grade B/C do better in the old intermediate maths. They are not good enough for higher tier but too good for foundation.
- The C/D borderline students fall into a gap that they cannot access a lot of the higher level material but in order to get a C on the foundation paper they have to get such a high percentage of the paper correct, which for our students under exam conditions they find hard.
- The foundation paper leaves no room for errors which is what C/D borderline students make. It is a graveyard for grade C's
- The intermediate tier was the perfect situation for borderline C/D students and it gave a chance to get a B grade, the foundation tier for these students is limiting. It is also good for weak higher candidates who struggle with the algebra needed for A*/A. Also now the higher exam has only a smaller proportion of A/A* questions which does not sufficiently exam enough of the difficult material which good candidates will have spent a lot of the previous two years working on. The move to a two tier GCSE for Mathematics was a backward and limiting step.
- The lack of an intermediate tier has caused real difficulty at the C/D borderline in terms of needing a very high score on foundation to achieve a C (and thus the penalty for silly numerical errors being more severe) vs. the frustration of only being able

- The loss of the old Intermediate Tier means pupils in the B/C area have to be taught the Higher syllabus but without covering the full content - some have been unhappy that they are not expected to be able to attempt all the questions on an exam paper.
- The major issue is now trying to get the entries right for those students who might get a B. We have to play safe with these to a large extent. For instance, with our third set who would previously have done the intermediate tier, we now put them in for Foundation Tier in November, and if they get the C, they then go on to try Higher Tier in the following summer. We make certain exceptions however, where some students who were close to getting a C in November, are allowed to sit a Higher Tier mock in March and if they get a C in this, we change their tier of entry to Higher for the summer.
- The problem we have is KS3 Level 6 students do not have enough challenge in Foundation Tier but are not up to Higher Tier.
- The strong grade C student who would be capable of achieving a grade B but would be put off by the A/A* content has suffered by the removal of the Intermediate tier
- The students who would have previously been entered on the intermediate tier and gained a B find the Higher Tier too difficult, particularly Mods 3 and 5, but the Foundation does not challenge them and they get bored and switched off
- The thought was that the new scheme would give low attainers more motivation because a grade C is available does not work. We use a modular scheme and by the end of year 10 the students are already aware of the grade they are likely to get. For C grade candidates the Foundation exams have too large a percentage of marks on relatively easy topics, the assessment should challenge them more. Low grade B candidates are in a difficult position and many revert to the Foundation tier - the old intermediate exam was perfect for these.
- the three tier system was good for those students who were aiming for a B or C as they feel demoralized when they cannot attempt the A* and A grade questions. The fact you can get a C on foundation has helped to motivate weaker students
- The two-tier is arrangement is DEMOTIVATING for the middle attainers - they have to struggle through two years of hard (for them) mathematics with the 'enticing' prospect of achieving less 40% in their final exam for a C or B. In my current school, where no pupil is below the national average in mathematics, girls think they are bad at mathematics because they do feel they are not achieving well at all, even when they are meeting expectations for B or C.
- There is some parental pressure for students to be put in for the Higher when I know the student is not capable of any of the A grade work. The Intermediate paper was far more suitable.
- Those students who would, with hard work target B/C are bored on foundation mathematics but overwhelmed by higher. Even though I assure them they can learn some of the higher mathematics and target a B, the experience of sitting an exam where they cannot access some of the questions is de-motivating for them. I only used to enter students who would be extremely lucky to get a D if they worked hard on foundation, so sitting an exam where C is available has not made a big difference to them either. Having 2 tiers has caused the school to only give us 2 mathematics sets in KS4, rather than 3. It is not what I wanted and I don't believe there have been any benefits at all to the 2-tier system. In the old system, If a student was on foundation and made such good progress that they were scoring high on the foundation papers,

they could be taught a bit extra and entered for Intermediate but we usually got the setting right.

- Three tier system preferable because provided the possibility of a B to C/D candidates
- We don't enter students for the higher paper unless we feel certain they will pass. We enter them early for the foundation paper and let them do the higher paper afterwards if they want to try for a B. I believe this has a negative effect on their final achievement levels, but teacher hours are focused on the D/C kids, driven by league tables, not personal achievement or Value Added.
- We have found that even our B grade students have found Higher tier difficult and have been discouraged. Previously with the Intermediate tier they felt successful. Our C/B students are being entered for Foundation as experience has shown they do better on the Foundation compared to Higher (UMS marks from both tiers when retakes at other level has occurred).

Against – progression (20)

- 2 tier puts too much pressure on those who would previously have been entered at foundation or intermediate level. Higher level students are frequently not taught the full syllabus and are thus ill-prepared for AS level maths.
- A grade B at higher level is insufficient for progress at AS level. These students are the ones who can come out with a grade which looks good but lack the rigours of algebraic manipulation which is essential for success.
- As a Grammar school the old 3 tier system served our needs better with students able to meet a good amount of A* algebra prior to AS, clearly our needs are not representative of all schools
- By dropping higher to a grade D there is not enough room for A* questions. If we are to produce the mathematicians the world will need then we must push the top end as far as we can. By dumbing down higher tier there is less emphasis on harder mathematics leading to a lack of ambition from the very best. Intermediate tier allowed those who were 'quite good' to get a decent grade whilst leaving higher tier with room to stretch and challenge the top. Simply to change something to bring it into line with other GCSEs was very poor. Do not quote that it brought a C grade onto foundation so raising motivation- if you were doing the old foundation you knew you had no chance of a grade C anyway, you may as well put an A grade on it.
- For high achievers the current Edexcel higher tier papers present no challenge whatsoever. Our Y10 top set students typically complete the exam in 30-45 mins. They have mainly done old style past papers so that there are more of the harder questions for them. It is a waste of their time and educationally pointless. Good mathematicians make a lot of arithmetical slips, so the high grade boundaries for A* mean careful students can achieve A* but the best mathematicians may just get an A. For students at our lower end (i.e. the few who are likely to get only a C) the new higher tier is ok, but the Intermediate paper was better. All these students have been taught the whole syllabus and can pick marks up on A and A* questions so I would always teach all the material.
- Higher paper no longer stretches good candidates as much. It's very difficult to achieve a C at foundation so more students (many of whom were suited to intermediate tier) now

have to study higher. Essentially, teaching is still 3 tier in terms of differentiating teaching.

- I am really concerned about Higher tier students not being fully prepared for AS/A2 level and the less able students seem to be working from one module to the next with very little quality teaching time.
- I am unhappy that the Higher exams appear to be getting easier. I have spent 50% of my time in yr 11 teaching A* and high level A grade work to find only one 2 mark question testing A* work on the 2010 non calculator paper.
- It does not stretch the most able and has changed the nature of an A/A* student. Pupils can do well on the higher tier despite having poor algebraic skills. The new higher paper is less good preparation for A level than the old 3-tier higher paper. C and B grade students are put onto the higher tier and can only access about half of the paper - this is discouraging and gives them the impression of a good grade but with little grasp of the subject.
- It is important to stretch the A*/A GCSE candidates to help prepare them for AS Mathematics because 2-Tier Papers examine less top-end content overall. Top Foundation and top Higher Tier candidates can get bored, but trade-off is students leaving Exam Rooms feeling "good about Mathematics" - and this is important.
- It is only good prep for AS level if they are in a top set and achieving a grade A
- Miss the intermediate tier; some students are entered for the higher tier but are unable to access A/A* questions; the higher paper is not a good preparation for A Level because there are not enough questions at the A/A* grade.
- Not enough A* material in higher paper. Some of the brighter student's can't show off what they do.
- Students are presenting for AS level with a grade A GCSE. These students do not have the required algebraic and numerical processing skills. They have experienced a regime of repetitive practice to prepare for a highly predictable paper and are unable to
- The two tier exam is too easy for the most able students - they don't get the opportunity to show their true skills and feel let down with the ease of the exam; neither does it prepare them for A level mathematics. The weakest students struggle with the
- There is a problem here with C grade Foundation students who want to study some of our AS levels (e.g. Chemistry & Applied IT) as they have not done enough Algebra. So these subjects are having to increase their entry grade to a B to ensure they have.
- There is a real lack of A and A* work in the current GCSE. I have students who were Low Level 6 at KS3 getting A and A* on the modular GCSE. This is not good...
- We do modular for the whole cohort. I am very concerned about the A/A* candidates. There are so few questions on the modular paper to differentiate the grade boundaries it is easy for them to miss the A* grade. I am also concerned that Edexcel only award 2.5% A* on the modular because they feel that the brighter students in most schools do the linear paper and the weaker students do the modular, but I know of other schools who only use the modular. (we use linear for our small number of overseas students who arrive at all times during the year, and resits) I like the fact that grade C is accessible to all candidates but feel the top end are not getting enough depth to prepare them for AS mathematics, an A grade is achievable with very little A grade content.

- We have had to change admission to A level to a grade A at GCSE (overall and for the final module) as pupils who achieved B grades cannot cope with it. These are old "intermediate" pupils.
- We insist on a high grade from the Unit 3 exam to gain qualification for AS Level. This is written into our prospectus.

Against – return to three tier (13)

- I feel that the two tiers GCSE is considerably lower than the 3 tiers GCSE.
- I prefer the 3-tier arrangement
- I would prefer 3 tier Higher, Intermediate and Foundation but with possibility of C at Foundation unlike old system.
- Please can we have our Intermediate Tier Back!
- Please, please, please... powers that be... bring back intermediate tier!
- The intermediate was a big loss when it went. We would much prefer the three tier system but with foundation having the opportunity to get a C. We had swapped on to the OCR graduated assessment and are very disappointed it has not been approved for teaching from Sept 2010, it seems to be the most sensible system.
- The old three tier system was MUCH better; however it needed a possible C grade at foundation. A much better system would be to have all students sit two main exams to qualify for a up to a B grade and then have a third paper for students trying to get an A/A*
- The only improvement that could be made is that we go back to 3 tiers but leave the option of getting a grade C in at Foundation, which won't be an option.
- The three tier arrangement was better as the intermediate tier was specifically targeted at the Grade C students. It was unfair that students could not get a C on the Foundation tier even if they achieved a high mark but this could have been addressed whilst retaining the three tier structure.
- The three tier system should have stayed with just an amendment that the Foundation went to C grade as previous Foundation students give up when they realise that they cannot achieve a C grade on the paper even though they would not achieve it. At KS3 students work on 4 tiers 3-5, 4-6, 5-7, 6-8. To then to have condensed this to two tiers at KS4 is ridiculous
- Three tier would be better but with the opportunity to obtain a C on foundation could then make the higher tier better suited to prepare students for A level (possibly A* - B)
- Three tiers of entry was much more suitable for this subject. It led to more coherent teaching, targeted at the ability of each individual. Students should not have to sit an exam where they have not been taught some of the material because it is too hard for them at present.
- We do not have many A* candidates so the Intermediate tier was excellent for about 50% of our students. Even though it is a good thing that Foundation students can achieve a grade C, we are still mourning the loss of an Intermediate tier.

Against – other and multiple (14)

- 3 tier system should have been kept with amendment of foundation tier having access to C grade. 2 tier is detrimental for C / B students, also holds back high achievers as not enough preparation takes place for AS studies.
- Can't afford not to spend time on the grade C and D work due the weighting of marks, but this is at the expense of the grade A and A* work
- Foundation better now that C is allowable, but Higher has been diluted of A*/A content as a consequence. B grade students not well catered for.
- I always felt that the 3 tier system should've been introduced for all subjects, the grade e/f students are in the same position it's just that we can now tell them that 'well of course you could still get a grade C' knowing that they aren't capable of it, as they do in all the other subjects, the problem is 'you must get a C or you have failed' rather than get the best you can
- I do not know any maths teacher, teaching in any kind of school who believes the 2 tier GCSE is an improvement on the previous 3 tier arrangement.
- It is a poor arrangement for all levels of pupils. Top pupils are ill prepared for A-Level. Many pupils who would have previously been Intermediate pupils are de-motivated by a 'very difficult' exam for them. Many lower ability pupils get false hopes about achieving Grade C.
- Previously B grade at GCSE were successful at AS level. 2009 only 20% achieved a pass at AS level. 2010 is looking even worse. Previously 50% of higher was at A/A*. Now 50% is at C/D a student can achieve a B grade without answering a single A*/A or even
- Some borderline C/D students are risk-takers and cope well with the Higher papers; some are sloggers and cope well with the high-accuracy demands of the Foundation paper; some are lazy and it is a difficult call... The current system lets down more students than the three tier did - especially the good intermediate students. Hardest are those that get a B and then believe they are ready for A-level.
- Statement 1: I think there should be a 3 tier system with the intermediate reintroduced as some higher pupils cannot access the harder materials. Statement 2: Although all students should be taught the A*/A material there is no point in spending too much
- The 3 tier system allowed the least able to tackle an exam in which they could more easily demonstrate their skills. Overlapping grades between the tiers allowed for more flexible entry decisions.
- The impact on preparation for further study has been shocking. When will government learn that one size does not fit all?
- Two tier has disadvantaged grade B students. They now have to either learn material beyond their capability (at the expense of being able to consolidate material), or sit a paper which they do not know all the topics. Two Tier has disadvantaged A* students. Too few A* questions allow students to demonstrate ability. Additionally, only a very few errors are permissible before only a grade A is achievable at best.
- We have to careful what we do and don't teach to students aiming for grade B.
- With three tier, it was much easier to understand the background of a student. Knowing that a student had completed the old Higher tier (even if they had only achieved a grade B) meant a reasonable expectation that they had been exposed to all the Higher

Other and mixed (23)

- 2 Tier not good for most able students, but better for motivation of Foundation Tier students. All Higher Tier students should be taught some A/A*, but not necessarily all.
- 3-tier was kinder to the grade C student who aspired to a B. Now, a typical grade C student will be petrified of the Higher paper and only exceptionally do we find such students doing Higher. A pity. And this leads to more Foundation entries and grade Cs at the expense of B grades. This is outweighed by the better motivation of C/D/E students who are less likely to give up. It might be impractical but the old 3-tier Higher and Intermediate papers and the current Foundation would be best for us. In particular the current Higher doesn't stretch the ablest in the same way as the old paper did.
- Although the low ability students have gained from the move in terms of motivation for top students to achieve an A* comes down to their ability to be accurate rather than their deep understanding of the whole curriculum as there are too few A* questions
- Better for lower attaining students. Not so good for A/A* students.
- Books for old Inter students don't seem to be available. Teaching B/C students from Higher books a nightmare.
- Early entry would give pupils the opportunity to see where they are at. Many do not agree (or are in denial) of their situation until they see official results. With the advent of target grades, they seem to believe that the target grades they have been set is what they will achieve or even have achieved!
- Generally a positive change for low and middle ability students. Recent exams have not provided the challenge or opportunity for higher ability candidates.
- Good for weaker students (motivation) but does not extend top students enough. Discouraging for the hard working B grade students- the old Intermediate paper worked for them.
- Intermediate suited those aiming for a B, but Foundation was de-motivating because grade C wasn't available
- It is much better for "real intrinsic" Foundation students to be able to get a grade C. The higher exam is in our opinion too easy which means many more students can access it (without being able to do any real algebra/geometry) and it definitely does not meet the needs of the more able and G and T students and makes the jump to AS far too great. Not ours, but some schools don't teach sine/cosine rule at all as it doesn't appear on the exam papers, nor the quadratic formulae or any complex algebra and students can still get A grades. I don't like this.
- Linear is a better preparation for AS than Modular
- Our lower attainers were at C & B and the intermediate tier was perfect for them. The Higher tier covers way too much material and it reduces the challenge and satisfaction for high attainers. GCSE is too easy for top 10% and we have to supplement with Add Mathematics to properly prepare for A level Mathematics/Further Mathematics.
- Our students leave at the end of year 11. Some go onto college, but very few have continued the study of maths.
- Some of these statements need to be applied to individuals in order to make a judgment

- The change has seen a reduction in the number of students attaining grade B from our centre. It is hoped that our early entry policy will see an improvement in this as students who have already attained a grade C in November of year 11 have been able to concentrate on grade B material for all, and grade A for a minority.
- The new 2 tier GCSE works well for the more & least able students, although so far the questions seem to mirror the old Intermediate tier papers, rather than the Higher - there are few questions to really stretch the most able.
- There are a large number of B-grade students that find the A* and A material too difficult, especially the algebra. However, many of them can cope with 3-D coordinates and circle theorems.
- these questions are not making the distinction between modular and linear
- This is only place I can put this comment even though it does not answer the question. As a result of changes to GCSE all my pupils will now be entered for the IGCSE.
- Two tier is definitely better for the lower attaining students who may just achieve a grade C but not so good for the top end students who do a large part of their exam as c/b material.
- Undecided as to which is better for our students, difficulties arise with those who are borderline B/C, entering them for higher means there will be a large proportion of the paper that they cannot access, so they are only being tested on a small part of their knowledge. However it wouldn't be right or fair to enter them for Foundation level.
- Weaker (for our school) GCSE students often like Maths at GCSE level and mistakenly choose it as an AS choice without being able to appreciate the different demands beyond GCSE
- Whilst the opportunity to achieve a 'C' at foundation tier is a huge improvement, the two tiers make it a real gamble to the last minute before the exam as to which tier to enter the students in. It is also very off-putting for the C/D borderline students to know there are big chunks in the paper they can't do. It really affects their confidence. I would really welcome an intermediate tier but I would also like to keep the 'C' grade in the foundation tier.

APPENDIX A4: Reasons to take part (or not) in the linked pair pilot

Reasons that influence decision to take part:

Preparation for A level (1)

- The higher tier also looks like it will prepare higher attaining students for A-level

Applications/Functionality (4)

- More opportunities for Applications of Mathematics...and double Mathematics points for students
- The OCR linked pair gives some flexibility on entry levels and we will hopefully be able to target the right content at the right students. The financial literacy content is a good development and is of educational value for the students.
- To reinforce the teaching of functional mathematics, mathematics with relevance; to make mathematics more accessible and to allow for more cross curricular activities
- More examples of how mathematics can be used in the real world with the applications paper.

Stretch and Challenge (5)

- Apart from 2 GCSEs, it has 'in built' early entry' to keep management happy. The mathematics is far more challenging, this will be the future so get in now,
- As a grammar school we needed something else to stretch our students but Additional Mathematics wasn't working. Linked Pair has the potential to solve our problems as well as give parity with English and, to a lesser extent, Science.
- It seems more challenging than the current GCSE and I would like to push our pupils a little more.
- The opportunity to stretch high attainers.
- Will offer more Mathematics for able students who are keen to do something extra; in the past we have offered GCSE Stats and Add Mathematics - but I feel Twin Pair will be better option.

Advanced preparation (4)

- We are a mathematics specialist school and felt it would be appropriate for us to pilot.
- Prior knowledge is a good thing
- Since the plan is to have 2 GCSEs by 2015, we might as well start with the pilot now which will help us prepare for 2015, assuming the government gives the go ahead!
- Was not part of pilot for functional mathematics and felt unprepared.

Maths should be worth two (7)

- By awarding two GCSEs there is, at last, acknowledgement that Mathematics GCSE is more demanding and needs more time than other GCSEs. The students will be able to get an extra qualification, with some extra content, but with no need for additional teaching time
- ENCOURAGED BY SOME COLLEAGUES WHO SIGNED UP FOR IT. ALSO WOULD LIKE TO GIVE EXTRA TO OUR G&T GROUP BY ALLOWING THEM TO GET 2 MATHS GCSEs.
- Have always thought that content of GCSE mathematics, particularly at higher tier, is the same as two GCSEs in other subjects. More difficult than most as well.
- Mathematics worth more than 1 GCSE + want to be in at the beginning
- Mathematics should be worth more than 1 GCSE.
- We have entered students for the Additional Mathematics paper for OCR for 4 years with increasing success and feel that 2 GCSE Mathematics grades is a fair reflection for the effort we put in over 11 years
- A good opportunity for students to have two chances to achieve a C and help them see

Double points/Two bites at the cherry

- Our students can have two GCSEs in Mathematics just like in English and Science. I also feel our students will perform better in Methods.
- The chance to gain TWO GCSE Mathematics qualifications – we currently also do the GCSE Additional Mathematics exams
- The opportunity to gain two qualifications (as now) as we do the GCSE Additional Mathematics Pilot too
- Also for middle attainers they only need one C for their C in mathematics so we are hoping this will increase results
- The prospect of students possibly gaining two GCSEs. The possibility that a borderline C/D student might be able to get a C on at least one of the pair.

Reasons that influence decision NOT to take part:

Other pressures/priorities (21)

- Department too much in flux with staffing to do anything other than concentrate on necessary changes for GCSE
- Enough already on our plate. Prefer to see the outcome before jumping in.
- Far too many things to be planning at the moment to get involved
- New management, new head of dept, new teachers - too much to take on.
- Not able to spare the additional time needed to take part in a pilot.
- No time to do anything else new - enough changes already!
- Not enough time

- No time to plan and implement with many other more pressing initiatives/targets.
- the department is going through too much change at the moment, we felt it better not to take on a pilot
- Time and structural change in the college have prevented the department taking part.
- To NOT take part...extra work and no guarantee that the final linked GCSEs will even go ahead let alone go ahead in the pilot form.
- Too busy
- Too many initiatives. Need time to concentrate on main issue- new GCSE. Overall feeling that no qualification lasts for more than 2-3 years WHY?
- Too many other changes going on (not just do with mathematics) to be able to focus on another change
- We would have been a pilot but we are just opening a sixth form and it would have been too much on top of that
- We are currently compressing our KS3 curriculum in the school, so we did not want to be trying new things in more than one key stage.
- We are introducing a large number of other new options and qualifications in the mathematics department his year including a new cohort of year 7 for the first time.
- We have a very small cohort and so would not be a useful centre, would have helped us though
- Did not want to be distracted from the many tasks already on the agenda
- Prefer to deal with the new changes introduced before making yet further changes.
- Cohort very small. Decided independent parents wouldn't want more exams for their daughters!

Staffing Issues (4)

- Staffing issues - we are going to be two experienced teachers short due to maternity leave and an inexperienced new teacher
- We have a very inexperienced mathematics team and they are only just getting to grips with the most recent changes so I think it would be too much to take on this pilot.
- At this point I have insufficient depth of expertise in my department for them to deliver the pilot with confidence and without significant risk.
- I was going to enter, but I wasn't sure if I would be staying as HOD in the school so I thought it unfair to take on the pilot

No perceived benefit (3)

- Did not think it would benefit our students.
- Linked pair does not offer the advantages I hoped.
- Getting our pupils through one GCSE in two years is hard enough already.

Unaware/Not asked/not allowed/advised (8)

- No-one asked us as far as I'm aware. But even if they had, we have enough to do without taking part in untested qualifications.
- I applied to be a pilot school but we were not chosen.
- We were unaware of the pilot until too late
- We applied to be part of the pilot but have not heard back. I would have put them all in to have a go.
- We weren't asked! We do have a lot of change at the moment, so it probably would not be appropriate for us anyway.
- Wanted to be but applied too late!
- Not my decision, I would like to have been involved.
- Advice from LEA

Against pilots in general (4)

- Not prepared to mess about with this rubbish
- Prefer not to be involved in pilots in general
- We have had a number of changes in recent years and the pilots have often been very different to what has actually happened in the end. We don't want our students to be guinea pigs.
- It is completely unprofessional to experiment on students - whatever academics that keep coming up with these changes should test it themselves.

Other (7)

- I trialled the papers with my current Y11 and they did not like the style/format of the questions. I do like the range of additional topics though, such as business links.
- It happened too quickly, and is open to abuse. It would be easy for a school to focus on what was perceived as being the 'easier' option.
- It was just a means to get more students a GCSE in mathematics (in my opinion).
- Our cohort is too small for the pilot study.
- We are a small school (120 in a year), all students currently take the same type of exam. No extra teaching time was available for the subject.
- Not applicable. Switched to IGCSE because of the seemingly annual changes to GCSE.
- Will not take part because it is only a modular option and we want our pupils to enter a linear specification in preparation for A level

Appendix B: Use of Mathematics survey

Contents

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Part A: Sample Description

1. Overall description and 'movement' from GCSE schools

This analysis is based on the responses of a total of 948 students distributed among the 27 centres which participated in the surveys, as follows:

Table 20: Responses by Educational Centre

Type*	Age range	Frequency	% of sample	% of students within Centre who moved since GCSE
Comp	11-18	27	2.9%	11.1%
Comp	11-18	10	1.1%	20.0%
Comp	11-18	26	2.7%	0%
Comp	11-18	16	1.7%	6.3%
Comp	11-18	7	0.7%	42.9%
Comp	11-18	10	1.1%	0%
Comp	11-18	14	1.5%	14.3%
SEL fd	11-18	20	2.1%	0%
FE	16+	63	6.7%	98.4%
GFEC	16+	26	2.7%	96.2%
GFEC	16+	32	3.4%	100%
GFEC	16+	31	3.3%	96.8%
GFEC	16+	31	3.3%	93.6%
GFEC	16+	46	4.9%	75.0%
GFEC	16+	49	5.2%	100%
SFC	16+	5	0.5%	100%
SFC	16+	143	15.1%	95.8%
SFC	16+	7	0.7%	85.7%
SFC	16+	26	2.7%	100%
SFC	16+	59	6.2%	94.9%
SFC	16+	23	2.4%	86.4%
SFC	16+	53	5.6%	96.2%
SFC	16+	45	4.8%	97.7%
SFC	16+	12	1.3%	91.7%
SFC	16+	10	1.1%	90.0%
SFC	16+	26	2.7%	96.2%
SFC	16+	131	13.8%	93.0%

*Centre classifications are taken from the DfE's achievement and attainment tables (http://www.education.gov.uk/performancetables/)

Comp – Comprehensive (here including all maintained schools)
SEL fd – Selective Foundation school
FE – Further Education
GFEC – General Further Education College
SFC – Sixth Form Centre

Table 21: Distribution of students based on 'movement from GCSE school'

		Frequency	%	Valid %
Moved to a different school/college?	Yes	777	82.0	83.5
	No	153	16.1	16.5
	Total	930	98.1	100.0
Missing	System[7]	18	1.9	
Total		948	100.0	

The vast majority of the students (83.5%) reported that they have moved to a different school from the one in which they had completed their GCSEs (see Table 2 for details). For the 777 students who changed schools, the type of the school where they did their GCSEs is reported below, according to their reports:

Table 22: Distribution of students by the Type of GCSE school they moved from

		Frequency	%	Valid %
Type of GCSE school	11-16	606	63.9	78.1
	11-18	150	15.8	19.3
	Other	20	2.1	2.6
	Total	776	81.9	100.0
Missing	System	172	18.1	
Total		948	100.0	

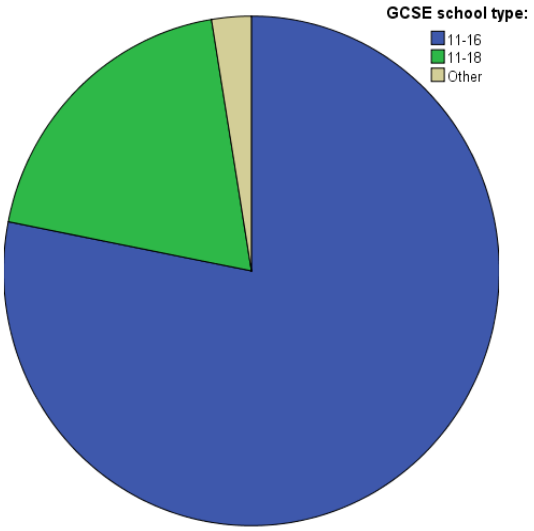

Figure 20: Pie chart of students by GCSE school

However, further investigation of the 'other' category in combination with the information about the students who did not change school, led to a more comprehensive categorisation of the 'type of GCSE school'. This resulted with the following three categories of schools:

Up to 16: Mainly schools defined as 11-16 but also some schools with younger students as well

Through 16: Mainly 11-18 but also some 14-18 schools

From 16: Sixth Form Colleges and FE colleges

It should be noted that the 'other' category was further investigated in relation to information given by students, and in most cases the reported school was fitting into one of the three categories with only a few exceptions (e.g. 'home educated' and some international schools with no clear description regarding their type).

Table 4 and Figure 2 show the distribution of all the students, independently of whether they moved school or not, based on the type of their previous school:

[7] System missing defines the number of students within the sample who did not give a response at the question/variable under investigation. These are reported to show the differences between the overall and 'valid' percentages. Hence "valid %" represents the % when excluding from sample the 'system missing' responses.

Table 23: Distribution of students by the Type of GCSE school (revised) they moved from

		Frequency	%	Valid %
Type of GCSE school	Up to 16	610	64.3	65.5
	Through 16	273	28.8	29.3
	From 16	49	5.2	5.3
	Total	932	98.3	100.0
Missing	System	16	1.7	
Total		948	100	

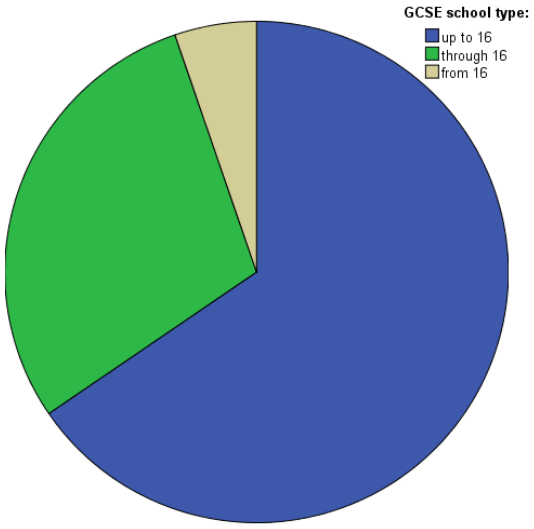

Figure 21: Pie chart of students by GCSE school (revised)

Table 5 shows the distribution of students who changed institution, across GCSE school type, by gender.

Table 24: Distribution of students across Type of GCSE School by gender

Type of GCSE school		Gender		
		Male	Female	Total
Up to 16	Count	386	173	559
	% within Gender	68.4%	61.3%	66.1%
Through 16	Count	151	98	249
	% within Gender	26.8%	34.8%	29.4%
From 16	Count	27	11	38
	% within Gender	4.8%	3.9%	4.5%
Total	Count	564	282	846
	% within Gender	100.0%	100.0%	100.0%

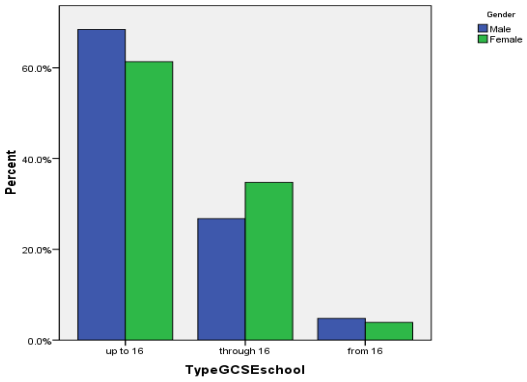

Figure 22: Type of students' GCSE school by gender

The apparent gender differences between the students' distribution, as also shown in Figure 3 hint at some interesting distinctions but are not statistically significant [Pearson chi-squared=5.826, df=2, p= 0.054].

2. Background and demographic characteristics

This section presents the description of the sample based on students' reported background information (i.e. gender, ethnicity).

2.1 Gender

Table 6 presents the gender split of students in the sample. As can be seen, 9.4% of the initial sample did not respond. From the remaining responses (N=859) the majority are male students (66.4% compared to 33.6% female). This is very similar to the proportions in the full cohort according to AQA's data, in which 66.5% of Use of Mathematics students are male.

Table 25: Distribution of students by gender

		Frequency	%	Valid %
Valid	Male	570	60.1	66.4
	Female	289	30.5	33.6
	Total	859	90.6	100.0
Missing	System	89	9.4	
Total		948	100.0	

2.2 Ethnicity

Students were asked to record their ethnicity by selecting the group they regard themselves to belong to, from a list of 16 choices (Item 23 of the questionnaire). The distribution of students' responses in regards to these initial ethnicity categories are shown in Table 7.

Table 26: Distribution of students based on initial ethnicity categories and recodings

		Frequency	%	Valid %		Recoding N (%)
Valid	White British	653	68.9	77.0		White (British)
	White Irish	15	1.6	1.8		668 (78.8%)
	Any other White background	21	2.2	2.5		
	White and Black Caribbean	8	.8	.9		
	White and Black African	3	.3	.4		Other Mixed -> Other
	White and Asian	6	.6	.7		56 (6.6%)
	Any other Mixed background	8	.8	.9		
	Any other ethnic group	10	1.1	1.2		
	Indian	31	3.3	3.7		
	Pakistani	15	1.6	1.8		Asian
	Bangladeshi	21	2.2	2.5		99 (11.7%)
	Any other Asian background	23	2.4	2.7		
	Caribbean	6	.6	.7		
	African	16	1.7	1.9		Black -> Other
	Any other Black background	3	.3	.4		25 (2.9%)
	Chinese	9	.9	1.1		
	Total	848	89.5	100.0		
Missing	System	100	10.5			
Total		948	100.0			

An initial grouping of these categories split the students into White British, Asian, Other Mixed and Black students (as shown with the colour coding in Table 7). However because of the small

number of students in the 'Black' category and 'theoretical assumptions' for keeping the 'Asian' group as a useful category, ethnicity was finally recoded as a three-category variable.

3. About Use of Mathematics: Students' Level and Year of Study

Students were also asked to report which year they were in, and the level of Use of Mathematics they were studying at the time of the survey. According to the results, 75% of the sample are students in their AS year of Use of Mathematics (N= 707) compared to 25% who are on the A2 year (N=237). Table 8 shows the distribution of the sample based on their year of study, and Table 9 presents the cross-tabulation of the level and year of study (with both column and row percentages).

Table 27: Distribution of students based on their Year of study

		Frequency	Percent	Valid %
Valid	Year 12	575	60.7	61
	Year 13	310	32.7	32.8
	Year 14	27	2.8	2.9
	Other	31	3.3	3.3
	Total	943	99.5	100.0
Missing	System	5	.5	
Total		948	100	

Table 28: Cross-tabulation of Level of Use of Mathematics studied and Year of study

Year of study		Level of Mathematics		
		AS	A2	Total
Year 12	Frequencies	571	4	575
	% within Year of study	99.3%	.7%	100.0%
	% within Level of Mathematics	81.1%	1.7%	61.1%
	% of Total	60.7%	.4%	61.1%
Year 13	Frequencies	92	217	309
	% within Year of study	29.8%	70.2%	100.0%
	% within Level of Mathematics	13.1%	91.6%	32.8%
	% of Total	9.8%	23.1%	32.8%
Year 14	Frequencies	12	15	27
	% within Year of study	44.4%	55.6%	100.0%
	% within Level of Mathematics	1.7%	6.3%	2.9%
	% of Total	1.3%	1.6%	2.9%
Other	Count	29	1	30
	% within Year of study	96.7%	3.3%	100.0%
	% within Level of Mathematics	4.1%	.4%	3.2%
	% of Total	3.1%	.1%	3.2%
Total	Frequencies	704	237	941
	% within Year of study	74.8%	25.2%	100.0%
	% within Level of Mathematics	100.0%	100.0%	100.0%
	% of Total	74.8%	25.2%	100.0%

Given the complex ways in which students follow different curriculum pathways, at differing speeds and including retakes, we wanted to be able to identify the main, homogeneous groups for analysis. There are three interesting categories of students in the sample: Year 12 (Y12) AS

Students (N=571), Y13 AS students (N=92) and Y13 A2 students (N=217). In order to develop a combined variable to describe the Level and Year group of students these three categories were initially selected. Y12 A2 students were not considered for this variable due to their small number. In the 'other' category the majority of the students come from the same school (School Number 17) and most of them are younger students compared to the rest of the sample. This might be a year 11 group and are therefore considered atypical. The 'other' category was incorporated into the new combined variable, and the composition of this group should be kept in mind when considering the further analysis.

The distribution of the students on this combined variable is shown in Table 10, together with the gender split. It should be noted that gender percentages are more uniform, and without any significant difference [Pearson chi-square=1.076, df=4, p=0.898].

Table 29: Cross-tabulation of combined Level of Use of Mathematics/Year of study and gender

Year/Group_Level		Gender		
		Male	Female	Total
Y12-AS	Count	348	181	529
	% within Gender	61.3%	63.1%	61.9%
Y13-AS	Count	52	28	80
	% within Gender	9.2%	9.8%	9.4%
Y13-A2	Count	136	60	196
	% within Gender	23.9%	20.9%	22.9%
Total (including Y14/Other)	Count	568	287	855
	% within Gender	100.0%	100.0%	100.0%

4. Students' previous attainment

Under this section students' self reported previous attainment is presented.

4.1 GCSE Mathematics, Science and English Grades

In question 2 students were asked to report their grade in GCSE English, mathematics, and science. Because of the variety of grades reported by the students, some recoding was necessary. This led to the construction of a 4-category variable for each of the subjects. The 4 categories can be described overall as (i) A and A*, (ii) B, (iii) C and (iv) D and below. Table 11 shows how this classification was performed with GCSE mathematics, whilst details about English and science are presented in Appendix 1.

Table 30: Initial frequencies and recoding of GCSE mathematics grades

	Frequency	%	Collapsed Category
Grade	28	3.0	No response
A	94	9.9	
A*	4	.4	A or A*
AA	1	.1	
AB	2	.2	
B	458	48.3	B
BA	1	.1	
BB	4	.4	
BC	5	.5	
C	340	35.9	C
CB	1	.1	
CC	5	.5	
D	5	.5	D
Total	948	100.0	

The distribution of the students' grades for each core subject is presented in Table 12.

Table 31: Distribution of students based on their GCSE grades at core subjects

	GCSE		
Grade	Mathematics	English	Science
A and A*	99 (10.8%)	89 (9.8%)	90 (10%)
B	465 (50.5%)	296 (32.7%)	351 (39%)
C	351 (38.2%)	448 (49.5%)	390 (43.3%)
D (and below)	5 (0.5%)	72 (8%)	70 (7.8%)

As can be seen from Table 12 and Figure 4, the percentages of students with A and A* are very similar in the three core subjects. However, more than 50% of students achieved a B in mathematics compared to considerably lower percentages in science (39%) and English (32.7%). The most common results in these subjects are grade C (43.3% for science and 49.5% for English). There are also higher percentages of lower grades (D and below) in English and science compared to mathematics. These data might indicate that this cohort achieved slightly higher on average in mathematics than in science and English and this might explain their interest in pursuing level 3 mathematics.

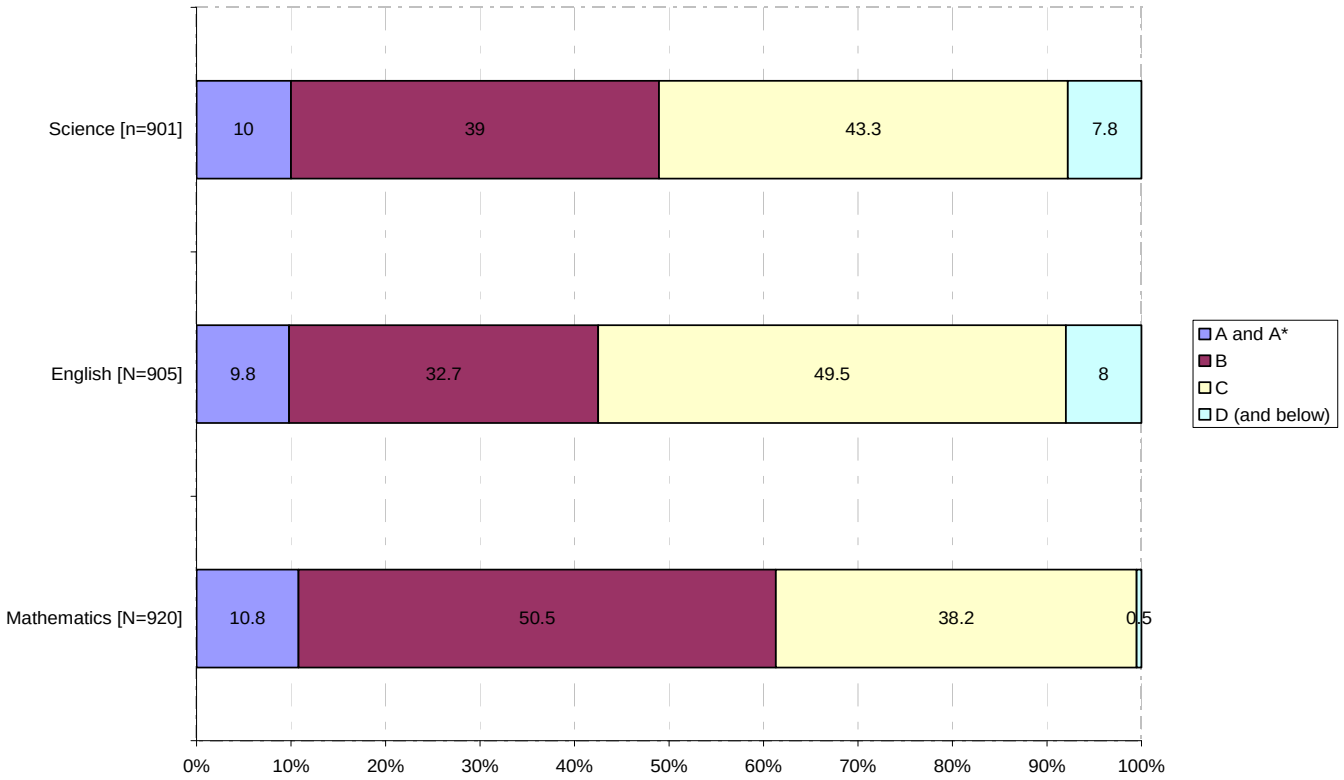

Figure 23: Students' GCSE grades in mathematics, English and science

Part B: How did students come to do Use of Mathematics?

1. Reasons for deciding to do Use of Mathematics

In order to understand the reasons behind students' decision to study Use of Mathematics, they were asked to respond to two open ended questions. The first one asked 'Why did you decide to study Use of Mathematics?' (Question 6). The second one was targeted at students who had initially considered studying A Level Mathematics rather than Use of Mathematics, and asked 'Why did you decide to do Use of Mathematics instead?' (Question 7). In this section we include a methodological note on the derivation of some meaningful categories from students' responses followed by further analysis of the derived categorised reasons.

1.1 Classification of reasons for deciding to do Use of Mathematics

Students gave a variety of responses to the question of why they decided to study Use of Mathematics. Some of these responses are listed below:

- To back up Psychology e.g., the stats from Use of Mathematics.
- I wanted to take a mathematics subject to help with my other subjects.
- it looked more interesting and less complex than proper mathematics
- I wanted to continue mathematics but thought AS mathematics would be too hard.

- Needed to do a mathematics course for Physics.
- Because I am interested in mathematics but not in a career choice way.
- I enjoy mathematics
- I like to apply my knowledge to practical things.
- Because I enjoyed mathematics.
- I enjoyed it. Found the work understandable.
- Because I wanted a Mathematics A level but thought normal mathematics would be too hard.
- Because it was a last choice and I had no choice!
- Because it was in conjunction with my physics
- Because I was not clever enough to do real mathematics.
- Complimented Biology.
- wanted to study less conventional courses
- it looked easier than proper mathematics
- to take physics I need a mathematics subject
- I felt I needed to further my mathematics education
- Mathematics was relevant to my other subjects
- I enjoyed mathematics and wanted to carry it on
- it seemed interesting as it was a different approach to mathematics
- it is used in real life situations
- Mathematics is a good thing to have on your CV
- Normal mathematics is too hard. Using Mathematics in life is another reason.
- Wanted to do some sort of mathematics and could not get the grades for mathematics and further mathematics.
- Offered more units that are more representative of mathematics used in real life.
- Told that normal mathematics would be too hard. Still wanted to take mathematics so this was the next option.

These qualitative statements could be grouped into eight categories, as shown in Table 13. Examples of students' statements are listed on the right column of the table.

Table 32: Categories of students' reasons for choosing Use of Mathematics with example statements

	Category	Example reasons
1	Prior Attainment	I didn't get a B in GCSE mathematics
2	Advice/Direction	I was forced. Teacher recommendation

3	Positive Disposition (Enjoyment/Interest)	I enjoyed mathematics at GCSE.
4	Easier than… (AS traditional, other,…)	Because I thought it would be easier than Pure Mathematics.
5	Negative towards traditional mathematics (Including dropout)	Failed A level mathematics. I originally did mathematics but found the course irrelevant and that I did not enjoy it.
6	Use value/Applications (to other current subjects,…)	…what drove me to choose Use of Mathematics was the ability of using it in real situations. Because it's different and it allows me to apply mathematics to the real world.
7	Future needs (Courses, careers)	Helpful for preferred career path. Because I need it for my forensic science course at uni'.
8	Exchange value (UCAS, …)	Because it is a good subject to have to go to University. To get enough UCAS points so I can attend University.

It should be noted that some students reported more than one reason in their statements so two relevant variables were derived from this coding.

As already mentioned, the 579 students (61% of total sample) who responded positively to the question 'Did you consider studying A level Mathematics instead of Use of Mathematics?' (Question 7a) were also asked to give their reasons for this decision. Some of their responses are listed below:

- Because I struggled to cope with the workload in A level mathematics.
- I was advised to take Use of Mathematics instead because of my grade
- Mathematics is too time consuming to mix with my other subjects
- Because in the end it looked more interesting and I didn't get the expected grade.
- I didn't think I would be good enough for mathematics.
- Use of Mathematics seemed more understandable.
- The college suggested that Use of Mathematics would suit my level better than Mathematics
- Because it will help me in my future career and university.
- It was recommended to me as an easier mathematics course to help with Physics.
- I was advised to take Use of Mathematics instead of traditional mathematics because I might find tr
- Because I did not feel that I would be capable of the work in AS mathematics.
- At the Open Day the man giving the talk was very discouraging and said effectively unless you have
- I believe the workload with other subjects would have been too great.

In this case, their statements suggested that there were five main categories (see Table 14). In addition some students mentioned reasons related to exchange value (e.g. it is easier to get a grade with Use of Mathematics) and even though the frequency of this response is very low, because of its potential interest, it was included as a sixth category (Table 14):

Table 33: Categories of students' reasons for choosing Use of Mathematics instead of AS mathematics

	Category	Example reasons
1	Difficulty (AS traditional is hard, Use of Mathematics	The other mathematics courses sounded hard and complicated. The course looked easier.

	easier, …)	
2	Self-efficacy (not clever, low confidence,…)	Wasn't clever enough. didn't have confidence in my ability to cope with A-level mathematics Because I did not feel that I would be capable of the work in AS Mathematics
3	Advice/Direction/*Forced* (because of grades)	Was not able to take A level as I had not achieved the appropriate grades. They would not let me. it was compulsory
4	Tried AS traditional and was hard or failed	I did study it and found it too difficult. Failed AS mathematics previously.
5	Use value/Applications/ Interesting	Seems to be more general and practical than normal mathematics. More realistic to the world
6	Easier to get grade (exchange value?)	Because I had a higher chance of passing Because I thought I might get a better grade in Use of Mathematics.

In addition, some interesting student statements for category 5 (i.e. use value/applications/interest) are listed in Appendix 2.

1.2 Why did you decide to study Use of Mathematics?

In this section the categorised reasons of students for choosing to do Use of Mathematics will be presented based on background and other variables like students' gender, other courses, school and previous (mathematical) attainment. Most of the results are based on students' first reported reason (whenever there were two or more reasons given).

First, Figure 5 shows the overall percentages of each reason as given by the students. As can be seen, the most common reason is 'positive disposition' towards the selected Use of Mathematics course (reported by more than 25% of the students). Second most popular reason is the use value and applications. These two responses are clearly very different from the remaining reasons, the remainder of which were cited with similar frequency (approximately 10%), with the exception of the 'easier than…' reason which was reported by approximately only 5% of the students.

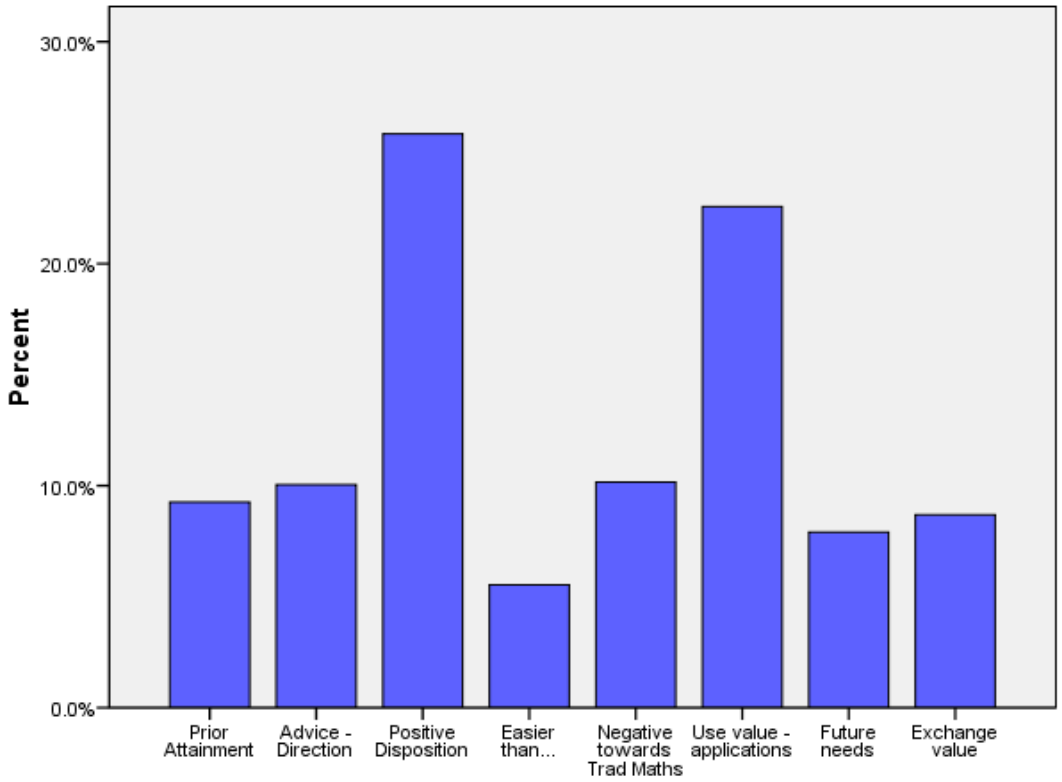

Figure 24: Bar chart with percentage of Students' reasons for choosing Use of Mathematics (Q6)

Figure 6 shows the distribution of the reasons based on students' gender. It should be noted that the percentages are within gender (i.e. the sum of the percentages for all reasons for each gender group totals 100%). The figure shows some differences in male and female students' reasons. The most apparent one regards the 'positive disposition' which is much more common within the female group compared to the male one. In addition, reasons like 'exchange value', 'use value' and 'prior attainment' are more popular for male students.

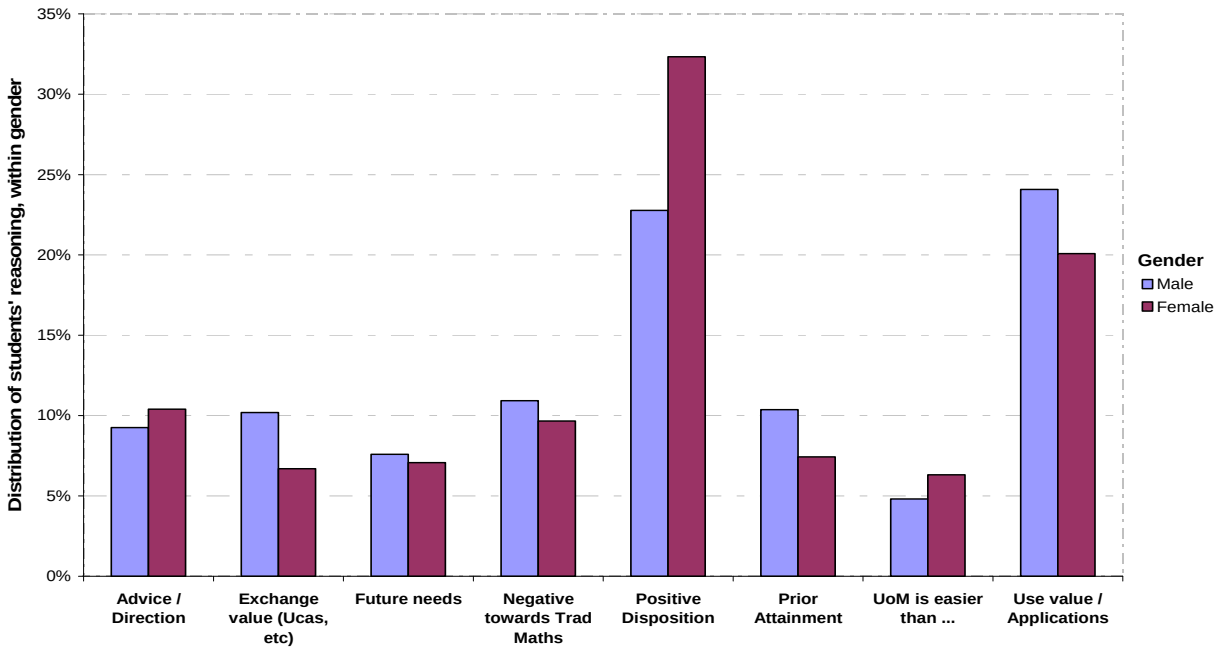

Figure 25: Students' reasons (Q6) by gender (% within gender)

The distributions of students' reported reasons for choosing Use of Mathematics is presented in Figure 7 based on GCSE school type. There are only a couple of observations for possible differences based on this variable: First, 'advice and direction' was reported in higher frequency from students coming from 'through 16' schools (e.g. 11 to 18). For the same group of students 'prior attainment' is less popular as a reason compared to the students coming from other school types. Another observation is regarding the students coming from 'from 16' schools for whom 'negative attitudes towards traditional mathematics' was not reported as a reason for their choice to do Use of Mathematics. These are probably students from other colleges who had not previously been studying, or considering, A level mathematics and so for whom the comparison was not important.

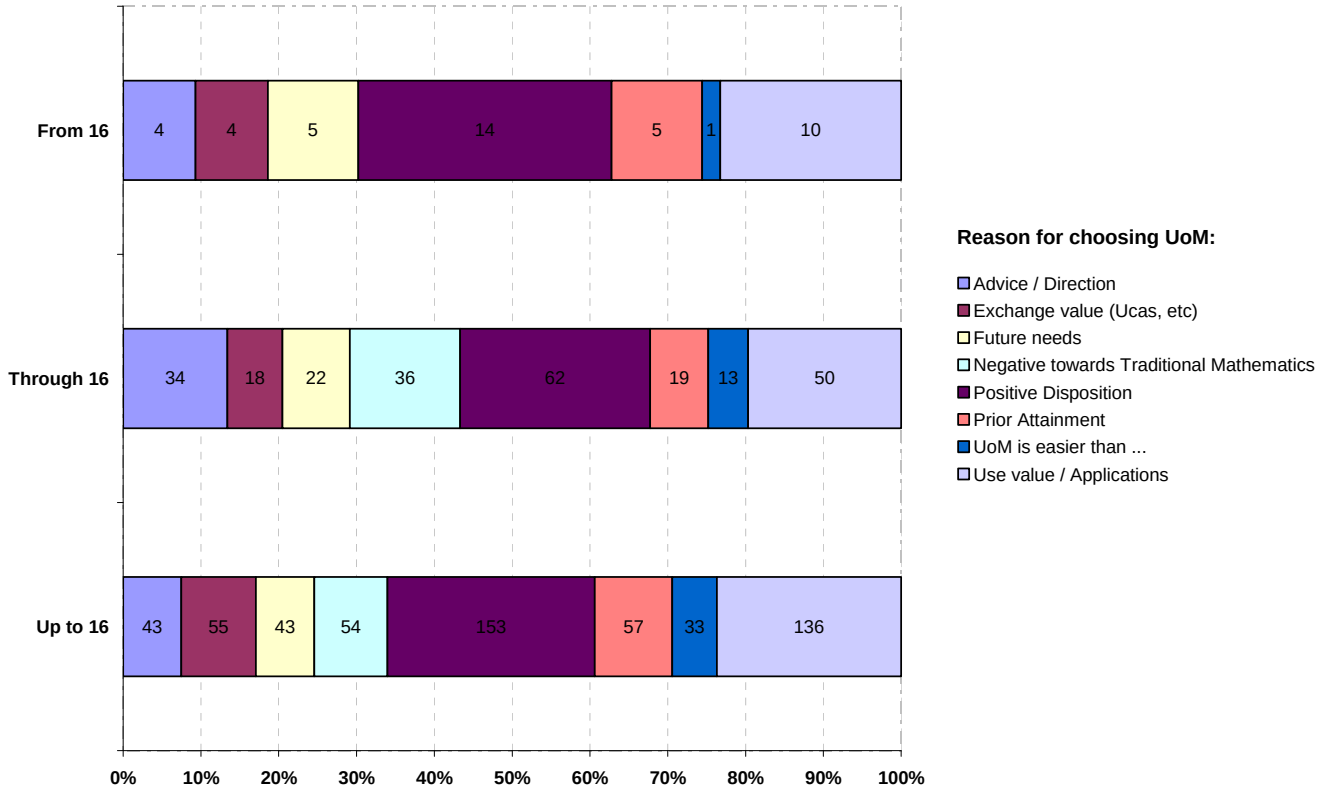

Figure 26: Students' reasons (Q6) distributed by their GCSE school type

Figure 8 shows how the students' reasons are related to their previous mathematics attainment. As can be seen, for students with GCSE grade A 'negative attitudes towards traditional mathematics' and the 'Use value/applications' aspect of Use of Mathematics are the main reasons for their choices. They reported these reasons comparatively more frequently than students with lower grades. It is unsurprising that these are the students that might be more negative towards traditional mathematics as they would be targeted in recruitment for that course, whereas students with grade B would, in general, not be as strongly encouraged into traditional mathematics. For students with grades B or C the most popular reasons are 'positive dispositions towards mathematics' and 'use value'. As expected, students' with lower grades tend to report 'prior attainment' with higher frequency. The same pattern is also observed for 'exchange value' and 'future needs'.

Figure 9, shows the distribution of students' reasons based on their Year Group and level of study. One interesting observation regards the 'other group' which as already mentioned mainly involves younger students from mainly one school: as can be seen the most popular reason for these students is 'advice/direction' which implies some particular policy of this school. For AS students the distributions of their responses are very similar when comparing the Y12-AS with the Y13-AS; minor differences involve the increased popularity of 'prior attainment' and 'Use of Mathematics is easier' for the Y12 students, and 'use value' and 'exchange value' for the Y13

students. 'Prior attainment' and 'advice/direction' are also more frequently reported reasons by the Y13-A2 students than the Y13-AS.

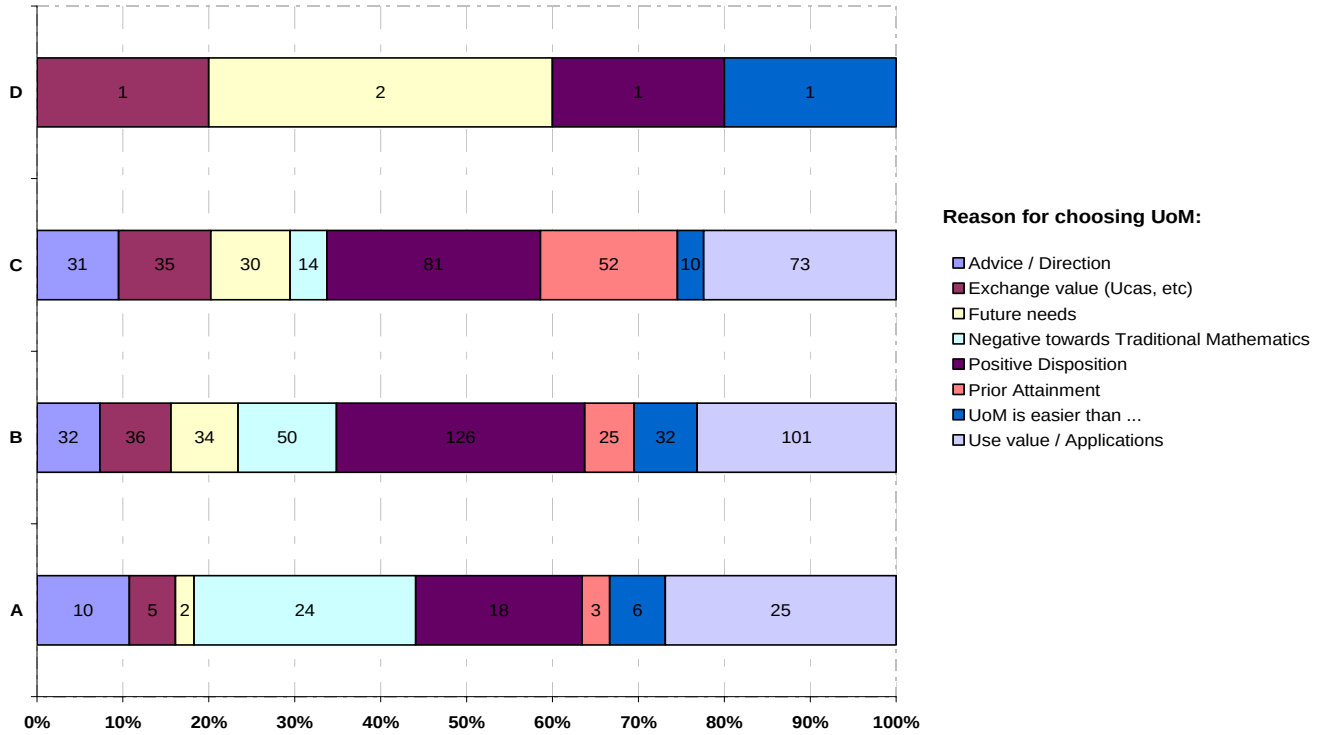

Figure 27: Students' reasons (Q6) by their GCSE mathematics grades

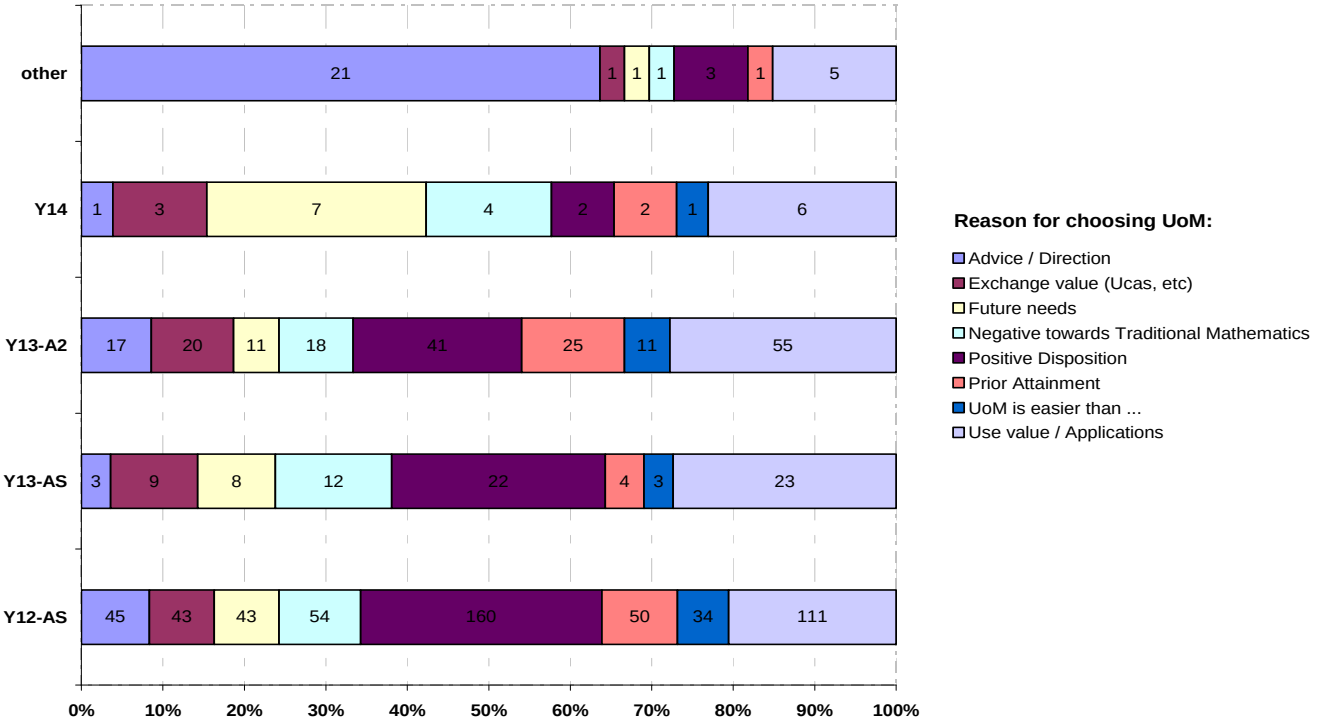

Figure 28: Students' reasons (Q6) by combined Level and Year of Study

1.3 Why did you decide to study Use of Mathematics Instead of traditional mathematics?

The reasons for choosing Use of Mathematics instead of AS traditional mathematics given by the 579 students who responded positively to the question 'Did you consider studying A level mathematics instead of Use of Mathematics?', are given in Table 15, based on students' level of study and year group.

Table 34: Reasons for choosing Use of Mathematics instead of AS traditional by Level and Year Group

	Year Group and Level					
Reasoning	Y12-AS	Y13-AS	Y13-A2	Y14	other	Total
Difficulty	86	11	32	2		131
Directed/advised/forced	141	9	61	5	4	220
Easy to get grade	8					8
Self-efficacy	9	1	5			15
Tried and failed / hard	31	16	16	4	2	69
Use value/applications/interesting	60	9	27	3	1	100
Total	335	46	141	14	7	543

Similar patterns can be observed in the responses of students of Y12-AS and Y13-A2: the most frequent reason for both groups is 'directed/advised/forced' and then 'difficulty'. 'Use value/applications/ interesting' comes next in popularity for both groups, followed by 'tried and failed/hard'. This last reason is the most popular among the Y13-AS students, followed by 'difficulty'. Some other patterns in these reasons are shown in Figures 12 and 13 in respect of other background variables.

For example, Figure 10 illustrates how males reported that they were 'directed/advised/*forced*' to study the Use of Mathematics course in much higher frequencies than females. In contrast, 'difficulty' was a more popular reason among females. So boys seem more like to attribute their reasons to someone else whereas girls seem more likely to make a decision based on some sense of their self efficacy.

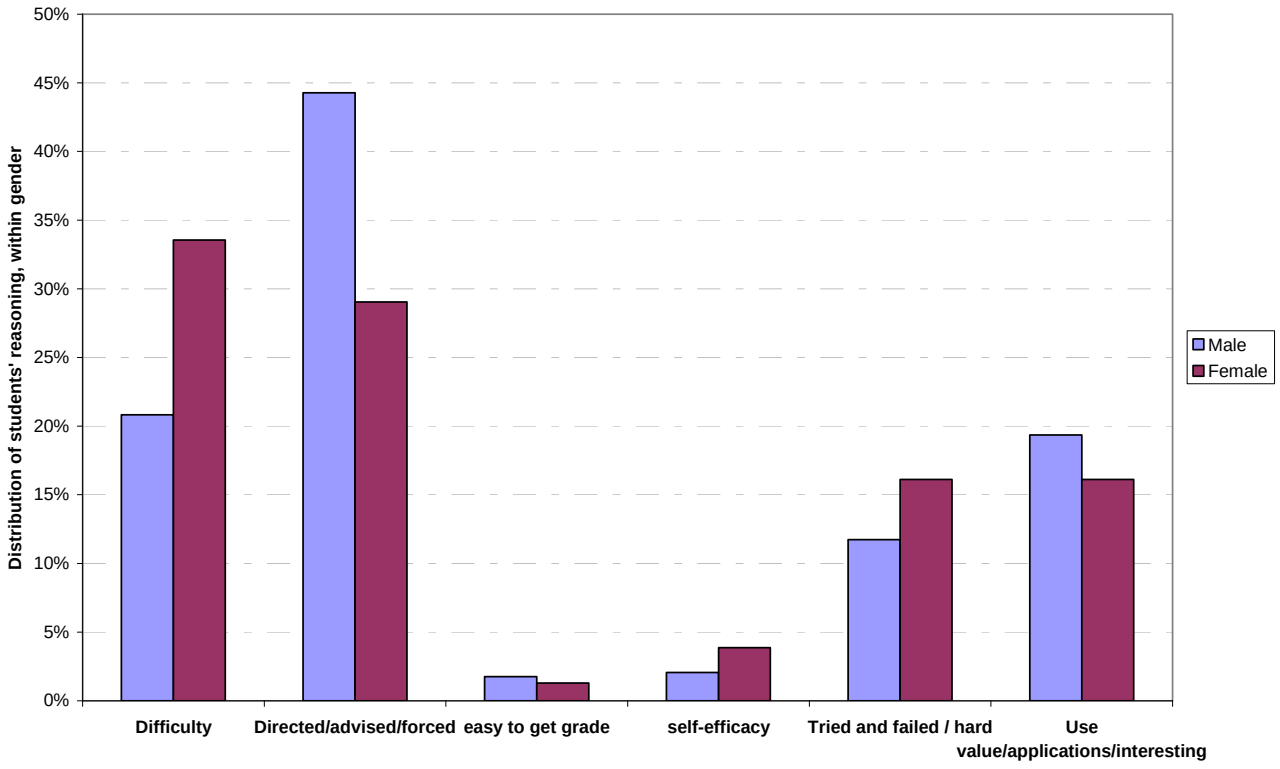

Figure 29: Gender differences in students' reasons (Q7) for choosing Use of Mathematics rather than AS traditional mathematics

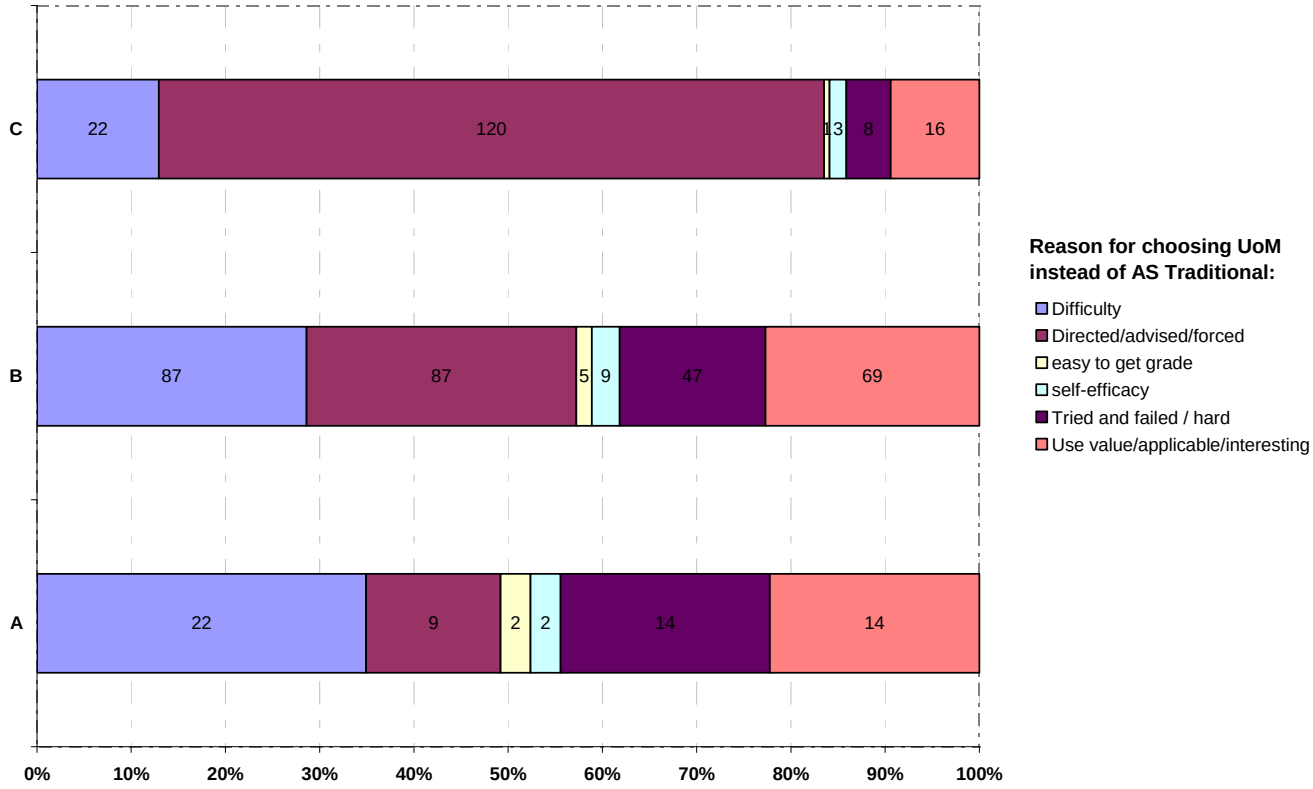

Figure 30: Students' reasons (Q7) distributed by their GCSE mathematics grades

Figure 11 shows the distribution of reasoning based on students' GCSE mathematics grades. Perceived 'difficulty' is reported more frequently among higher attaining students (31.7% of those with grade A students compared to 12% of those with grade C). The frequency of responses in the 'directed/advised/ forced' category increases as the GCSE attainment reduces, reaching a very high 70.6% among the students with grade C. In contrast, the popularity of 'tried and failed' and 'use value...' increases with higher attainment. This does raise serious questions about whether students with GCSE grade C are being given the opportunity to access A level mathematics.

2. Advice in the deciding to study Use of Mathematics

Students were asked to rate the advice they received from various sources in making their decision to study Use of Mathematics. The summary of their responses (frequencies and % for each chosen category) are presented in Table 16.

Table 35: Frequencies (and %) of students' ratings for advice they received in decision making

Advice from:	Very helpful	Helpful	Not very helpful	No Advice	Not applicable	Total
GCSE teachers	61 (6.5%)	194 (20.7)	98 (10.5)	404 (43.2)	178 (19)	935
teachers when registering for Y12	137 (14.7)	491 (52.5)	132 (14.1)	101 (10.8)	73 (7.8)	935
school/college at open day	85 (9.1)	407 (43.6)	159 (17)	159 (17)	124 (13.3)	935
family	73 (7.8)	278 (29.7)	131 (14)	297 (31.8)	156 (16.7)	935
careers advisors	44 (4.7)	127 (13.6)	137 (14.7)	383 (14.1)	242 (25.9)	933
websites	22 (2.4)	143 (15.4)	117 (12.6)	379 (40.8)	269 (28.9)	930

Figure 12 illustrates better the most popular source of advice, since it plots the percentages of positive responses (i.e. 'very helpful' and 'helpful').

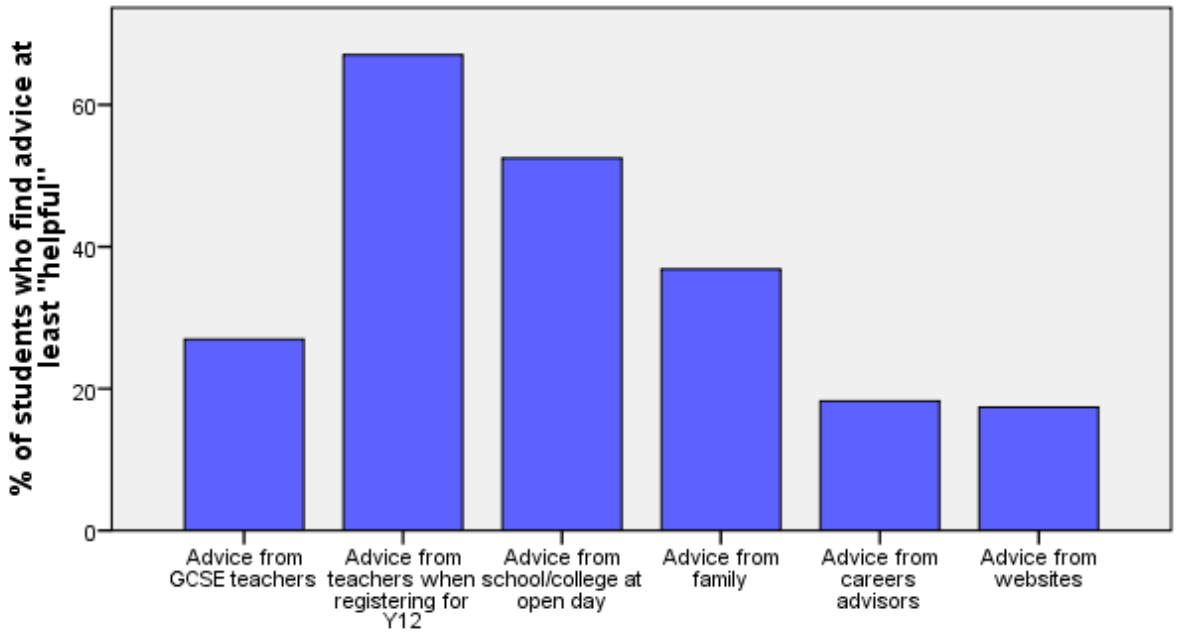

Figure 31: Bar chart with % of students who find at least helpful the advice they received from various sources

The most helpful advice seems to come from teachers when registering for Y12 and then from school or college at open days. Advice from family was also considered helpful by about 40% of the students. The advice from GCSE teachers, careers advisors and websites were not rated very favourably.

Our analysis of this by gender suggests that there are only minor differences: female students rated slightly more positively advice from school/college at open day, advice from GCSE teachers and advice from family, compared to male students. In contrast male students were more positive about the advice they got from career advisors.

Figure 13 shows the percentage who rate different sources of advice as helpful by students' ethnicity. Perhaps the most significant difference involves the lower percentage of White English students with positive ratings about the advice they got from their GCSE teachers compared to Asian and students of other ethnic groups. Asian students overall tend to be more positive about most of the sources of advice, with the exception of open day which is similar for all groups.

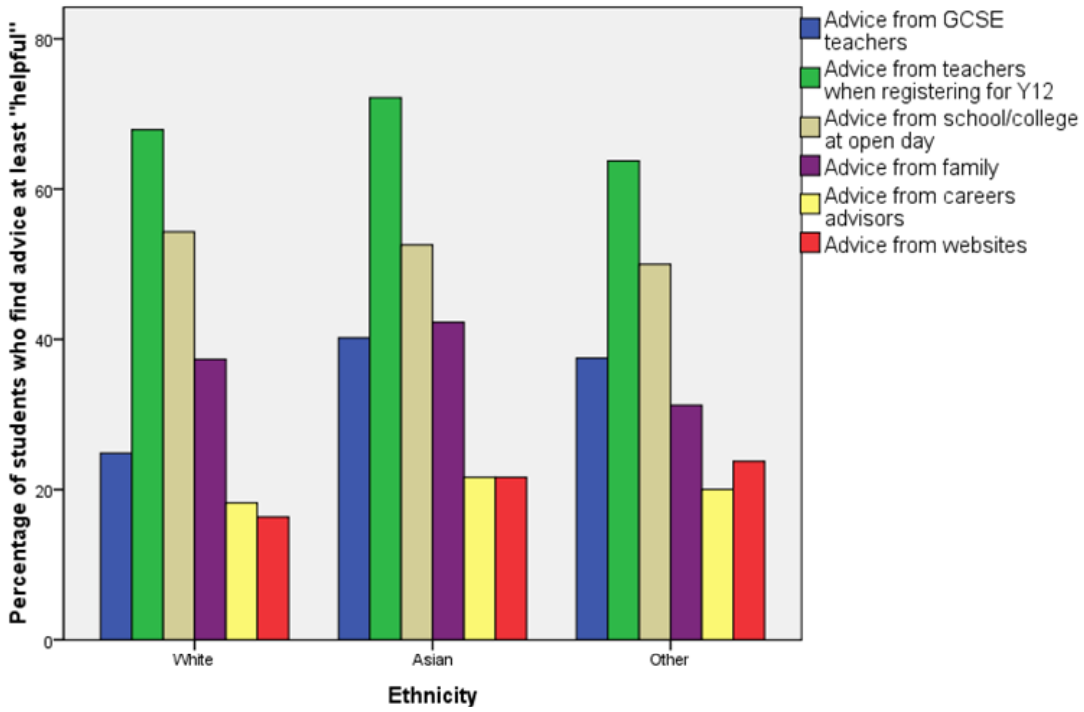

Figure 32: % of helpful advice by ethnicity

Figure 14 shows the percentage who rate different sources of advice as helpful by the type of students' GCSE school. Satisfaction with advice from GCSE teachers increases when the school type changes from 'up to 16' to 'through 16' and 'from 16'. This is important and supports our findings elsewhere that students get quite a different deal in terms of progression if they are in 'to 16' or 'through 16' schools. The opposite pattern appears for advice from teachers when registering for Y12. More students from 'from 16' schools found advice from family, careers advisors and from websites helpful.

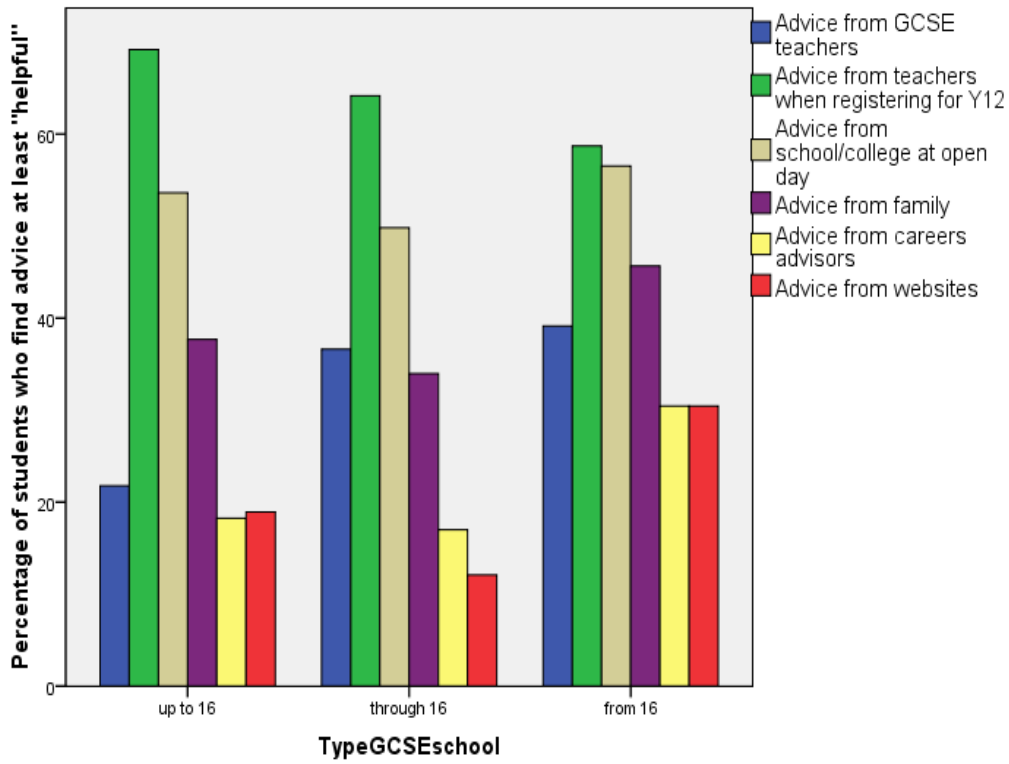

Figure 33: % of helpful advice by Year group and level of study

Relatively few students identified advice from GCSE teachers as helpful in informing their choice of Use of Mathematics. Figure 15 explores whether or not moving school after GCSE and from which type of school made a difference.

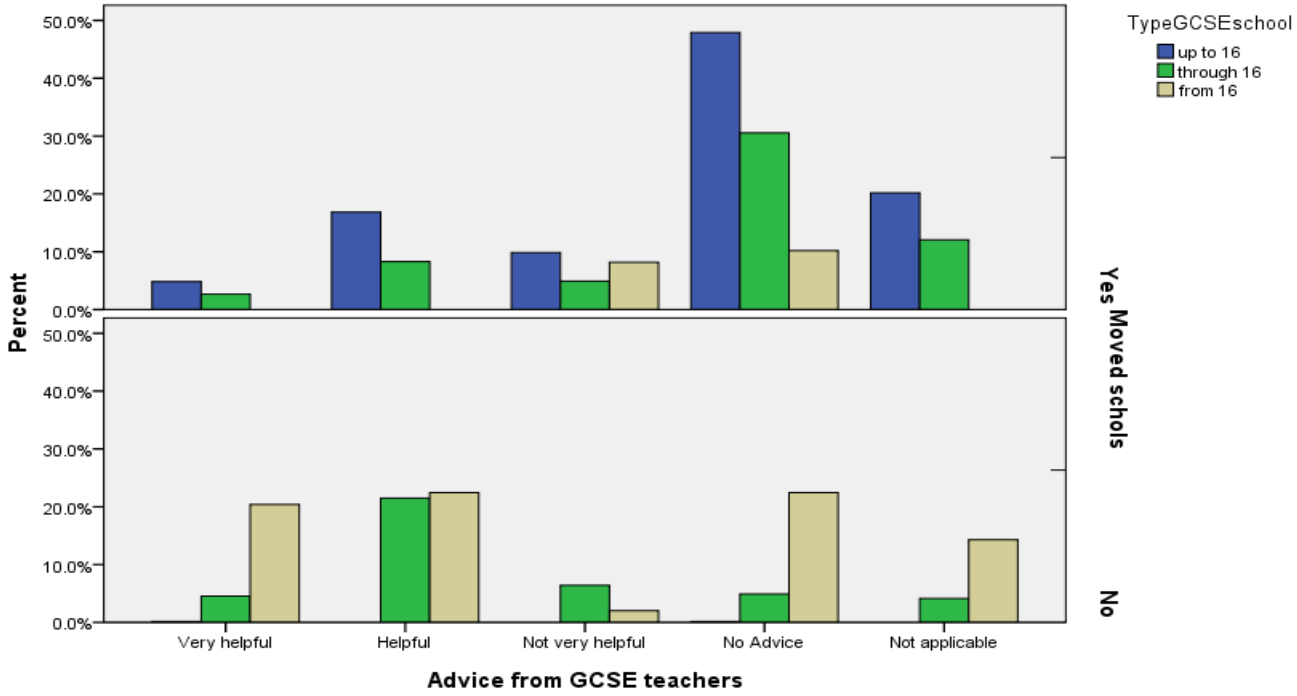

Figure 34: Rating of the Advice from GCSE teachers by 'movement' and type of GCSE school

As shown in Figure 15, students who moved school tend to report that they received 'no' advice from their GCSE teachers. This is an issue that needs addressing if Use of Mathematics is to be taken up more widely. In comparison, the majority of students who did not move schools rate the advice they received as 'helpful'. Differences based on type of school can also be seen.

Some further explanations regarding the quality of advice students received can also be found in their qualitative statements in Question 10 (If you think you received any particularly helpful or unhelpful advice please explain below). Some example responses are listed here, and the comprehensive list of all responses is attached as Appendix 3:

- Connexions and my family helped but my old school were no help at all
- Didn't give full information on the open day of the course. Focused on pure Mathematics.
- GCSE teachers should bring awareness regarding Use of Mathematics, I didn't know it existed
- I was not advised by my GCSE mathematics teacher as I don't think she knew what the course was about
- Knowing more about the course from the college open day really helped.
- My Tutor told me to take Use of Mathematics instead of A-level mathematics because I wanted to be an accountant. He knew nothing.
- No one told me the difference and the effect on getting a University place if you wish to study mathematics further

Part C: Students' experience with Use of Mathematics

1. Student perceptions of Use of Mathematics difficulty compared to traditional mathematics

Students were asked: Do you think that Use of Mathematics is easier than traditional A level mathematics? (Question 8). They responded as shown in Table 17:

Table 36: Frequencies (and %) of students' ratings of difficulty of Use of Mathematics compared to A level mathematics

Use of Mathematics easier than A Level?		Frequency	%	Valid %
Valid	Yes	542	57.2	58.5
	No	52	5.5	5.6
	Don't know	332	35.0	35.9
	Total	926	97.7	100.0
Missing	System	22	2.3	
Total		948	100.0	

Even though the majority (57.2%) perceive that Use of Mathematics is easier, there is still a very high proportion (35%) who reported that they don't know. These are student perceptions -most have no experience of A level mathematics- and the variation between centres suggests that those perceptions have been shaped by the way in which the course has been marketed to them.

2. Evaluation of AS Use of Mathematics units

In question 11 students were asked to record the individual FSMQs they did or are doing. Within the pilot certain units are compulsory and students are then able to 'choose' two further optional FSMQs, but at AS level only. At AS level USE1 is compulsory and at A2 Calculus, Mathematical Applications and Mathematical Comprehension are all compulsory. We make some claims below about the extent to which students have any choice about which units they follow. Students listed the units of Table 18 in their responses (with the corresponding frequencies) however subsequent analysis is based only on the first 6 (highlighted ones) which are part of the pilot AS. It is not clear to us how many of these students have a mixture of units from the pre-pilot and pilot FSMQs but we suspect that these may be students who started Use of Mathematics in Y12 before moving onto the pilot in Y13.

Table 37: List of AS Use of Mathematics units completed by students

Use of Mathematics Unit	Frequency
USE1-Algebra (AS compulsory)	738
9993-Data Analysis (AS option)	699
9994-Hypothesis Testing (AS option)	48
9995-Dynamics (AS option)	69
9996-Personal Finance (AS option)	244
9997-Decision Mathematics (AS option)	517
9983-Using Data (non-pilot)	2
9986-Data Handling (non-pilot)	85
9988-Algebra and Graphs (non-pilot)	87
Statistics	17
Data	20
Exponential	1
Mathematics	1
Analysis of Mathematics	1
Business Studies	1
DT	1
Design Mathematics	1
Total	2532

It should be noted that initially the number of students who reported doing Statistics was larger (N=351). Since this does not correspond to any official unit like the rest of the numbered units, we decided to recode it based on an analysis of students' other recorded units[8]. Subsequent analysis is performed only on the pilot units and for some results the units with low response frequencies are not presented. A small number of the responses were not recognised as either pre-pilot or pilot units.

Figures 16 and 17 illustrate the distribution of FSMQs (i.e. the non-compulsory units) among gender and ethnicity students groups. As can be seen (Figure 16) gender differences are very small: female students show preference for Hypothesis Testing (9994) whilst male students are slightly more in favour of Dynamics and Personal Finance.

[8] Statistics was recoded to "Data Analysis" if students also reported USE1 or to "Data Handling" if they reported 9988.

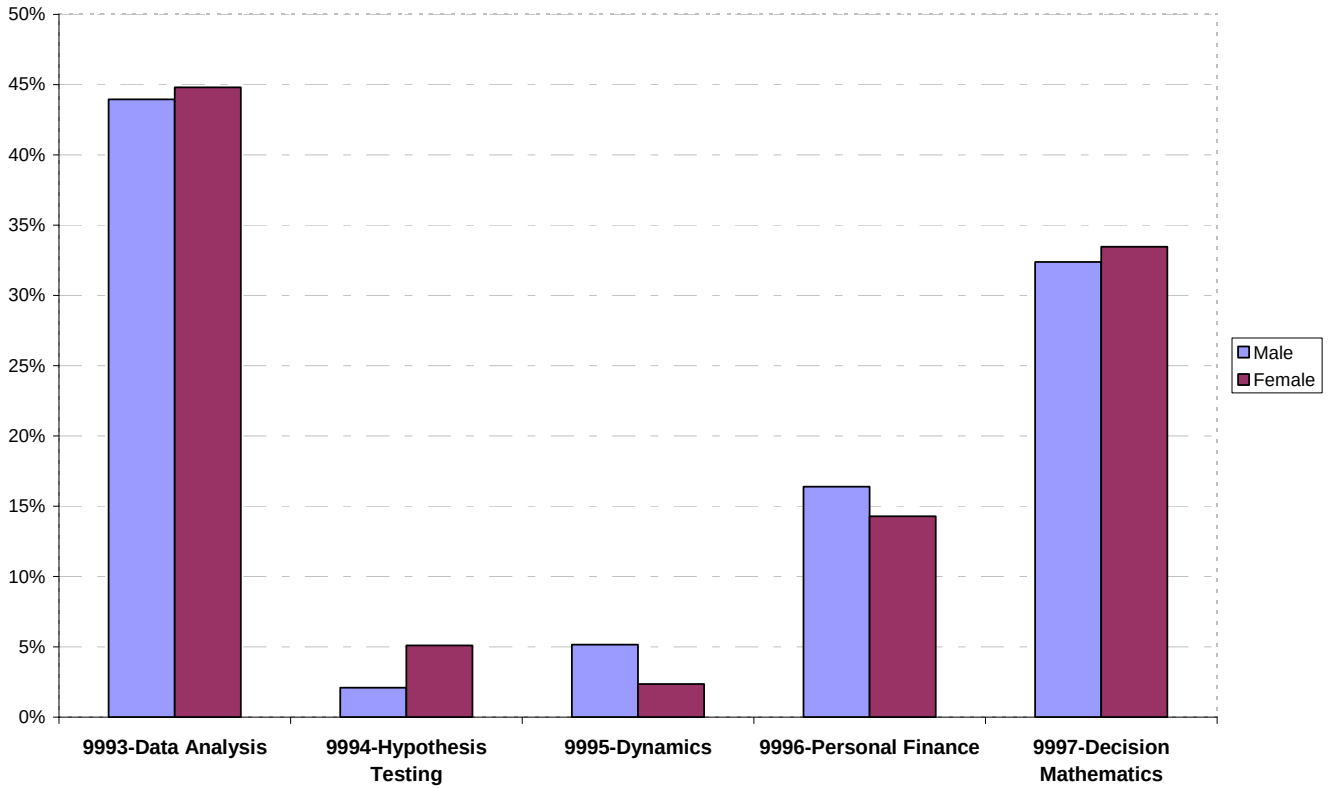

Figure 35: Selected Use of Mathematics FSMQs by students' gender

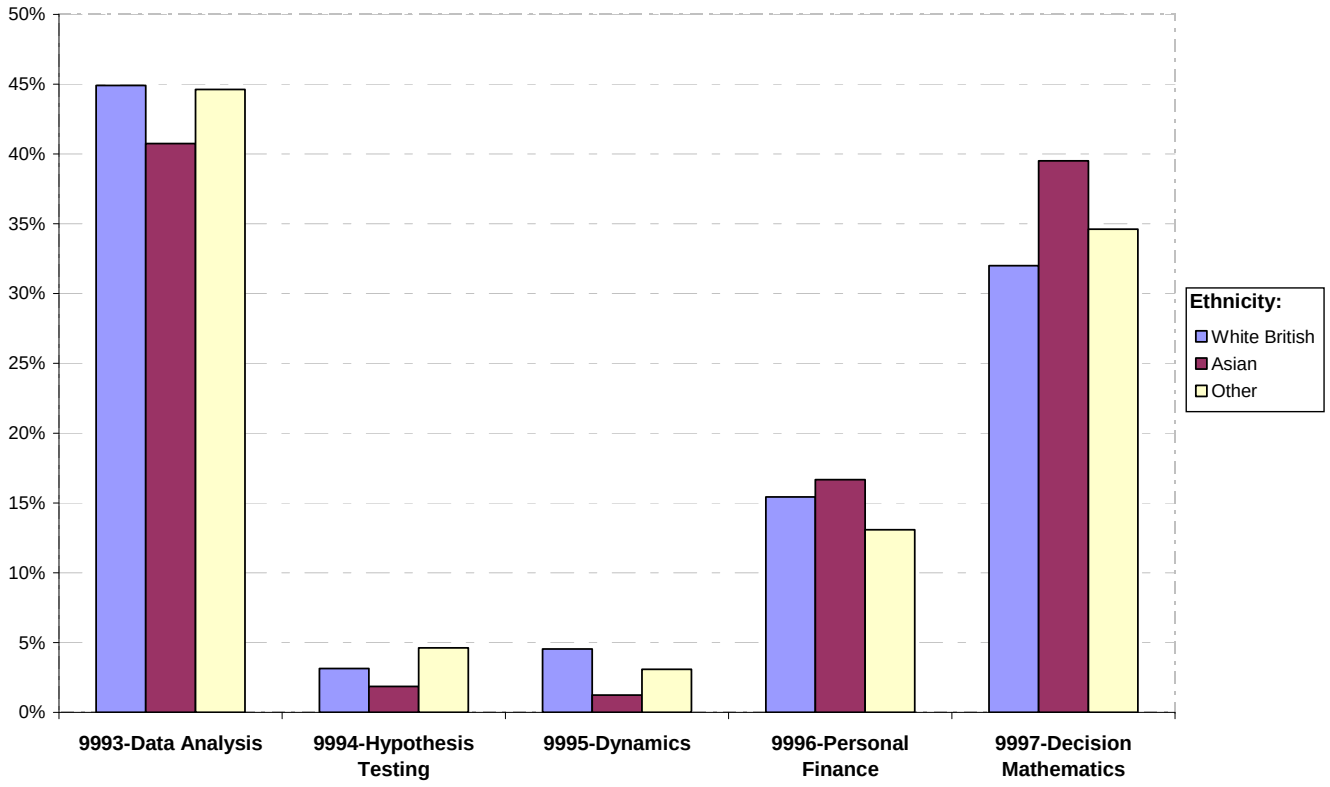

Figure 36: Selected Use of Mathematics FSMQs by students' ethnicity

Ethnicity differences are more apparent, particularly regarding the popular subjects (Figure 17). Asian students appear to prefer Data Analysis less compared to White British and students of

other ethnic backgrounds; the opposite pattern appears for Decision Mathematics. However, given the small number of centres involved these differences might be caused by the decisions of a few key staff in centres with large cohorts with high proportions of Asian students.

The 'choice' of units is dependent upon the centres and the limited options available to students within each one, as shown in Table 19. It seems that a lot of centres (19/27) do offer only two options to students and these are usually a combination of Data Analysis, Decision Mathematics and Personal Finance (with the first two pairing as the most frequent). This has important implications for the development of Use of Mathematics as an alternative pathway that might cater for the varied mathematics needs of a range of level 3 learners.

Table 38: Frequencies of Pilot Units taken at each Centre

Centre ID	9993-Data Analysis	9994-Hypothesis Testing	9995-Dynamics	9996-Personal Finance	9997-Decision Mathematics	USE1-Algebra	Total
1	11			4	17	13	45
3	3			4	1	5	13
6	28				27	28	83
7	121			133		116	370
9				7	7	5	19
10	27				29	27	83
11	2			27		26	55
13	26				26	26	78
14	46		17	32		47	142
15	16				19	15	50
16	2				10	2	14
17	22				23	23	68
18	9				13	8	30
19	46		20	13	14	45	138
21	28	3		2	40	32	105
22	9	12				9	30
24	1				8	1	10
25	13			8	15	4	40
26	27				28	29	84
27	22				22	22	66
29	7				6		13
30	5				9	5	19
31	2			13	10	13	38
33	110				114	96	320
34	32				37	39	108
35	47	33	28			59	167
36	37				42	43	122
Total	699	48	65	243	517	738	2310

2.1 Self Reported grades for each Unit

Table 20 presents a cross-tabulation of the grades students reported attaining in the most frequently reported Use of Mathematics units.

Table 39: Frequencies of Grades received at each unit

Unit	Grade							Total
	A	B	C	D	E	U	Total	
USE1-Algebra	28	28	67	18	15	4	160	738
9993-Data Analysis	27	29	37	22	18	8	141	699
9994-Hypothesis Testing	1		1	1	1	1	5	48
9995-Dynamics	1	3	3	6	2	2	17	69
9996-Personal Finance	3	2	6	14	6	15	46	244
9997-Decision Mathematics	19	18	23	22	13	10	105	517
Total	79	80	137	83	55	40	474	

Figure 18 illustrates better the grades distribution for each unit. As can be seen, students in the survey scored higher grades in Data Analysis and Decision Mathematics, given the cumulative percentages of A and B grades. Personal Finance seems to be the most difficult unit with very low percentages of A and B grades and one third of the students failing. We do not have access to comparative data from AQA but it would be worthwhile exploring these patterns with the whole cohort because they have implications for the future development of the programme, in a similar way to the limited choice issue referred to earlier.

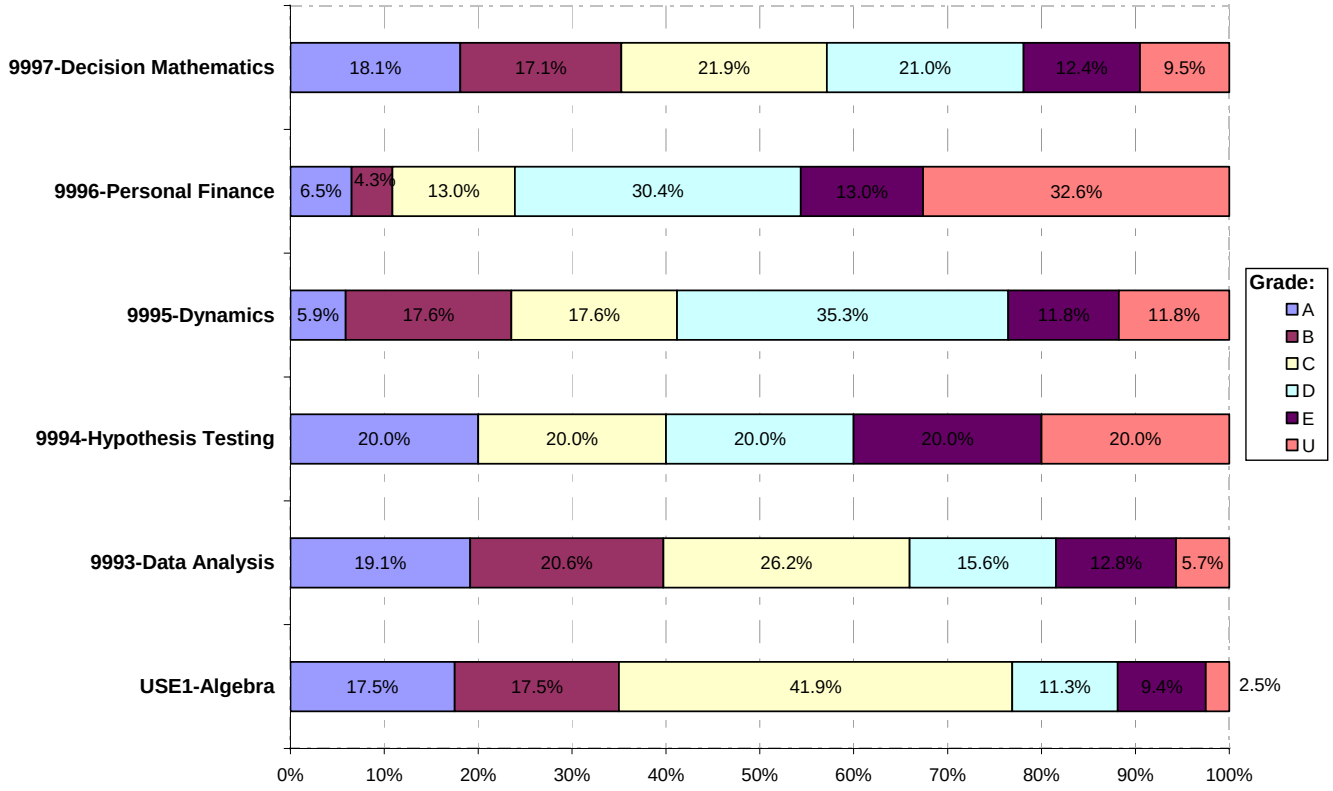

Figure 37: Distribution of grades achieved for each Use of Mathematics unit

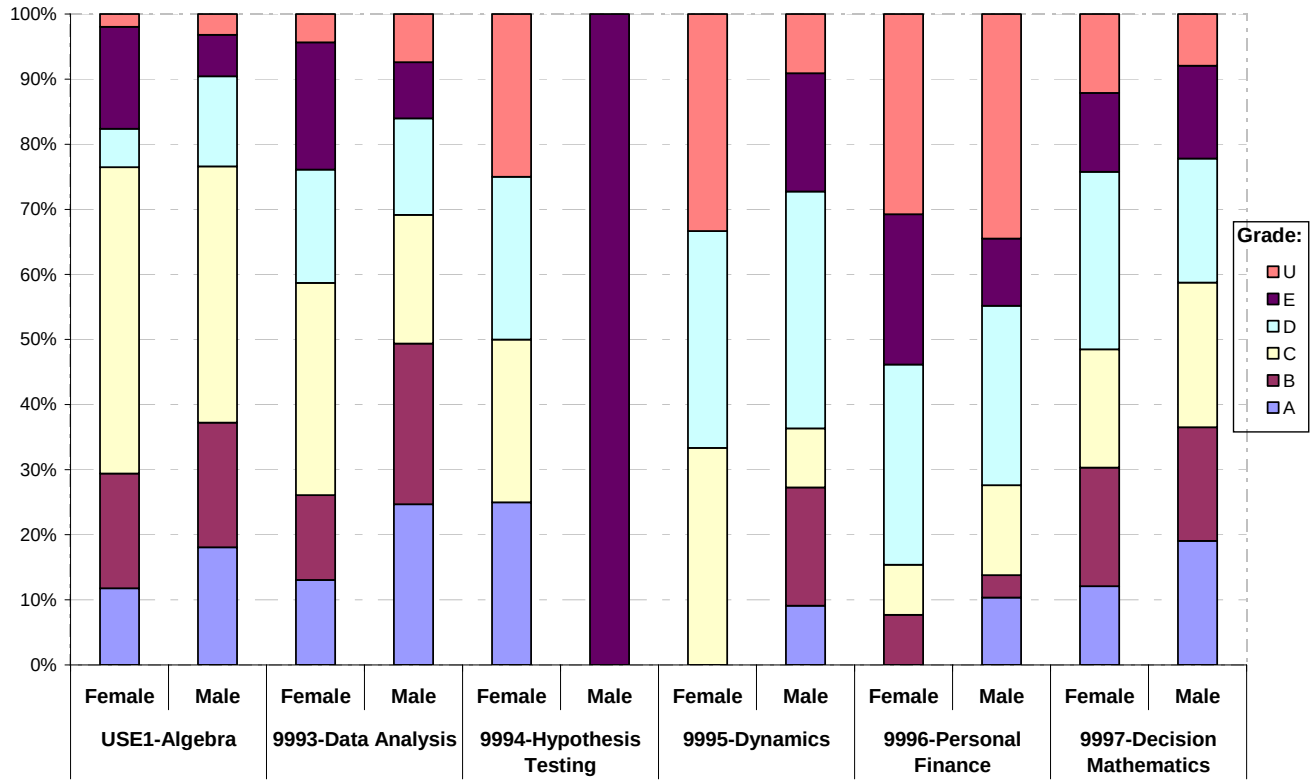

Figure 38: Grades achieved for each Use of Mathematics unit by students' gender

Figure 19 illustrates gender differences for the pilot units. These differences are no doubt related to prior attainment and other factors (e.g. teacher quality) but in the early stages of a course like this teachers will start to make assumptions about units and their suitability for their cohorts, sometimes based upon one-dimensional analyses like this. This analysis is not aiming to combine these various explanatory variables (e.g. gender, prior attainment, ethnicity) in order to explore the contribution made to outcomes.

The cumulative percentages of A and B grades suggest that overall male students score higher in all units, but again this might be due to prior attainment rather than their gender. The biggest difference appears to be for Data Analysis. C and D grades are more uniformly distributed among gender groups (with some exceptions). Excluding Dynamics, which has very low frequencies of known grades, it can also be said that the failure rates are similar for male and female students.

2.2 Perception of how enjoyable each unit was

Students were also asked to report how enjoyable they found each unit using a scale of 1 (Not enjoyable) to 5 (Very enjoyable). The distribution of their ratings for each of the 9 most frequently reported units is presented in Table 21. These responses are better illustrated in the stacked bar chart of Figure 20.

Table 40: Frequencies of perceived 'enjoyability' of Use of Mathematics units

Unit	Enjoyable (1-Not, 5-Very)					
	1	2	3	4	5	Total
USE1-Algebra	43	95	277	191	77	683
9993-Data Analysis	38	90	242	220	52	642
9994-Hypothesis Testing	10	9	18	8	3	48
9997-Decision Mathematics	28	60	135	154	103	480
9995-Dynamics	1	7	20	24	6	58
9996-Personal Finance	14	14	83	85	30	226
Total	134	275	775	682	271	2137

The most enjoyable subject based on top rating (5) is Decision Mathematics, and according to the combined percentages of top ratings (4 and 5), Personal Finance and Dynamics are also considered as equally enjoyable. Hypothesis testing appears to be the least popular subject, with the compulsory core unit of USE1-Algebra not scoring very highly neither (less than 40% of the students rated it with 4 or 5 on the enjoyability scale).

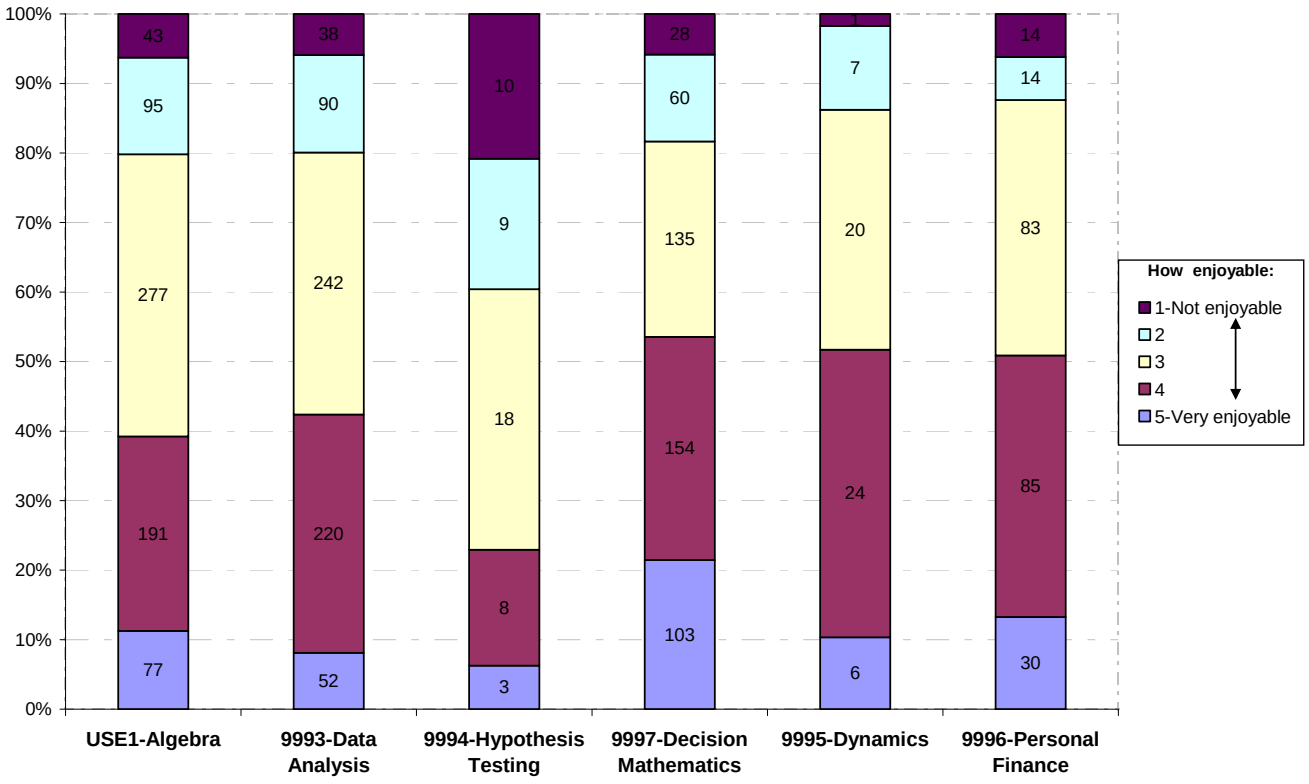

Figure 39: Distribution of ratings for 'enjoyability' of each Use of Mathematics unit

In order to show any possible relationships between students' enjoyability ratings and their achieved grades, the two variables are cross-tabulated in Table 22 for the pilot units (with self-reported students' grades).

Table 41: Cross-tabulation of perceived 'enjoyability' of Use of Mathematics units and Grade

Unit	Grade	How enjoyable					Total
		5	4	3	2	1	
USE1-Algebra	A	10	13	4			27
	B	6	8	12	1	1	28
	C	5	25	27	6	2	65
	D	2	4	6	5		17
	E	1		8	3	2	14
	U		1		1	1	3
USE1-Algebra Total		24	51	57	16	6	154
9993-Data Analysis	A	5	13	6	1		25
	B	3	15	8	2	1	29
	C	5	12	12	5	2	36
	D	2	3	8	6	2	21
	E		7	4	5	2	18
	U		1	2	3	2	8
9993-Data Analysis Total		15	51	40	22	9	137
9994-Hypothesis Testing	A	1					1
	C			1			1
	D			1			1
	E			1			1
	U			1			1
9994-Hypothesis Testing Total		1		4			5
9995-Dynamics	A	1					1
	B	2	1				3
	C		3				3
	D		3	2	1		6
	E	1			1		2
	U		2				2
9995-Dynamics Total		4	9	2	2		17
9996-Personal Finance	A	2		1			3
	B		2				2
	C			4	2		6
	D		4	6	4		14
	E		3	3			6
	U		1	5	1	7	14
9996-Personal Finance Total		2	10	19	7	7	45
9997-Decision Mathematics	A	6	7	3	1		17
	B	7	8	2	1		18
	C	9	7	5	1		22
	D	3	7	5	4	3	22
	E	1	7	4			12
	U		3	2	3	2	10
9997-Decision Mathematics Total		26	39	21	10	5	101
Total		72	160	143	57	27	459

In most cases there is a general pattern from grades A to D. As might be expected, students with higher grades tend to give higher 'enjoyability' ratings to the units. For lower grades the patterns are not so stable. Decision Mathematics also appears with a different pattern within the high grades (increasing up to C) and then disordered for lower grades and failures.

2.3 Perception of usefulness of each unit for the future

Students were also asked to report how useful they found each unit with a scale of 1 to 5 (1-Not at all useful to 5-Very useful), although we didn't specify what we meant by usefulness. The

distribution of their ratings for each of the 6 pilot units is presented in Table 23. These responses are better illustrated in the stacked bar chart of Figure 21.

Table 42: Frequencies of perceived 'usefulness' of Use of Mathematics units

Unit	Useful (1=Not, 5=Very)					
	1	2	3	4	5	Total
USE1-Algebra	63	89	228	184	92	656
9993-Data Analysis	33	63	190	230	103	619
9994-Hypothesis Testing	5	13	9	13	5	45
9995-Dynamics	1	3	11	27	14	56
9996-Personal Finance	7	7	40	78	84	216
9997-Decision Mathematics	52	77	172	114	48	463
Total	161	252	650	646	346	2055

The most useful units according to the combined percentages of top ratings (4 and 5) seem to be Personal Finance and Dynamics but only a small number of students took these units. However, this is useful data given the concerns expressed earlier about the limited choice of units available to students in centres. Data Analysis is next in perceived usefulness. Decision Mathematics and Hypothesis Testing are considered to be the least useful in students' opinion, with the compulsory core unit of USE1-Algebra not scoring very highly either (42% of the students rated it with 4 or 5 in the usefulness scale).

Figure 22 illustrates the distribution of students' usefulness ratings based on their gender. Overall, male students rated as more useful all the subjects and this fits in with the earlier finding that more male students than female students attributed perceived usefulness as a factor in their decision to study Use of Mathematics.

Table 24 illustrates potential associations between grades achieved at each unit with perceived usefulness. As shown, for the core unit USE1-Algebra, Decision Mathematics and Data Analysis, the observed pattern of responses indicates an association between grade and perceived usefulness (students with higher grades tend to rate the unit as more useful). The low frequencies for Personal Finance and Dynamics do not allow for meaningful interpretation or pattern identification.

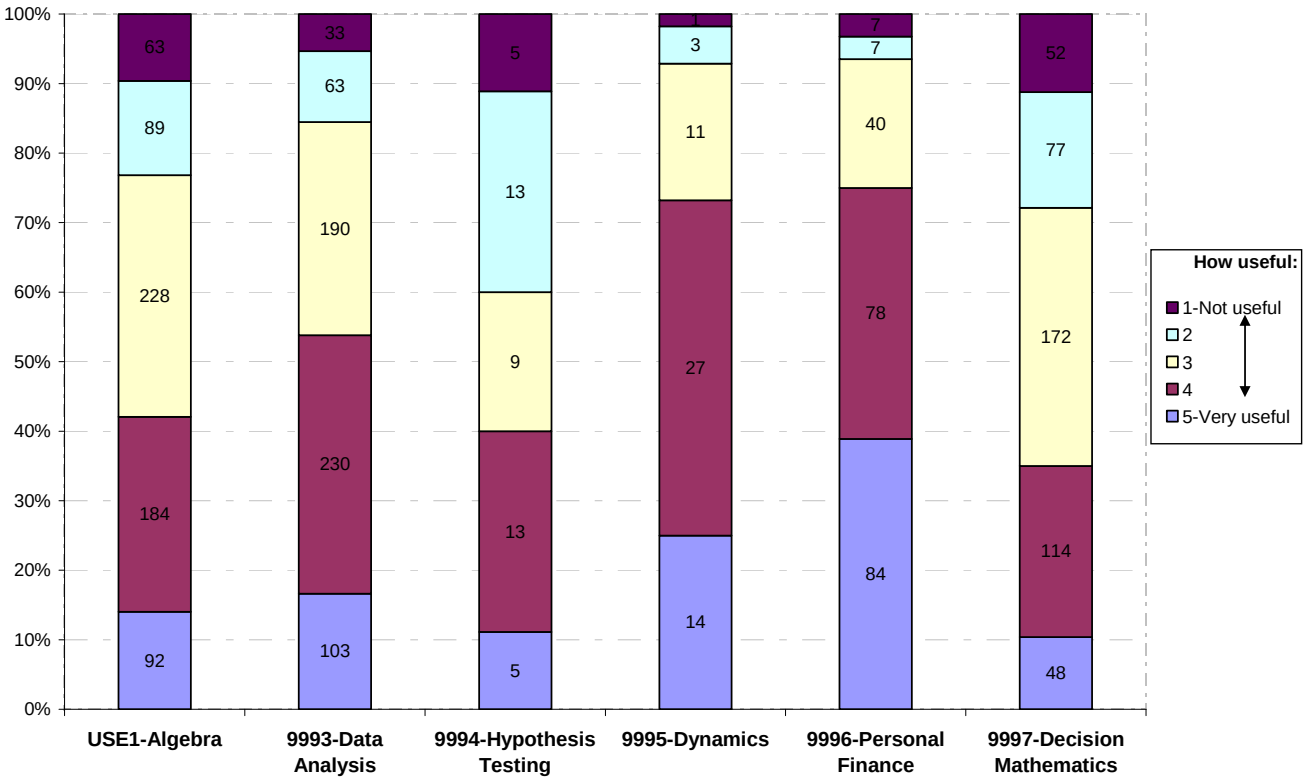

Figure 40: Distribution of ratings for 'usefulness' of each Use of Mathematics unit

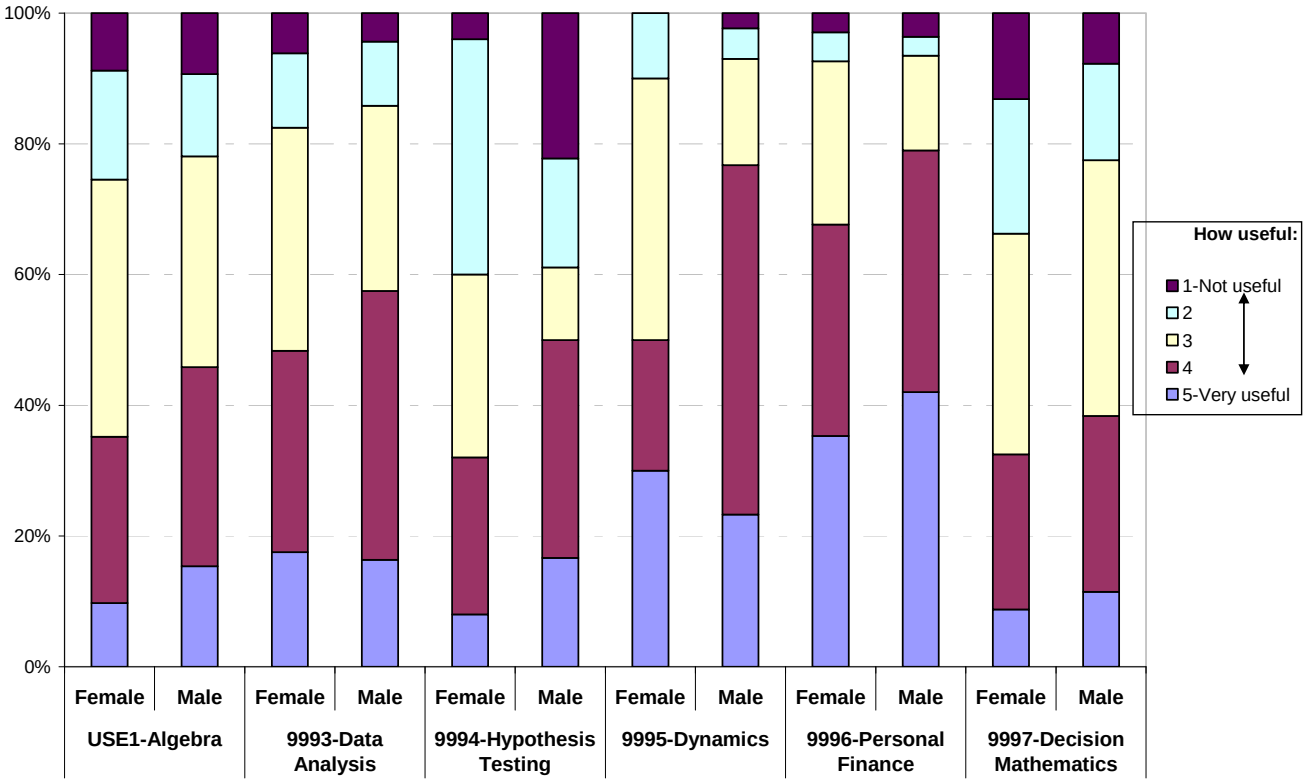

Figure 41: Distribution of ratings for 'usefulness' of each Use of Mathematics unit by gender

Table 43: Cross-tabulation of perceived 'Usefulness' of Use of Mathematics units and Grade

		How useful? (5-very useful, 1-not useful)					
Module	Grade	5	4	3	2	1	Total
USE1-Algebra	A	11	9	6		1	27
	B	4	9	10	2	1	26
	C	9	22	22	8	4	65
	D	3	2	7	3	1	16
	E	2	1	7	3	1	14
	U					2	2
USE1-Algebra Total		29	43	52	16	10	150
9993-Data Analysis	A	5	10	8		2	25
	B	4	12	8	4	1	29
	C	6	11	16	1	1	35
	D	2	9	2	4	2	19
	E	2	9	6	1		18
	U		2	4		2	8
9993-Data Analysis Total		19	53	44	10	8	134
9994-Hypothesis Testing	A	1					1
	C					1	1
	D			1			1
	E				1		1
	U			1			1
9994-Hypothesis Testing Total		1		2	1	1	5
9995-Dynamics	A	1					1
	B	1	2				3
	C	1	2				3
	D	1	3	2			6
	E		1				1
	U		1	1			2
9995-Dynamics Total		4	9	3			16
9996-Personal Finance	A	1	1	1			3
	B	2					2
	C	2	1		2		5
	D	2	8	3	1		14
	E	3	2	1			6
	U		6	6		2	14
9996-Personal Finance Total		10	18	11	3	2	44
9997-Decision Mathematics	A	3	3	7	3	1	17
	B	3	4	8	2	1	18
	C	1	5	8	5	3	22
	D		4	9	2	6	21
	E		3	5	3		11
	U			2	4	3	9
9997-Decision Mathematics Total		7	19	39	19	14	98
Total		70	142	151	49	35	447

Part D: Future Aspirations

This section presents the results about Use of Mathematics students' future aspirations. It details the AS students' responses in regards to the likelihood of continuing to A2, and then presents the responses of A2 students' mainly in regards to their career and university choices.

1. Likelihood of AS Use of Mathematics students to continue to A2

The distribution of the responses of the students to the question 'How likely do you think it is that you will continue to A2 Use of Mathematics' (Q12) are shown in Figure 23 (%).

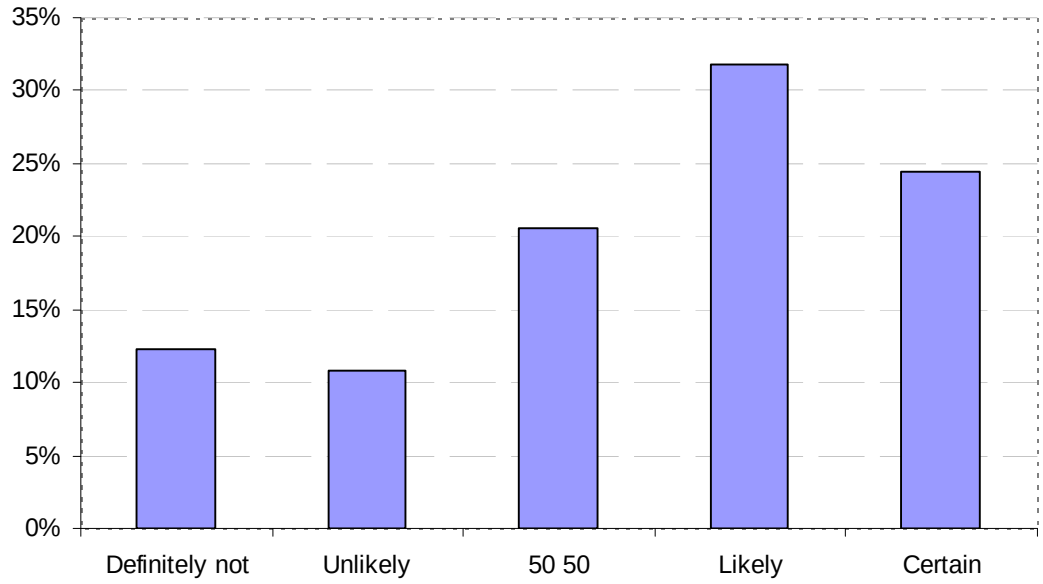

Figure 42: Likelihood of AS Use of Mathematics students to continue with A2

As shown the most frequent response was 'likely' with 'certain' coming second, which seems to be a positive sign for the course. However we want to explore any patterns behind these responses, particularly in regards to students who reported that it is unlikely or they definitely won't do A2 Use of Mathematics.

Figure 24 shows the distribution of students' responses by type of current school, respectively. As shown, students from 11 to 18 schools (through 16) are more likely to respond 'definitely not' or 'unlikely' to continue to A2 Use of Mathematics.

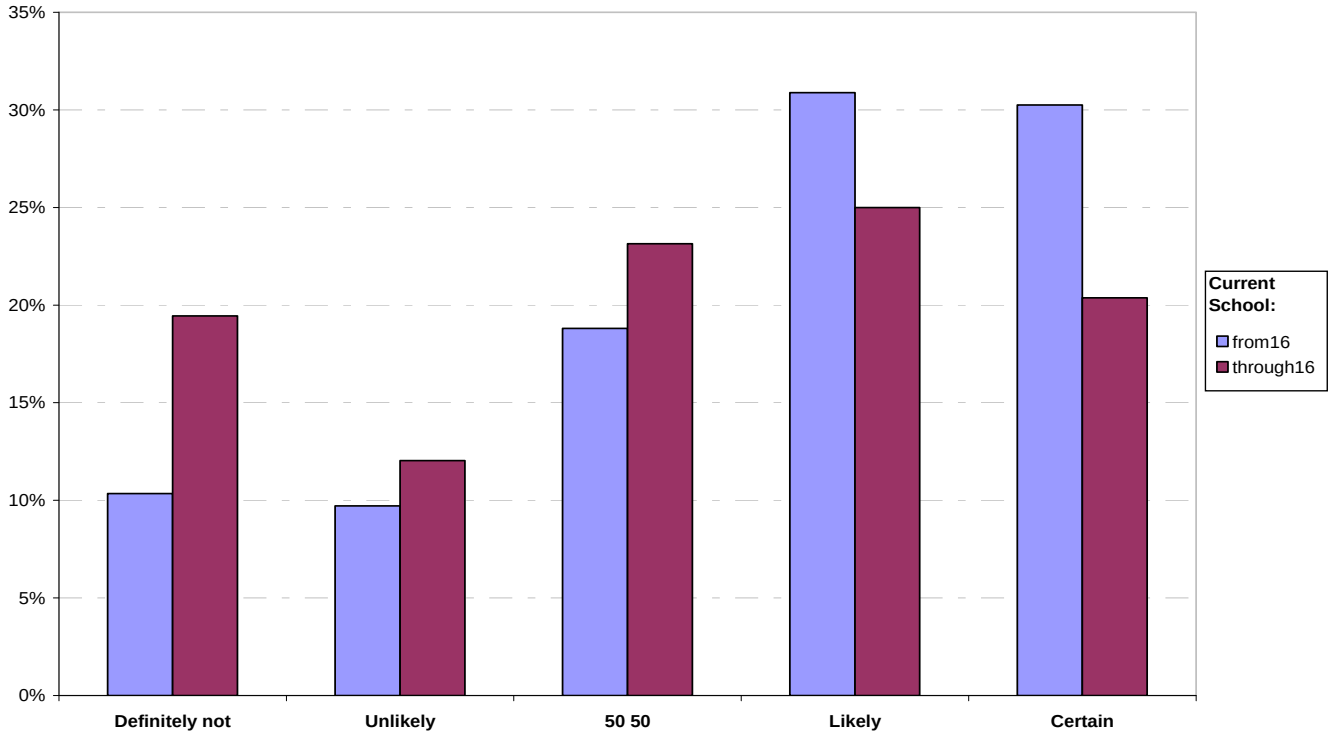

Figure 43: Likelihood of AS Use of Mathematics students to continue with A2, by type of current school

More qualitative explanations for students deciding not to continue with Use of Mathematics are found in their responses to Question 13 (If you are unlikely or definitely not going to continue to A2 please explain why below). The most frequent reasons given by students are presented in Table 25. Apart from 'going to university' which is the most frequent reason, students reported among others that they did not enjoy the course, it was too hard, they are finishing college and they prefer other subjects.

Table 44: Most frequent reasons for not continuing with Use of Mathematics A level

Reason	Freq
going to university	33
don't enjoy	17
too hard	12
finishing college	11
prefer other subjects	9
do not want to	5
change subjects	4
hate it	4
Impossible because College does not offer A2 Use of Mathematics.	4
leaving college	4
not doing A levels	3
was compulsory	3
boring	2
not for me	2

Other reasons given by students are listed in Appendix B4

2. Future plans of A2 students

2.1. Overall Plans

The future plans of the 218 A2 students are presented in Table 26.

Table 45: Frequencies of responses to Question 16 (Future plans of A2 students)

What are your plans beyond A level and any gap year?	Frequency	%
University	154	70.6%
Policy, Emergency Services, Armed forces	13	6.0%
Apprenticeship	18	8.3%
Traineeship	1	0.5%
Work - no further study	9	4.1%
Other	14	6.4%
No plans	9	4.1%
Grand Total	218	100%

2.2. Course choices of students who plan to go to University

Students who applied to University were asked to list their institutions and courses (with 5 options per student). The course were categorised based on their mathematical demand and some broad categories as shown in Table 27.

Table 46: Cross-tabulation of mathematical demand and broad categories of university subject choices

	Mathematical demand			
Categories	Low	Medium	High	Total
Arts-Humanities	72	29	5	106
Computing		17	44	61
Engineering		22	67	89
Life Sciences		76		76
Medical-related		11		11
Physical Science		2	42	44
Social Science	6	163	30	199
Total	78	320	188	586

The most common subjects among these students are social sciences followed by the Arts and Humanities. Engineering and Life Sciences came next, followed by Computing and Physical Sciences shows that the vast majority of students' course choices (five per student) are of 'medium mathematical demand[9]' or are 'highly mathematically demanding courses'..

The University choices of the students were also classified according to the 'mission' groupings as shown in Table 28. Broadly speaking the 1994 and Russell group universities can be thought of as 'old' or red brick universities whilst the Million+ and University Alliance are new, post-92 universities.

Table 47: University type 1 by the five choices

Mission Group	Choice 1	Choice 2	Choice 3	Choice 4	Choice 5
Russell Group	22	18	16	20	7

[9] This is probably influenced by the big number of students (N=163) falling under what we have categorised as medium mathematical demand social science subjects.

1994	14	17	14	11	8
Million+	39	41	44	23	18
University Alliance	59	48	43	25	21
Grand Total	134	124	117	79	54

Since there are no apparent differences between the different course choices for the rest of the results, only the first choice will be considered. For university classification comparisons the first one is chosen because it is more comprehensive.

Figures 25 and 26 show how the course choices are distributed based on University type. There are students applying to 'old' universities to study physical sciences and engineering. On the other hand many of the Russell Group applicants are intending to read arts/humanities or social sciences.

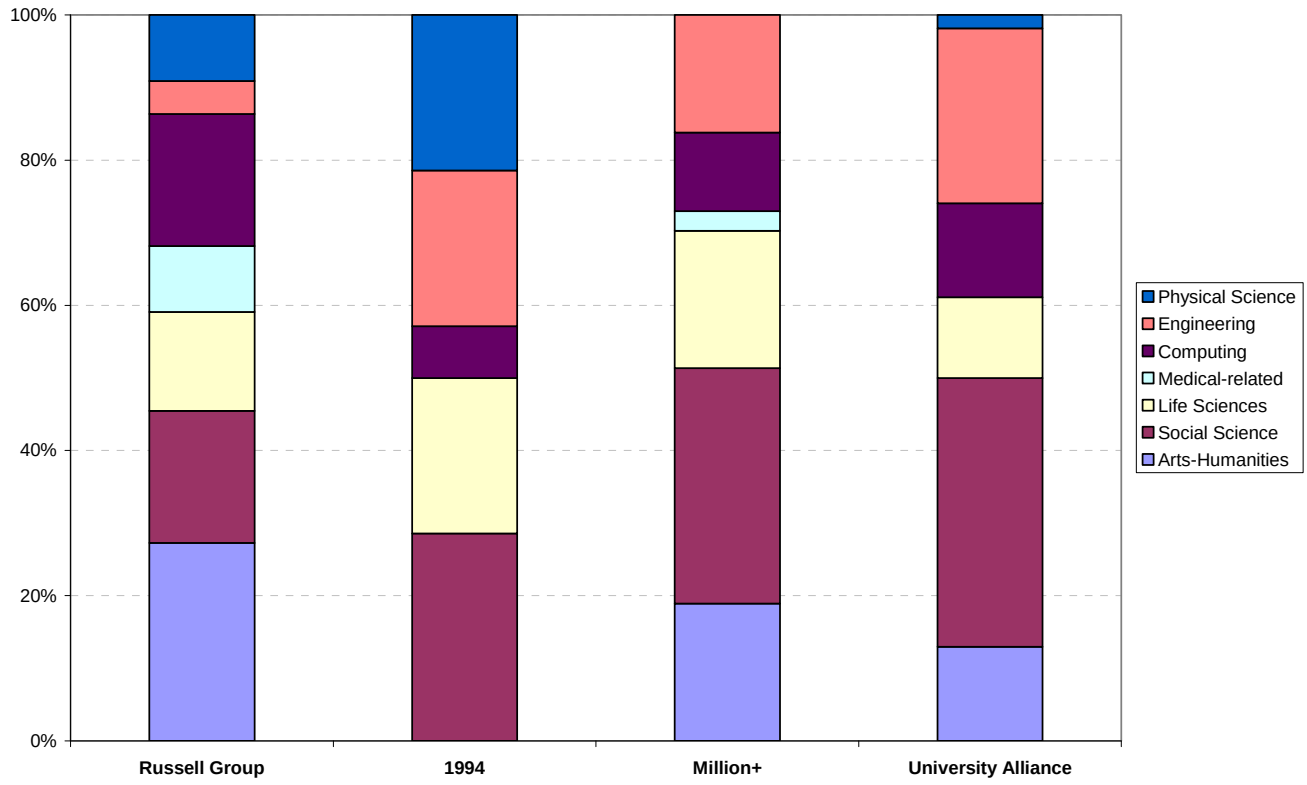

Figure 44: Course choices by University type

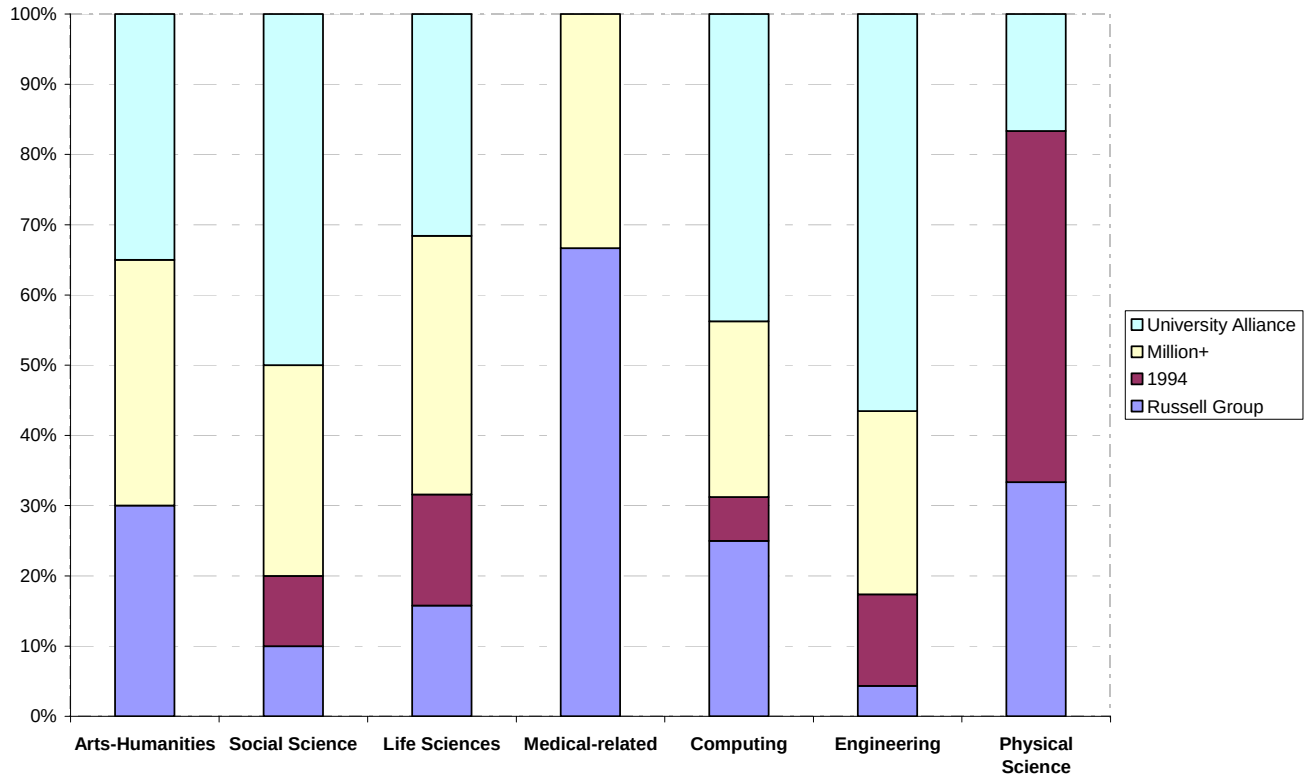

Figure 45: University type within each subject choice

Some gender differences are presented in Figure 27, in regards to subject choices. As might be expected, choices in Arts and Humanities and medical related subjects (e.g. nursing) are more popular for female students. In contrast Engineering is selected only by male students. This fits with earlier findings regarding the reasons given for choosing Use of Mathematics: more male students citing its perceived usefulness.

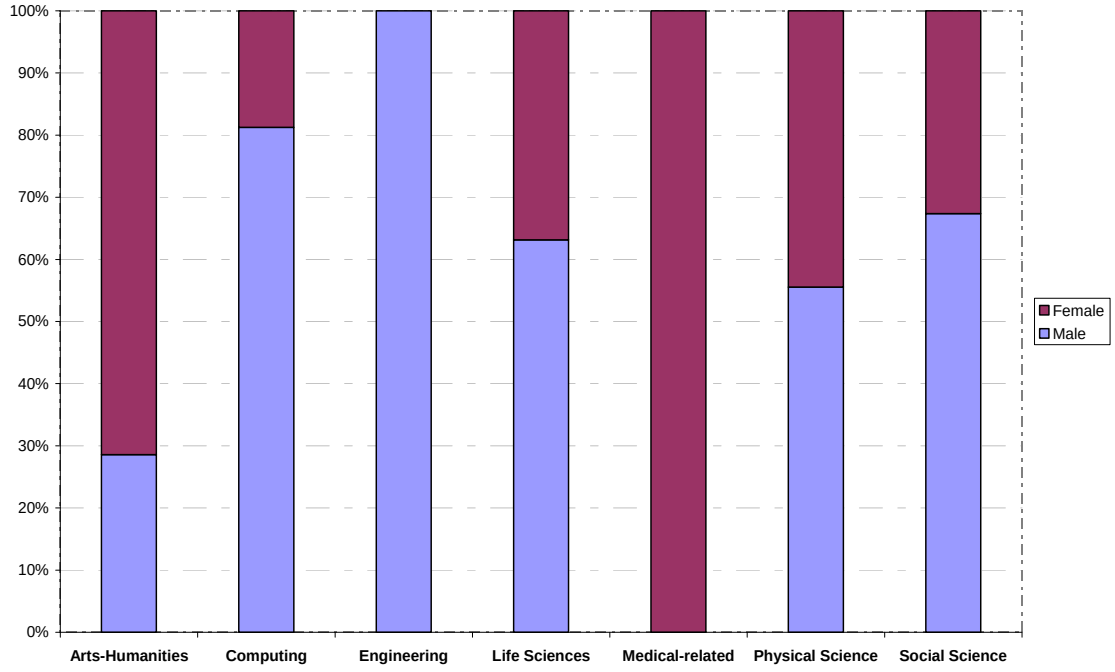

Figure 46: First course choice by gender

Finally some differences in students' perceptions about mathematics being a requirement of their course choice are presented in Figures 28 and 29 (split by type of University). The question remains as to whether those applying for physical science and engineering courses (many of them to 'old' universities, see Fig. 29) were aware of this requirement at the outset of their studies and whether or not Use of Mathematics meets the demands of admissions tutors.

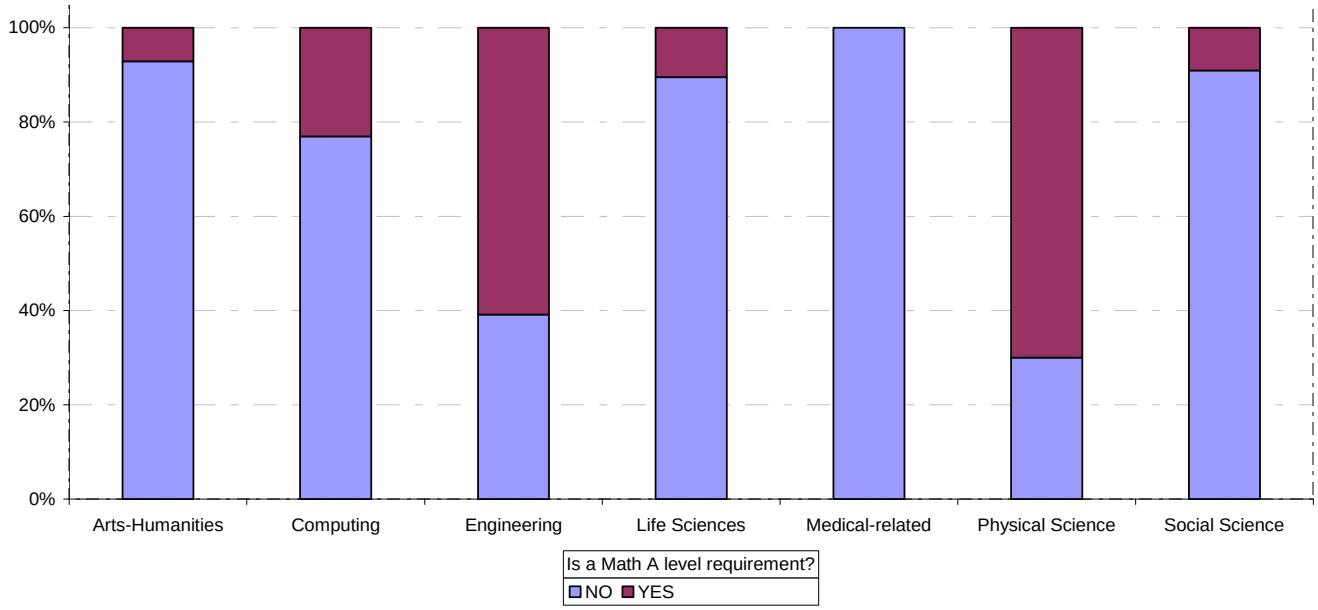

Figure 47: First course choice by perceived requirement for mathematics A level

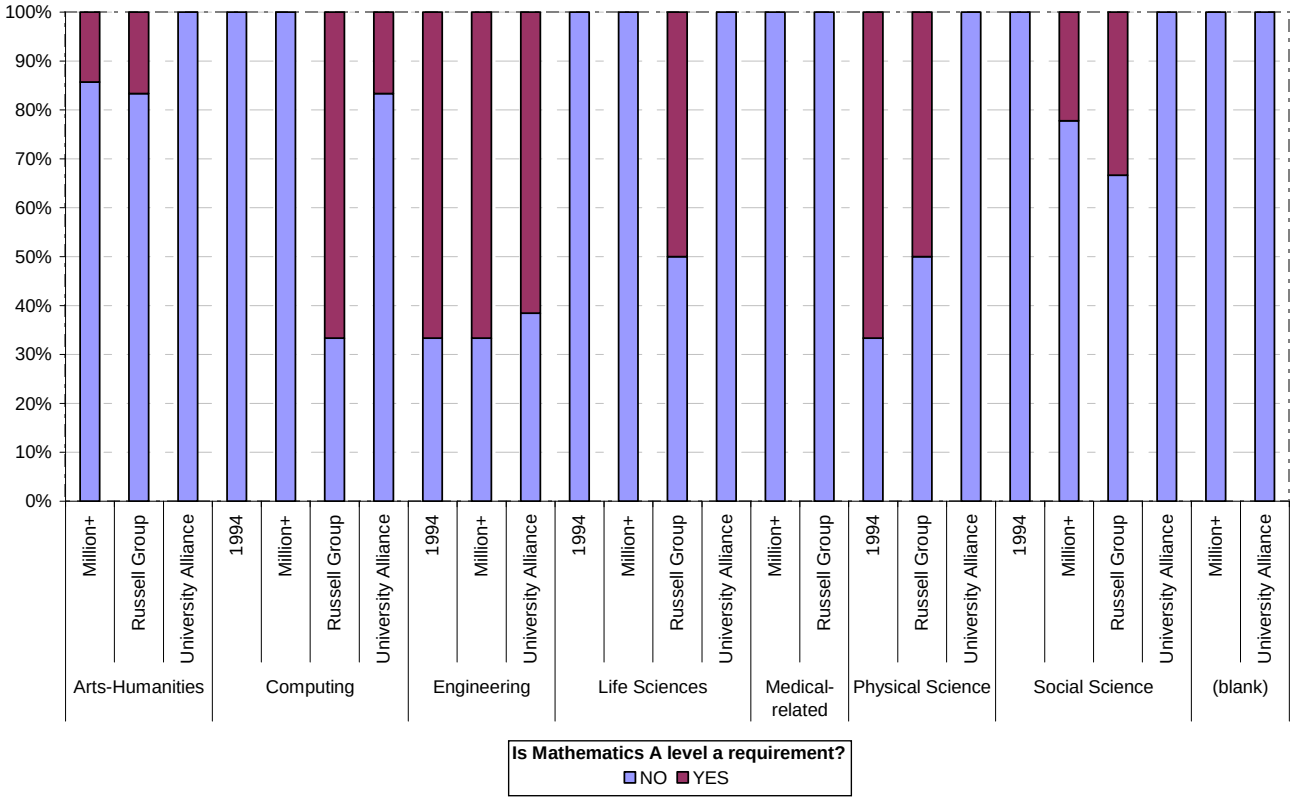

Figure 48: First course choice by perceived requirement for mathematics A level (split by University Group)

2.3. Issues arisen when applying to University

Finally, students were asked to report whether any issues have arisen concerning their Use of Mathematics qualification when applying to university (Question 18). From the 176 students who responded to this question, 30 said 'yes' (17%) and the remaining 146 (ie the vast majority) reported no issues. Table 29 shows how the students who reported issues arising when applying to University based on their first choice subject and University category. Most of them are in STEM related disciplines.

Table 48: Distribution of students who reported issues when applying to University, by first choice subject and University type

	University Group			
First Subject Choice	Russell Group	1994	Million+	University Alliance
Arts-Humanities [N=3]			1	1
Social Science [N=4]		1		1
Life Sciences [N=1]	1			
Medical-related [N=1]	1			
Computing [N=7]	4			2
Engineering [N=6]		2		3
Physical Science [N=4]	2	2		
Missing [N=4]				
Total [N=30]	8	5	1	7

From the qualitative statements of the students with issues it seems that many university admissions tutors do not know about the Use of Mathematics qualification. The list of responses to this question is given below:

- Did not know the course / Some universities haven't heard of it before. (N=7)
- University unaware of course content and whether applicable. (N=4)
- Not recognised by some institutions. (N=4)
- When I asked for straight physics courses at university they said they would only accept A Level mathematics, however astrophysics was no problem.
- They prefer proper A Level Mathematics.
- UEA not sure on whether to accept Use of Mathematics Course.
- The fact that a lot of universities refused to accept me because I was just doing the AS Level.
- Sheffield, Durham and York rejected me on grounds of inferior mathematics. Sheffield tutor described it as 'primary school mathematics'. With help from my tutor, they changed their minds
- Sheffield University's Computer Science Department did not recognise it.
- Not required as a mathematics course- not pure mathematics.
- Not A Level and not a science.
- Need a mathematics qualification

- Is it worth same amount of UCAS points as A Level mathematics?
- It is an English qualification, not Scottish
- Do not think you will get the grades and mathematics studied at AS and A2 will be different mathematics at university.
- Did not have required grade for AS but because I am retaking it was OK.
- Calculus restricted what I could do
- At an interview the interviewer questioned what exactly the course was.

APPENDIX B1: GCSE English and Science Grades

A. English

		Frequency	Percent	Valid Percent	Recoded
Valid		43	4.5	4.5	
	A	65	6.9	6.9	4. A and A*
	A*	9	.9	.9	4. A and A*
	A* A	1	.1	.1	4. A and A*
	A*A	1	.1	.1	4. A and A*
	A*A*	1	.1	.1	4. A and A*
	AA	11	1.2	1.2	4. A and A*
	AA*	1	.1	.1	4. A and A*
	AB	24	2.5	2.5	3. B
	AC	3	.3	.3	3. B
	B	223	23.5	23.5	3. B
	B B	1	.1	.1	3. B
	BA	6	.6	.6	3. B
	BB	39	4.1	4.1	3. B
	BC	51	5.4	5.4	2. C
	BD	2	.2	.2	2.C
	C	335	35.3	35.3	2. C
	CB	21	2.2	2.2	2.C
	CC	39	4.1	4.1	2. C
	CD	8	.8	.8	1. D and below
	CE	2	.2	.2	1. D and below
	D	40	4.2	4.2	1. D and below
	DC	1	.1	.1	1. D and below
	DD	3	.3	.3	1. D and below
	DE	3	.3	.3	1. D and below
	E	11	1.2	1.2	1. D and below
	F	3	.3	.3	1. D and below
	U	1	.1	.1	1. D and below
	Total	948	100.0	100.0	

B. Science

		Frequency	Percent	Valid Percent	Recoded
Valid		47	5.0	5.0	
	A	30	3.2	3.2	4. A and A*
	A*	3	.3	.3	4. A and A*
	A*A	2	.2	.2	4. A and A*
	A*A*	3	.3	.3	4. A and A*
	A*A*A	2	.2	.2	4. A and A*
	A*AA	2	.2	.2	4. A and A*
	A*AB	2	.2	.2	4. A and A*
	A*B	1	.1	.1	4. A and A*
	AA	31	3.3	3.3	4. A and A*
	AA A*	1	.1	.1	4. A and A*
	AA*	3	.3	.3	4. A and A*
	AA*A	1	.1	.1	4. A and A*
	AAA	7	.7	.7	4. A and A*
	AAAA	1	.1	.1	4. A and A*
	AAB	11	1.2	1.2	3. B
	AB	42	4.4	4.4	3. B
	ABB	10	1.1	1.1	3. B
	ABBB	1	.1	.1	3. B
	ABBBA	1	.1	.1	3. B
	ABBC	1	.1	.1	3. B
	ABC	3	.3	.3	3. B
	AC	5	.5	.5	3. B
	B	129	13.6	13.6	3. B
	B B	1	.1	.1	3. B
	B BC	1	.1	.1	3. B
	BA	4	.4	.4	3. B
	BAA	1	.1	.1	3. B
	BABD	1	.1	.1	3. B
	BB	100	10.5	10.5	3. B
	BBA	1	.1	.1	3. B
	BBB	17	1.8	1.8	3. B
	BBBB	1	.1	.1	3. B
	BBC	19	2.0	2.0	3. B
	BC	80	8.4	8.4	2. C
	BCC	12	1.3	1.3	2. C
	BCCCC	1	.1	.1	2. C
	BCCD	1	.1	.1	2. C
	BCD	3	.3	.3	2. C
	BCE	1	.1	.1	2. C
	BD	4	.4	.4	2. C
	BTEC	1	.1	.1	2. C
	C	141	14.9	14.9	2. C
	C B	1	.1	.1	2. C

	C.D	1	.1	.1	1. D and below
	CA	2	.2	.2	3. B
	CB	27	2.8	2.8	2. C
	CC	88	9.3	9.3	2. C
	CCB	6	.6	.6	2. C
	CCC	15	1.6	1.6	2. C
	CCD	5	.5	.5	2. C
	CD	24	2.5	2.5	1. D and below
	CDD	1	.1	.1	1. D and below
	CDDD	1	.1	.1	1. D and below
	CPass	1	.1	.1	1. D and below
	D	21	2.2	2.2	1. D and below
	DBC	1	.1	.1	1. D and below
	DC	4	.4	.4	1. D and below
	DD	9	.9	.9	1. D and below
	DE	2	.2	.2	1. D and below
	E	3	.3	.3	1. D and below
	EE	1	.1	.1	1. D and below
	F	2	.2	.2	1. D and below
	Merit	1	.1	.1	2. C
	Pass	3	.3	.3	2. C
	Total	948	100.0	100.0	

APPENDIX B2: Positive Dispositions towards Use of Mathematics

Just to learn more mathematics (5)

- Because I do not really need a maths qualification to do the course that I am applying at university git if I was offered to do other maths AS I would have done that as well.
- Didn't want to study pure maths with the other full on subjects I'm studying.
- Pure maths is no use to me.
- To increase my knowledge in mathematics.
- want to learn more from this subject

Breadth (3)

- Because I think I was better suited to it. Also it covers all areas of maths.
- Covered wider range of topics.
- Larger Spectrum

More applied/real-life (33)

- As I was told A level mathematics was an essential to do accountancy so I decided to do this subject as this is applied.
- As I was told it was applying maths to real life situations.
- Because I thought the real life application of mathematics would be better to go with my other courses.
- Because I wanted to do a type of maths which could be applied to real life situations and the other maths courses did not offer me that.
- Because it involved doing stuff I was more likely to come across in day to day life.
- Because it is more applied.
- Because it is more suited to my GCSE grade and it more relevant to real life.
- Because it seemed more appropriate to everyday life.
- Because Use of Maths appealed to me more as it's applied to everyday life.
- Because Use of Maths is more logical and I like the way it is related to real life which motivates me and makes it easier for myself.
- Because Use of Maths serves a purpose in real life as opposed to on paper.
- I prefer more practical maths.
- I thought that a subject relating to real life problems would be more useful to me at university
- I work better with Maths that is functional
- It seemed more relevant

- It suited me better because it is applied and real life data is used. It is easier to understand.
- It was a more relevant course
- It's more applied and has less units than A level maths
- More applicable to real life.
- More practical.
- More practical.
- More real world based.
- More realistic to the world
- More relevant for everyday use.
- Same answer as above.
- See above
- Seems to be more general and practical that normal maths.
- Sounded more practical and useful than standard maths.
- The subject areas in A level mathematics are not related to real life.
- Thought the course would be more relevant and a bit easier
- Use of Maths is more about real world situations with more statistics.
- Use of Maths is more practical and easier to manage alongside my BTEC Computing Course.
- Use of Maths was more practical and more useful to me and my subjects.

More interesting (17)

- As it was different
- Because in the end it looked more interesting and I didn't get the expected grade.
- Because the course looked a lot more appealing.
- Because this course looked better.
- Course suited me more, and the topics were more attention grabbing.
- I was more interested in why we use maths
- it appealed to me.
- It looked like a more interesting sort of maths.
- looked a more interesting course
- Looked more interesting and more to my liking and understanding than A level.
- Looked more interesting.
- More interesting
- More interesting and helpful as you see more application rather than abstract.
- More interesting course. I prefer applying knowledge

- More interesting. Recommended to me.
- Sounded less boring.
- The course seemed more appealing.

Particular module/topic (4)

- Algebra and data analysis attracted me
- Because I understood statistics.
- Because it combines the subjects of Decision and Mechanics at a more basic level.
- Finance took my interest.

Future (9)

- Because it is more noticed in the career world.
- Because it is slightly easier and more appropriate for me as I want a career possibly involved with maths but not based on it.
- Because it will help me in my future career and university.
- Better for career
- Helpful for future.
- I wish to get into engineering and UoM is more practical and suited
- It was more tailored to what I wanted to learn and the content was more likely to help me in later life.
- More understandable, useful in future. The A level maths did not relate to anything, I could not see why I was learning some of the stuff.
- Seemed more useful and relevant topic areas that will suit me in future career.

Complimentary (10)

- Course more suited to BTEC science
- Felt it was better to go alongside Engineering.
- Goes with business.
- I thought it would be too much with the other subjects I chose
- More relevant to Engineering.
- More relevant to my science practical skills
- Most suited to other subjects
- Most suited to other subjects
- Relates to stuff I will use
- The course is more relevant to my other subjects.

Other (20)

- After researching this course suited my needs.
- Appealed to me more at the time of choosing
- Because I believed it would benefit me more.
- Because I wanted a challenge.
- Because in the Use of Mathematics I have learns lots things and like the maths.
- Better suited.
- Didn't look appropriate.
- Don't need that much maths in my future.
- I decided UoM would suit me more
- I did not know that Use of Maths existed until I enrolled. It seemed a much better idea.
- It was the right choice for me
- Looked a better way of doing maths.
- Majority of syllabus was irrelevant to my studies and career path
- Mathematics involved a lot of stuff I'd already done.
- More appropriately suited to me.
- More suited to me.
- Seemed to be the more helpful choice
- The subjects in Use of Maths I knew more about.
- This is better suited in comparison to other types of maths courses.
- Use of Maths sounded better.

APPENDIX B3: List of helpful or unhelpful advice

Advice Given (122)

- A Chemistry teacher said it was more related to sciences.
- A level Maths teacher recommended change to Use of Maths.
- As I didn't have many GCSEs teachers helped me choose subjects that suited my abilities
- Brockenhurst College website and asked teachers about it. Started in the second year. I am doing FSMQ Modelling and Calculus alongside the AS Level.
- Career advisors explained it to me, family helped me decide to move to it
- careers advisor was helpful
- Clearly explained. Not relevant to me.
- College
- College staff said it is as good as A level maths but more real life.
- Connexions
- Connexions and my family helped but my old school were no help at all
- Connexions woman was very helpful.
- Couldn't decide between Use of Maths or maths. I got told Use of Maths would be easier for me.
- Encouraged.
- End of year 12, my teacher suggested I changed.
- Everyone at the college was very helpful and realistic about what they were saying, but other people didn't know what the course was like.
- Explain what each one was but couldn't choose for me.
- From College Open Day I received a lot of helpful advice on choosing this course.
- From my tutor when choosing options. Very helpful.
- From Open Day I received a lot of helpful advice about maths at college.
- From teachers at college.
- Gave me a better understanding of the subject.
- Helped me understand why I was moving courses
- Helpful - College Open Day telling me I was clever enough to do maths!
- Helpful - College prospectus.
- Helpful advice from maths teacher at a level who has taught both maths and Use of Maths.
- Helpful advice from my GCSE teacher.
- Helpful advice from teacher before, to move into this course.

- Helpful advice when I switched from maths to Use of Maths.
- Helpful: It is still equivalent to a A Level but the subject is not as difficult as further maths etc.
- I asked at the maths Department during year 11 whether there were different courses within the maths subject.
- I did receive help from my AS Use of Maths teacher because he was the one who told me about this subject and I think it was worth talking to him.
- I did not really receive any information about this course apart from when I came here on Open Evening and spoke to someone about it.
- I didn't know there was alternative to traditional maths until the Open Day.
- I didn't know what the course was about, so when finding out about the course content it helped my decision
- I got help from careers advisor who said UoM was a maths course for people who got a grade C
- I got told that it was very good to have finding a job and to go to University.
- I had helpful advice from my tutor that I had for Decision Maths.
- I have received helpful tips and advice from my subject tutor for my coursework.
- I learnt a fair bit, helpful
- I received help advice from the teacher I had when I was registering for Y12.
- I received helpful from teachers and family and websites. They help me if I don't understand anything during solving problems.
- I was advised to do so
- I was advised to do Use of Mathematics before I do an A level maths.
- I was advised when I found A-level maths too hard that an alternative course was available
- I was helped to get onto the right course for a C. So advice was helpful.
- I was shown a way to continue my math studies.
- I was told about the course as an equivalent course to traditional mathematics. However, as soon as I started the course there was talk of traditional students moving down, suggesting this was a lower course.
- I was told by teachers at my 6th form college to do UoM as I got a C at GCSE and because they wouldn’t let me choose another topic
- I was told it would suit me better.
- I was told that the course would be accepted by universities but 3/5 of my applications were rejected due to the maths, but on appeal have changed their minds
- I was told what careers I could follow with A level Use of Maths.
- I wasn't really told the difference until I met my maths teacher
- I would receive a higher grade and know more about how maths is used in the real world.

- Induction evening, tutor advised me to pick Use Of because statistically anyone with maths B struggled with A level maths.
- Information about the Use of Maths course was very helpful
- Intake Day, Head of Maths explained that Use of Maths would be better option for me,
- It gave me crucial information that contributed to my final decision i.e. how much algebra will I study, what difficulty.
- It was explained A level may be too hard. This aimed for C grade students.
- Just the information from the teacher about the course
- Knowing more about the course from the college open day really helped.
- Met with lecturers to discuss moving to Use of Maths.
- My AS decision teacher was helpful as he recommended that course because the statistics element complemented my other subjects.
- My GCSE maths teacher judged my grade and said I would cope well
- My GCSE maths teacher was very supportive
- My GCSE teacher was the most helpful but the careers advisers and websites were not.
- My teacher for decision maths said it would be suit me to do Use of Maths and it went well with psychology.
- My teacher of A Level Maths gave me the option of studying both AS and A2 Use of Maths in year 13.
- My teachers and family advised me on what would be in the course to help me decide.
- My teachers at college advised with my grades that I should take Use of Maths.
- My teachers provided the most help in helping me decide.
- My tutor and A level maths tutor suggested switching to Use of Maths.
- On open day got more information about it
- On signing up to college someone was very helpful in making a decision.
- On the College Open Day the mathematics teachers did advise students who got a B in GCSE maths that they would be better off taking Use of Maths.
- on the open day
- On the open day, teachers explained the differences.
- On the registration day teachers were very helpful in helping me made decisions.
- Open Day really helped because all course outlines were there to view.
- Outlining main course and also that there is coursework in Y13 (2nd year).
- Past Students
- persuaded to do it because it increases chances in other subjects
- Prospectus
- Prospectus said it was only an As.
- Received helpful advice about this course from GCSE teacher.

- Received helpful advice from people on enrolment day. Told me how it would help.
- School gave me the opportunity to study a subject that consisted of maths.
- School teachers and TAs helped me find flaws in my maths and led me to Use of Maths as it was more to my liking and advantage.
- Sixth form head was very helpful in making decision to do Use of Maths.
- Teacher explained it through well.
- Teacher gave me more details about the course.
- Teacher helped me pick UoM as it was perfect for me
- Teacher told me about course, sounded good.
- Teachers at college.
- Teachers at GCSE and A-level gave good advice as they knew what sort of grades I needed and would be likely to achieve
- Teachers helped to explain courses better
- Teachers were very helpful
- That you don't need to study pure maths to get a place on an Economics Degree.
- That you get free standing maths qualifications as well as an AS/A2.
- The 6th form options booth was very helpful.
- the college and teachers were helpful in thinking about what would be best for me to cope with
- the college guided me to UoM as they said I could get a better grade than at normal maths
- The College Open Day was particularly helpful as I could see what the different maths courses consisted of.
- The course was explained by a teacher and it seemed to be a course that suited me.
- the open evening was very useful
- The prospectus for Henley College said it was just an AS course.
- The prospectus helped me make my decision as it gave a good course description.
- the workshops have been very helpful
- They said Use of Maths was just like normal maths except it is what you might use everyday.
- They tell you why you should do the course and what it involves but do not tell you how difficult it will be.
- They were helpful because they told me what it involves and what I could do with the course.
- Told me which course would best for me.
- Tutor at one to one meeting.
- Tutor told me about the course and how it would suit me better.

- Very brief but available.
- When I enrolled the maths teacher did not suggest Use of Maths to me. It was only suggested by a humanities teacher uninvolved with maths.
- When I was applying for the course at QMC and was told that B grade at GCSE was required for me to do A Level Mathematics or it could be too hard.
- When registering they made me take this course which was good.
- When registering, gave me more information on the course. My family supported my decision and took an interest.
- When visiting the maths department I was told what would be involved
- Whether universities accept or take UoM as a maths subject/how well it is perceived by them.
- You will not do well in maths if you do not get an A

Lack of information/advice (42)

- At College it was not advised as an option on Open Day.
- Because I originally signed up for traditional maths when I changed subject. I was not told much about the course.
- Because the course is in the pilot stage, I only received advice on the old course.
- Did not know about it until Year 13. Only did FSMQ decision in Y12.
- Did not receive any particularly helpful or unhelpful advice.
- Didn't get any
- Didn't give full information on the open day of the course. Focused on pure I.
- GCSE teachers should bring awareness regarding UoM, I didn’t know it existed
- I did not ask them.
- I did not know much about the course.
- I did not receive any advice because it was a last minute course I chose.
- I did not receive any advice.
- I did not talk to any teachers/go to open days/talk to family etc.
- I only knew about it by the college booklet and that was not really enough information.
- I was not advised by my GCSE maths teacher as I don’t think she knew what the course was about
- It wasn't explained what the course involved. I think I would have been better suited to another type of maths.
- Maths' teacher at GCSE was unhelpful and didn't care.
- Maths' teachers weren't very helpful
- No
- No advice on Use of Maths

- No discussions of subjects I was taking for Year 12 with Year 11 teachers.
- No one knew what it was in my previous school. The open day was a shambles.
- No one told me anything except when I enrolled. It wasn't very helpful
- no one told me the difference and that effect University placement if you wish to study math further
- Nobody informed me of Use of Maths till I had failed.
- None
- None Given
- Not many schools or teachers know of the course at other schools that not teach it.
- Not many tutors teach it you're struggling in the subject.
- Not very helpful from university websites and prospectus.
- Old school had not even heard of it.
- Teachers when registering for Y12 courses did not really explain what A level Maths was.
- The teacher I asked wasn't helpful as she did not know much about the course.
- The teachers did not know about 2nd Year for Use of Mathematics.
- There is not a lot of good advice for the Use of Maths
- There was just more advice about traditional maths
- They did not say in the prospectus that Use of Maths was an option, and on Open Day they didn't really explain the course.
- They didn't tell me anything about it
- Took AS maths last year and failed. Teachers did not tell me abut Use of Maths. Only after I failed was I told about it.
- Wasn't really told much about it
- When choosing maths A level I wasn't told that Decision and Statistics Maths were part of a module of core A level of maths so moved to Use of Maths then found out I couldn't move back.
- You never know unless you experience it. GCSE teachers gave me a taster, but not enough for me to understand.

Conflicted (8)

- Form Tutor made the differences between the maths unclear and it feels as though she pressured me into this course.
- I was not looking for advice to study Use of Maths because I did not want to do it at the start.
- My Tutor told me to take UoM instead of A-level maths because I wanted to be an accountant. He knew nothing.
- Told that the Use of Maths would be valued as highly as pure maths, but it is not.
- Unhelpful - GCSE teachers saying I shouldn't do any maths courses even though I got grade B.

- Unhelpful as I wanted to do decision but the advisor made mistake and said it is the second hardest.
- Was advised to take UoM instead of traditional maths. Wish I had taken traditional maths
- Was swayed into courses I did not want to do and now doing three years because of this.

Other (18)

- by explaining what the course is, whether it is a good course and whether it would help me
- Could have more detail
- General help
- Get more of an understanding from the teachers
- Good for the future.
- I don't think so.
- I only really considered doing statistics.
- It’s better to have an A in UoM than a B in A-level maths
- Just do it is another A Level.
- misleading
- Shouldn't make Use of Maths seem for the unclever.
- Taught me to add the numbers together.
- The faster lessons for Use of Maths was cancelled
- Tutor complained to me.
- UoM is too easy for me
- Useful in future.
- Was told I could study pure maths and then had my course changed when I started college.
- When I applied for the courses I done different one but now I am in different course.

APPENDIX B4: Further reasons for AS students not continuing to A2

- Going into RAF
- going to work
- Because I wanted to do Geography and ICT more.
- Because I am currently in my second year of college and do not wish to stay for another year.
- Because I do not need mathematics for the career I want to do and I think there are other courses that I will need.
- Because I only am doing it because I dropped mathematics which I chose as an extra subject which I did not want to continue.
- Because I only intended for it to be an AS.
- Because I said that I confuse myself very easily with digits and the techniques of mathematics that are used for the course are the areas I struggled in at GCSE.
- Because I won't get the grades needed for A2.
- Because I would prefer to carry on with my favourite subjects.
- Changing college so I can do pure mathematics.
- The course is too long winded, and the things we're taught aren't useful.
- the first year was good and I think I could do well
- The teacher is not teaching Decision properly and the class is struggling with this unit
- There is no subject as A2 Use of Mathematics and also I will be going to university next year.
- Thought it would be more interesting and a bit easier.
- Not enough support from teachers, which is causing me to fail, badly.
- Mathematics is not my strongest area of academics and I struggle with AS level so therefore A2 level does not appeal to me.
- Not currently working at a satisfactory level.
- too much focus on using calculators
- university or work
- A-level mathematics instead
- Fall too far behind. No help offered, so will fail.
- I am a Year 13 student not looking to complete a 3rd year.
- I am an A2 student so therefore I will be leaving college.
- not relevant to career
- offer to other college
- prefer essay based subjects

- I am doing A-level mathematics instead
- I am stronger in my other A level courses.
- I am taking on a BTEC course next year
- I don’t feel like I'm making much progress and a couple of the units seem irrelevant to what I'll use in later years.
- I don’t need it for what I want to do
- I enjoy my other subjects more
- I enjoy Use of Mathematics but would like to change my mathematics course possibly to mechanics
- I feel other subjects will be more beneficial to my future
- I have been told that I am not capable as I am not the best at algebra.
- I have picked 4 subjects that complement each other
- I have to drop something and I cannot drop anything else.

Appendix C: Summary of Recommendations

Stage 2 – December 2007

Recommendation	Commentary
Separating GCSE mathematics and functional mathematics qualifications presented awarding bodies with a difficult transition process to manage and created some confusion in centres.	**Changes to specifications were implemented for summer 2009. The revised SAMs caused concern amongst OCR centres and the number of candidates, particularly at Foundation tier, reduced considerably.**
The change in structure of GCSE mathematics has introduced a potential problem relating to the status of functional mathematics, its place in the range of mathematics qualifications and consequent questions regarding its role in the curriculum.	**April 2009 – Jim Knight wrote publicly to Ofqual saying that achievement of grade C or above in GCSE English, mathematics and ICT would not be dependent on achievement of level 2 functional skills.**
Participation in a*dditional* mathematics GCSE was not the main focus of trialling work and there is need for direction with regards to expectations regarding GCSE 2 participation. The agreement that GCSE 2 grades from the pilot qualifications can count in the candidates' 5A*-C count is helpful.	**Participation in *additional* mathematics GCSE has held up throughout the pilot whereas entries for the pilot GCSE mathematics have fallen away over time.**
The perception of the role of *additional* mathematics GCSE in pilot schools was very mixed and this is perhaps indicative of the lack of clarity about progression and pathways.	
Pathways: from the outset we heard relatively little discussion about mathematics pathways and a great deal of talk about qualifications. This discourse privileges assessment over teaching and learning.	**We are only a little further on with understanding learner pathways than at this stage in the project. This foundational principle for the Pathways Project has still not been adequately understood or engaged with. In addition, recent discussions on GCE development and the linked-pair pilot present new challenges and opportunities for the development of pathways principles.**

Stage 2 – December 2007

Recommendation	Commentary
GCE mathematics: in the GCE pathways pilots there was a notable imbalance in the size of the two projects and they reflect quite different levels of continuity from the Phase I pathway models.	**The OCR pilot remained very small and become smaller during the evaluation, despite considerable efforts to raise awareness and encourage participation.**
ICT: There was some early discussion in meetings of the Post-14 Mathematics Advisory Group regarding the role of ICT in the pathways project but there appears to be limited momentum in this area at this time.	**ICT, which was prominent in Phase I models and advisory group discussions has had a low profile. The level 3 consultation included the proposal to remove the non-calculator assessment in GCE mathematics.**
Support: Teachers involved with the pilot would like more opportunities to meet with, and explore with each other, implementation issues. We would urge that additional support be provided by appropriate agencies such as the NCETM, possibly through the establishment of a forum for participating centres.	**Some teachers continued to report that there were not enough opportunities to meet with other pilot centres although Awarding Bodies have run meetings for centres which have included networking opportunities.**
Pathway terms: Given that there is some confusion about purposes and meanings of the various pathways components we think it would be helpful to develop a shared understanding (accepting that language is problematic and there will not be full consensus) of meanings such as functional, applied, context based, etc.	**This has remained an issue throughout the project.**

Stage 3 - April 2008

Recommendation	Commentary
Modelling of the **hurdle**, i.e. level 2 functional mathematics as a necessary precondition of access to 'good' grades at GCSE mathematics (and *additional* mathematics), needs to be given high priority following the June examinations.	**This was conducted but ceased to become an issue in 2009**
The intended qualification status of ***additional* mathematics** should be clarified, i.e. whether it can count as the mathematics grade in the 5A*-C count beyond the duration of the pilot. Although both GCSEs count for this performance measure during the pilot phase we anticipate that what happens when qualifications are rolled out will have an impact upon participation rates.	**This GCSE will not continue post-pilot. However the development work has informed the GCSE introduced alongside the new KS4 programme of study in 2010, particularly in relation to the assessment of mathematical thinking and problem solving.**
Greater clarity would be helpful regarding government expectations for participation rates in ***additional* mathematics**. Varying estimates from 'most or all' down to 50% have been suggested and this difference is significant for future learners and current pathway contractors, both in terms of their work with centres and in the design of qualifications.	**Early in the project we highlighted the mixed views of the purpose for, and expected participation in, a second GCSE. This two GCSE model will not continue post-pilot. However a new linked pair model is now being piloted.**
The purpose of **additional mathematics** should be clarified; particularly as in its present form it is not meeting its aims and objectives	**We do not see that the issue of purpose has ever been satisfactorily resolved. It would be important to address similar issues in future pilots**
Good practice in **KS4-post-16 liaison**, particularly where teachers of mathematics are effectively collaborating regarding student progress and curricular and pedagogic coherence, needs to be identified and disseminated.	**The DCSF commissioned NCETM to investigate transition from GCSE to level 3 and to identify good practice that can be more widely disseminated.**

Stage 3 - April 2008

Recommendation	Commentary
There needs to be urgent discussion about **the nature of the design of the pilot qualifications** so that each develops a more distinctive profile and better measures the mathematics that it sets out to assess. Such discussion should be informed by considering the likely experience of learners in working towards the assessment.	**This quickly became obsolete for the pilot GCSEs but there is still room for developing principles for the design of better assessment items, particularly given the powerful influence that assessment has upon the enacted and experienced curriculum.**
Careful consideration is needed of **how to better assess mathematical process skills**. To ensure that learners are encouraged to cope with mathematical problem solving, in both real world and mathematical contexts, consideration should be given to introducing less highly structured assessment than is currently prevalent.	**The new GCSE will continue to address this.**

Stage 4 - December 2008

Recommendation	Commentary
We continue to be concerned about the general lack of attention to the guiding concept of **pathways** in steering developments. Our scrutiny work highlights the experiential discontinuity between GCSE and GCE mathematics (mainly in level of algebraic demand). Given that the 14-19 landscape is changing so quickly *it would be instructive to rethink the pathway models to reflect a) the current position and b) possible future scenarios.*	**It continues to be difficult to see a clearly articulated set of curriculum principles, which underpin the Pathways project. The challenges are exacerbated by the various timeframes for GCSE and GCE changes, as well as the parallel developments of functional skills and diplomas.**

Stage 4 - December 2008

Recommendation	Commentary
The impact of the Level 2 functional mathematics qualification acting as a **hurdle** to obtaining higher level GCSE grades (A*-C) remains unclear. Current models from awarding bodies show substantial variation and time is running short for understanding and addressing this issue. This is exacerbated by the fact that development of the functional mathematics qualifications is iterative and ongoing. *Urgent consideration should be given to developing a strategy for ensuring comparability of expectations across awarding bodies.*	**The place of the hurdle has been resolved. However, functional mathematics remains and we wait to see how comparability of standards can be assured.**
Functional mathematics is seen by teachers as being more suited to particular groups of students (i.e. lower attainers). For many low attainers it is having some impact upon teaching and learning, thereby increasing motivation and engagement. Most high attaining students will complete it as soon as possible to 'get it out of the way'. For these students, we anticipate the separation of mathematics and functional mathematics. We also expect high uptake early in 2010-2011 as centres make the most of repeated entry rules to reduce any potentially negative effect of the hurdle.	**Most students will only experience functional mathematics within the GCSE curriculum and assessment, embedded as 'functional elements'.**
There is clear and growing evidence that the **removal of KS3 tests** will lead to a large proportion of schools starting their GCSE course early and completing it early (either in year 10 or part way through year 11). This could disrupt pathways at the end of compulsory schooling and we anticipate that the fallout from large scale acceleration could be very negative for learners. *QCA and others should consider carefully what the unintended consequences of this sudden change might be for mathematics and how this might be ameliorated.*	**Although this aspect of mathematics learning pathways fell outside of our evaluation remit we do think that it would be instructive to know how schools are actually responding to these changes. There was an initial concern that schools are looking at acceleration rather than enhanced experience. The knock on effects could seriously damage participation in level 3 mathematics. Our recent survey has explored these concerns in more depth**

Stage 4 - December 2008

Recommendation	Commentary
The future of ***additional*** **mathematics** GCSE remains unclear but we can be sure that it cannot exist in the current form. It is unfortunate that decisions have to be made at this stage in the pilot process as the iterative development of qualifications at Levels 2 and 3 might show us how such qualifications could be combined to create better continuity for learners. *Future development of a second GCSE should be predicated upon a clear and agreed understanding of aims and audience, and upon whether these aims are best met through such a qualification.*	**There have been significant developments here, and a new pilot of a linked pair of GCSEs commenced in September 2010.**
The hope that new qualifications will transform **teaching and learning** in the 14-19 age range is hindered by the current educational climate. Managerialism, school markets and performativity are compelling forces which constrain the actions of teachers and departments. In a minority of pilot schools, teachers are really making the most of the opportunities afforded by functional mathematics and *additional* mathematics but these are the exception rather than the rule; most teachers remain very conservative in their practice (though not always in their beliefs). Functional mathematics is likely to be limited by this climate so that student *functionality* is a measure of passing the test rather than in being mathematically functional.	**All learners are entitled to develop mathematical thinking, functionality and problem solving as well as technical fluency through their study of mathematics. Whether this happens in practice remains to be seen. At the end of the pathways project professional development structures that might be expected to support teachers with developing their practice are in a period of uncertainty. The NCETM consequently has an important role to play here in taking forward what has been learnt in piloting and supporting future professional development that supports this.**
The introduction of **two-tier GCSE** does appear to have had some negative effects on learners. There are early reports that the new higher tier has resulted in reduced algebraic fluency of current AS students.	**The new GCSE from 2010 has an A grade description which expects algebraic fluency. Papers will need to be designed so candidates can demonstrate that. This is different from the current situation in which criteria describe grade A performance based on content but require just 25% of the available marks to be targeted at grades A and A*. We reported on GCSE algebra in Stage 7.**

Stage 4 - December 2008

Recommendation	Commentary
Pilot **assessment items** across the range of pathways still tend to be very structured and although they have become less structured in the first cycles of the process of qualification development there is still some way to go. We have seen that sudden changes can lead to adverse reactions from pilot centres and it is apparent that many centres now consider there to be little incentive for continuing with the GCSE 1 pilot.	**Assessment design and development should become a priority given its influence on teaching and learning. It is not clear how this can be instigated, supported and sustained.**
There is compelling evidence that **GCE Use of Mathematics** would attract new students to study mathematics at level 3. There are some concerns amongst stakeholders about this qualification and careful consideration of the issues is needed.	**The level 3 consultation included criteria for two full A levels based on FSMQs: Use of Mathematics and Use of Statistics. Following a stalemate after the consultation the Use of Mathematics pilot is continuing with an increased limit on the number of centres.**
On the whole, changes to **GCE mathematics** have not been substantial. The two awarding bodies are piloting quite different models and before these have been evaluated there are discussions under way regarding future changes.	**We note that the QCA proposals in the level 3 consultations were more radical than either of the pilots and were broadly in line with ACME's level 3 mathematics position statement. With the exception of the continued Use of Mathematics pilot there will be no change at A level resulting from the Pathways project.**

Stage 5 – April 2009

Recommendation	Commentary
There is an ongoing need to make explicit a **clear vision for mathematics pathways** so that this can inform those closely involved with the pathways developments. At a later stage this needs to be communicated to teachers, senior managers in schools and colleges, parents, HE admissions tutors, employers and so on.	**This has been an ongoing concern for the EMP team. Should a better model of pathways be developing in the future it would need to build upon such a clear and commonly understood vision.**
'Public' awareness of the Use of Mathematics qualification needs to be increased, for students, parents/guardians/carers, teachers, HEI admissions tutors and employers.	**The GCE Use of Mathematics student survey in the spring/summer of 2010 (see section 5 of this report) shows that there is a need to raise awareness of these qualifications, particularly for students applying to pre-92 universities for mathematically demanding courses.**
There is a need for the development of case studies that inform mathematics departments of effective ways of implementing and managing the new pathways that can be developed using **FSMQs and Use of Mathematics qualifications.**	**EMP have produced an 8-page pamphlet on progression issues in 14-19 mathematics which goes some way to addressing this.**
We recommend that high priority be given to **supporting teachers** of FSMQs and GCSE Use of Mathematics at all levels as they develop and incorporate a range of new pedagogies into their practice, including their use of pre-release materials. This should include development of materials that support teaching and learning as well as professional development, drawing on existing models of good practice, for example the Nuffield Foundation resources.	**This remains a priority. It is important that teachers are supported with the introduction of the new pedagogies required. Although there may be some support in this case from charitable sources such as the Nuffield Foundation, curriculum development needs resources beyond those available at the time of the piloting of qualifications.**
Given the support for GCE Use of Mathematics, there is urgent need for consideration to be given as to what should happen post-pilot.	**The pilot has been extended and expanded so that further development and evaluation can take place before deciding upon the future of the GCE Use of Mathematics.**

Stage 5 – April 2009

Recommendation	Commentary
FSMQs and Use of Mathematics qualifications assessment writers should aim to make more of the **realistic contexts** framing their questions.	**This remains an ongoing challenge although progress is being made and the extra time afforded by the extension of the pilot should create the space for this to happen.**
There is need for further consideration of the scope and purpose of **computer-based assessment** in mathematics. Careful research should be conducted before introducing any form of computer-based assessment in mathematics.	
Transition advice needs to be developed for Key Stage 4 teachers which gives models of good practice in supporting students with continued study of mathematics across the transition boundary. It is particularly important that this has impact in 11-16 schools. QCA should consider how this can best be disseminated most widely.	**This is an outstanding need and our survey of Use of Mathematics students has highlighted the reduced availability of advice for students in 11-16 schools compared to those in 11-18 schools. Moreover, the GCSE survey (summer 2010) also highlighted varying early entry strategies in different school types, which will also have an impact on students' transitional experiences and the advice they receive.**
The **impact of two-tier** GCSE should be examined in more depth to establish the impact on various groups of learners and their mathematics learning trajectories.	**We have undertaken this in our summer 2010 GCSE survey (see section 4).**
In future evaluations of pilot qualifications, there needs to be sufficient space in the plan to be able to learn from the piloting process before decisions are made and roll out of new qualifications occurs. **Timelines** for deliverables by evaluators should be carefully dovetailed with other consultation activities and decision timescales in order to make best use of the resources available.	**During Stage 8 we have spoken to representatives of all of the Phase I and II teams who support this need for greater lead-in times if meaningful and beneficial changes are to be made. Clearly this presents challenges within the current political system in which changes are required to happen quickly.**

Stage 6 – December 2009

Recommendation	Commentary
The Awarding Bodies should, with QCDA's support, explore what can be learned from the development of **assessment** items in the pilot. In particular the *additional* mathematics GCSE papers appear to have allowed the development of some assessment items that require students to engage with a greater range of process skills than is the case in other current qualifications, and in some instances in contextual situations. These items may prove useful in informing principles for future assessment item writing.	**Much of this learning has supported the development of items for the new GCSE and is also informing the development of the linked-pair pilot and its evaluation**
QCDA and the Awarding Bodies should consider how evidence might be collected to evaluate the **impact of assessment changes upon student performance and teacher pedagogy**. If this is not readily available at this point its collection should be considered for future examination cycles.	**This evaluation has not been able to explore changes in pedagogy that have arisen as a result of the piloting. However, in the Stage 7 report we were able to show how students perform in algebra at GCSE.**
QCDA and other bodies should further highlight the disadvantages of what seems to be an increasing practice of **early entry** for GCSE. We recognise that this trend might be difficult to reverse given the pressure on schools to maximise grade C performance to protect 'league table' position or satisfy Ofsted or others.	**Although there is much expressed concern about this practice, and QCDA have made it clear that they do not condone such practices, it is clear that this trend is not going to be easy to reverse.**
Work needs to be done to determine whether the **early entry** patterns at GCSE reported in pilot schools are mirrored across England. Further and larger surveys of entry **trends at GCSE** should be conducted with a view to understanding what the implications are for continuity and progression in mathematics learning.	**The GCSE survey reported in Section 5 below explores this question.**

Stage 6 – December 2009

Recommendation	Commentary
Current and future developments of GCSE and other level 1 and 2 mathematics programmes should take into account the **needs of the lowest attainers** who appear to be no less disenfranchised under a two-tier regime than they were in a three-tier system of GCSE mathematics.	**More recent evidence suggests that this earlier concern regarding the attitudes of the lowest attainers might have been ameliorated.**
Policies need to be clarified in relation to whether a **level 1/2 certificate (in Use of Mathematics**) is equivalent to GCSE as an indicator of mathematical potential for future study/employment.	**It has now been made clear that this qualification will be a certificate and that the final structure will not be the same as that which was piloted. This leaves its status in question. Will it count, in practice, as a GCSE equivalent?**
All Year 13 **Use of Mathematics** candidates should be surveyed during 2010 to explore future aspirations, university entrance experiences, etc.	**This has been completed and is reported in this Stage 8 report**
A national strategy for the **professional development of mathematics assessment writers** should be considered. This is a problem that should be tackled by QCDA/ Ofqual rather than at Awarding Body Level, and is of particular importance in ensuring that qualifications can evolve to support desired curriculum and pedagogic change in addition to supporting innovation in new qualifications (such as Use of Mathematics).	**There are ongoing questions about the capacity in the system to run large scale pilots. Where new qualifications are being developed (or new strands within existing qualifications, e.g. problem solving at GCSE) there is a need to think about the development of assessment writers if we are to develop genuinely new, robust and relevant modes of assessment.**

Stage 7 – April 2010

At the time of writing the Stage 7 report has only just been made available to those stakeholders who might respond to its recommendations

Recommendation	Commentary
Decisions on the future shape of all of the Pathways qualifications, particularly the pilot AS/2 Use of Mathematics award, need to be made. There then needs to be rapid **communication** to all key stakeholders, including teachers.	**The decision has been made to continue the GCE Use of Mathematics pilot. Other than that there is an ongoing pilot of the GCSE mathematics linked pair and this has been supported by the new coalition government. Any changes to A level have been put on hold**
A strategy for developing high quality **support materials** for teachers and students, CPD opportunities, and networks of expert teachers should be developed to ensure a healthy start when GCE Use of Mathematics is introduced.	**This highlights that thought needs to be given about how to support changes resulting from the pilots of the pathways qualifications. At this stage it is not clear how this will happen although the Nuffield Foundation is supportive of this work.**
The future and purpose of **GCE Use of Mathematics** should be made clear at the earliest possible opportunity. Furthermore, there should be an effort to reach consensus across the community regarding the value and purpose of the qualification.	**There remains a lack of clarity on the future of this qualification, but we note the pilot is continuing.**
Centre reports about perceived lack of comparability of standards across units in Use of Mathematics need to be considered carefully, and whatever the cause, measures should be taken to ensure comparability and enhance user confidence.	
A coordinated strategy for ensuring that **CPD materials** and opportunities for developing pedagogies for problem solving, and process skills more generally, reach and impact classroom teachers should be developed. NCETM are well placed to lead this in parallel with the support offered by awarding bodies, publishers and other stakeholder groups.	**The National Strategies (Secondary) has led the workforce development associated with the new secondary programmes of study for mathematics.**

Stage 7 – April 2010

Recommendation	Commentary
Work should be undertaken to improve understanding of the future **mathematical needs of young people**, particularly those completing education with level 1 and 2 qualifications. Given that all young people will soon remain in full-time education or training until 19, with GCSEs no longer being the standard 'exit' qualification, the potential of GCSE mathematics to meet the needs of this group should inform future curriculum and assessment developments.	**ACME's mathematical needs project is seeking to address this.**
With reference to the assessment of algebra awarding Bodies should consider: 1. including more items that require the generation of algebraic statements from contexts where pattern and/or contextual structure is important; 2. designing mark schemes which incentivise answers which demonstrate algebraic competence compared with those which use a numerical approach; 3. working with examiners on the assessment of algebra.	**The annex on algebra was passed to the Awarding Bodies.**

Appendix D: Scrutiny of Papers

Scrutiny of the following papers was undertaken during 2008

board	Paper	date	questions	marks	notes	level
aqa	4306 1F	Specimen	28	100	GCSE	1
aqa	4306 2F	Specimen	27	100	GCSE	1
aqa	93002 FA	Jan-08	5	25	GCSE 9307 Foundation	1
aqa	93002 FB	Jan-08	4	25	GCSE 9307 Foundation	1
aqa	93003 1F	Specimen	11	50	GCSE 9307 Foundation	1
aqa	93003 2F	Specimen	14	50	GCSE 9307 Foundation	1
aqa	9305/a	Jan-08	3	25	functional maths level 1	1
aqa	9305/b	Jan-08	20	20	numbered 4-23 (continuation of above)	1
aqa	9306/f	Specimen	34	100	Foundation GCSE Additional Mathematics	1
aqa	9981/PM	May-08	10	40	Money Management L1	1
aqa	9982/PM	May-08	8	40	Spatial Techniques L1	1
aqa	9983/W	May-08	9	40	Using Data L1	1
ocr	B811/1F	Specimen	16	100	GCSE	1
ocr	B812/2F	Specimen	16	100	GCSE	1
ocr	B821F	Jan-08	19	100	GCSE 9307 Foundation	1
ocr	B822F	Jan-08	16	100	GCSE 9307 Foundation	1
ocr	J512/1	Specimen	20	100	GCSE Foundation	1
ocr	J512/2	Specimen	21	100	GCSE Foundation	1
aqa	9984	Jun-08	11	50	Financial Calc L2 Pilot	2
aqa	9985	Jun-08	7	50	Shape and Space L2	2
aqa	4306 1H	Specimen	24	100	GCSE	2
aqa	4306 2H	Specimen	26	100	GCSE	2
aqa	93001/1	Jan-08	30	30	functional maths level 2 - competency	2
aqa	93001/2	Jan-08	5	60	functional maths level 2 - functionality	2
aqa	93002 HA	Jan-08	6	25	GCSE 9307 Higher	2
aqa	93002 HB	Jan-08	6	25	GCSE 9307 Higher	2
aqa	93003 1H	Specimen	13	50	GCSE 9307 Higher	2
aqa	93003 2H	Specimen	14	50	GCSE 9307 Higher	2
aqa	9306/h	Specimen	26	100	Higher GCSE Additional Mathematics	2
aqa	9986/PM	Jun-08	8	50	Data Handling Intermediate	2
aqa	9988/PM	May-08	7	50	Algebra and graphs Intermediate	2
aqa	MD01	Jun-08	7	75	Decision 1	2
ocr	6989/01	Jun-08	40	40	Foundations of Advanced Maths	2
ocr	B813/1H	Specimen	16	100	GCSE	2
ocr	B814/2H	Specimen	18	100	GCSE	2
ocr	B823	Jan-08	17	100	GCSE Higher	2
ocr	B824	Jan-08	18	100	GCSE Higher	2
ocr	J512/3	Specimen	22	100	GCSE Higher	2
ocr	J512/4	Specimen	21	100	GCSE Higher	2

ocr	J915/01	Jan-08	8	100	GCSE Additional Mathematics	2
aqa	9996	Jun-08	6	40	Personal Finance L3	3
aqa	6360 XMCAS	May-08	15	125	Core 1 AS	3
aqa	9995/PM	May-08	5	40	Dynamics L3 2008 Pilot	3
aqa	FSMQ Data Analysis	May-08	5	40	Data Analysis L3 2008 Pilot	3
aqa	MFP1	Jun-08	9	75	Pure 1 Further Maths	3
aqa	MM1B	Jun-08	8	75	Mechanics 1 AS	3
aqa	MS/SS1B	Jun-08	7	75	Stats 1 AS	3
aqa	USE 1	Specimen	4	40	Advanced FSMQ	3
ocr	6993/01	Jun-08	13	100	Additional Maths L3	3
ocr	G801/01	Jun-08	29	40	AS Core 1	3
ocr	G802/01	Jun-08	10	75	AS Core 2	3
ocr	G804/01	May-08	6	75	Stats 1	3
ocr	G805/01	May-08	6	75	Mechanics 1 L3	3
ocr	G806	Jun-08	5	75	AS Decision Maths L3	3
ocr	G811/01	Jun-08	11	75	Statistics	3
ocr	B825	Jan-08	16	80	functional maths hurdle - levels 1 and 2	2

The following table includes details of assessment papers scrutinised during Stages 6 and 7.

board	Paper	date	questions	marks	notes	level
aqa	9981	2009	10	40	Foundation - Managing Money	1
aqa	9982	2009	8	40	Foundation - Using Spatial Techniques	1
aqa	9983	2009	7	40	Foundation - Using Data	1
aqa	4306/1F	2009	23	100	GCSE Foundation	1
aqa	4306/2F	2009	26	100	GCSE Foundation	1
aqa	93002/FA	2009	4	25	GCSE Foundation	1
aqa	93002/FB	2009	5	25	GCSE Foundation	1
aqa	93003/1F	2009	11	50	GCSE Foundation	1
aqa	93003/2F	2009	13	50	GCSE Foundation	1
aqa	9306/F	2009	29	100	Additional GCSE	1
ocr	B811	2009	21	100	GCSE Foundation	1
ocr	B812	2009	21	100	GCSE Foundation	1
ocr	J512/01	2009	19	100	GCSE Foundation	1
ocr	J512/02	2009	21	100	GCSE Foundation	1
aqa	9984	2009	10	50	Intermediate - Financial Calculations	2
aqa	9985	2009	8	50	Intermediate - Space and Shape	2
aqa	9986	2009	9	50	Intermediate - Data handling	2
aqa	9988	2009	6	50	Intermediate - Algebra and graphs	2
aqa	4306/1H	2009	25	100	GCSE Higher	2
aqa	4306/2H	2009	29	100	GCSE Higher	2
aqa	93002/HA	2009	5	25	GCSE Higher	2
aqa	93002/HB	2009	5	25	GCSE Higher	2

aqa	93003/1H	2009	10	50	GCSE Higher	2
aqa	93003/2H	2009	11	50	GCSE Higher	2
aqa	9306/H	2009	21	100	Additional GCSE	2
ocr	B813	2009	17	100	GCSE Higher	2
ocr	B814	2009	18	100	GCSE Higher	2
ocr	J512/03	2009	20	100	GCSE Higher	2
ocr	J512/04	2009	21	100	GCSE Higher	2
ocr	J915/01	2009	8	100	Additional GCSE	2
aqa	9994	2009	5	40	Advanced - Hypothesis testing	3
aqa	9995	2009	5	40	Advanced - Dynamics	3
aqa	9996	2009	7	40	Advanced - Personal Finance	3
aqa	9997	2009	4	40	Advanced - Decision Maths	3
aqa	9998	2009	5	40	Advanced - Calculus	3
aqa	9993/AS	2009	5	40	Advanced - Data Analysis	3
aqa	USE1	2009	4	40	Advanced - Algebra	3
aqa	USE3	2009	10	45	Advanced - Comprehension	3

Appendix E: Pilot centres involved in the EMP project

The following table lists those pilot centres (***187***) who have contributed to data collection in some way during the course of the project. This could have included agreeing to visits by a team member to discuss the pilot qualifications or by responding to surveys or other requests for feedback.

All Hallows Catholic High School
All Saints Academy
Altrincham Grammar School For Boys
Aquinas College
Ashfield School and Technology College
Bacon's College
Barrow-In-Furness Sixth Form College
Beckfoot School
Bedford School
Birley Community College
Blessed Robert Johnson Catholic College
Blessed Robert Sutton Catholic Sports College
Bosworth Community College
Bosworth Independent College
Bramhall High School
Braunton School And Community College
Brighton Hill Community College
Brighton, Hove and Sussex Sixth Form College
Brislington Enterprise College
Bristol Academy
Brockenhurst College
Budehaven Community School
Bungay High School
Bydales School
Camborne Science & Community College
Carlton Le Willows School
Carmel College
Casterton School
Castle College Nottingham
Chatham South School
Cheadle and Marple Sixth Form College
Moseley Park School
Myton School
New College, Swindon
Nicholas Chamberlaine Technology College
Noel Baker Community School
Northallerton College
Notre Dame Catholic College
Our Lady And St Chad Catholic Sports College
Our Lady Queen Of Peace Catholic High School
Our Lady's R C High School
Parkside Community College
Pattison College
Peacehaven Community School
Plashet School
Prior Pursglove College
Pudsey Grangefield School
Queen Elizabeth’s Grammar School
Queen Elizabeth's Community College
Queen Elizabeth's School
Queen Ethelburga's College
Queen Mary’s College
Queensmead School
Radcliffe Riverside School
Radyr Comprehensive School
Raincliffe School
Rainford High Technology College
Rastrick High School
Rendcomb College
Richmond School
Ridgewood School
Rivington And Blackrod High School

Cirencester College
City Academy Bristol
City Of Portsmouth Girls' School
Colchester Sixth Form College
Combe Dean
Conyers School
Cottenham Village College
Cowes High School
Dame Alice Harpur School
Dane Court Grammar School
Didcot Girls' School
Droitwich Spa High School
Dunraven School
Ealing, Hammersmith and West London College
Eastbourne Technology College
Eckington School
Etone Community School
Exeter College
Fairham Community College
Falmouth School
Fartown High School
Folkestone School for Girls
Gateway 6th Form College
Grange Technology College
Greenwood Dale School
Hamstead Hall Community Learning Centre
Harlington Community School
Havering Sixth Form College
Hayesfield School
Hele's School
Hereford Cathedral School
High Tunstall College Of Science
Highdown School & 6th Form Centre
Hipperholme and Lightcliffe High School
Holbrook High School
Holy Trinity C E Senior School
Homewood School and 6th Form Centre
Rodillian School
Roseland Community School
Rossett School
Ruskins Sports And Languages College
Saint Aidan's C of E Technology College
Saint Benedict Catholic School
Sandbach School
Shireland Language College
Shrewsbury Sixth Form College
Sir William Stanier Community School
South Cheshire College
South Leeds High School
Southlands High School
Southwark College
Spring Lane College
St Albans School
St Bede's School
St Benedict's Catholic High School
St Crispin's School
St Davids Catholic College
St Joseph's R C Comprehensive School
St Mary's School, Calne
St Nicholas Catholic High School
St Patrick's Comprehensive School
St Paul's Catholic School
St Thomas More School
St. John Rigby Catholic Sixth Form College
Stoke Damerel Community College
Sturminster Newton High School
Sussex Downs College
Taunton's College
The Bishops' Blue Coat High School
The Burton Borough School
The Chalfonts Community College
The Charter School
The College of West Anglia
The Dayncourt School

Honley High School
Hopwood Hall College
Hornsea School and Language College
Hounsdown School
Huddersfield New College
Hungerhill School
Huntingdonshire Regional College
Itchen College
Jack Hunt School (Foundation)
John Ruskin College
King Edward VI College
King George V College
Kings
Kingsfield School
Kingston College
Kirk Hallam Community Tech College
Kirkbie Kendal School
Lincoln College
Longley Park Sixth Form College
Maidstone Grammar School
Maricourt High School
Marshland High School
Mary Hare Grammar School for the deaf
Melior Community College
Millbrook Community School
Morley High School
The Deepings School
The Duchess's Community High School
The Emmbrook School
The Grange School & Sports College
The Henley College
The King's School
The Long Eaton School
The McAuley Catholic High School
The Nobel School
The Northfields Technology College
The Sixth Form College, Farnborough
The Walsall Academy
Thomas Telford School
Tower Hamlets College
Tuxford School
Verdin High School
Vyners School
Wales High School
Wetherby High School
Wilnecote High School
Winterhill School
Wolstanton High School
Worthing High School
Writhlington School
Wymondham College

Appendix F: Stakeholders and employer groups engaging with the evaluation

Awarding Bodies

Assessment and Qualifications Alliance (AQA)
Oxford Cambridge and RSA Examinations (OCR) part of the Cambridge Assessment Group

Professional and Advisory Groups

Advisory Committee on Mathematics Education (ACME)
British Society for Research into Learning Mathematics (BSRLM)
Department for Children, Education, Lifelong Learning and Skills (DCELLS)
Engineering Professors' Council (EPC)
The London Mathematical Society (LMS)
Institute for Mathematics and its Applications (IMA)
Joint Council for Qualifications (JCQ)
Joint Mathematical Council of the United Kingdom (JMC)
Mathematical Association (MA)
National Association of Mathematics Advisors
National Association for Numeracy and Mathematics in Colleges (NANAMIC)
National Centre for Excellence in Teaching Mathematics (NCETM)
Personal Finance Education Group (pfeg)
Specialist Schools and Academies Trust (SSAT)
The Association of Teacher of Mathematics (ATM)
The National Strategies

Sector Skills Councils and Employment Skills Boards

Construction Skills
Council for Administration
E-Skills
Environment and Land-based industries (LANTRA)
Financial Skills
Go Skills;
Government Skills
Logistics;
Merchant Navy Training Board
Skills Active
Training and Development Agency (TDA)

Large Employers

Experian
FlyBe

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