Coursework in Mathematics
A discussion paper
October 2006

"GCSE coursework, excellent in principle, hasn't worked well in practice. So school students are unaware of the excitement of studying maths and the opportunities it brings." (Tony Mann, Head of Department of Mathematical Sciences, The University of Greenwich). [1]

Summary

- Coursework was introduced for sound educational reasons; it is essential to understand these in order to be able to make sensible decisions about the most appropriate means of assessment.
- Coursework in GCSE Mathematics will soon be discontinued; it became increasingly unpopular following the introduction of the data handling coursework.
- Existing mathematics coursework at A-Level is fit for purpose; it should, therefore, be allowed to continue.
- Statistics 1 coursework in the MEI A-level had similar aims to the GCSE data handling coursework but was much more successful in achieving them. The reasons for this are explored in this paper.
- It is important that the skills we want our young people to acquire are measured and encouraged within the scheme of assessment.
- All specifications should be required to assess these skills; there may be flexibility in how this is done, but all approaches should be properly evaluated.

Rationale

Coursework was introduced into most subjects around 15-20 years ago, with the intention of encouraging appropriate learning outcomes. The recent announcement that GCSE Mathematics coursework is ending raises the question of what will replace it. The learning outcomes remain as important as ever and need to be fully understood so that successful aspects of coursework are allowed to continue, and unsuccessful coursework is replaced with something that will achieve what it was originally intended to do. This will require an understanding of the original aims of coursework and also of what aspects of present arrangements are unsatisfactory.

The purpose of this paper is to contribute to this process, promoting general discussion that will inform national policy. The paper draws on the general experience of GCSE mathematics coursework and also the particular experience of MEI with A-level coursework. Over the years MEI A-level students have submitted around half a million pieces of coursework; this considerable experience is obviously highly relevant to the ongoing national debate (see Appendix C).

Historical background

GCSE
GCSE was introduced for first teaching from 1986 and contained coursework in almost all subjects.

Coursework was initially optional in GCSE Mathematics, becoming compulsory after a period of a few years. Schools usually produced their own tasks for GCSE coursework, taking care to ensure that they complied with, and were marked to, examination board criteria. In a later development, some students were entered for a "coursework paper", consisting of an investigation to be done under examination conditions, as an alternative to coursework produced in the classroom.

Data handling coursework was introduced into GCSE Mathematics in 2001. Immediately before that, the common pattern was for students to complete two investigations, both relating to Using and Applying Mathematics, with the marks being taken from their better performance across both pieces; the overall contribution of the coursework to GCSE Mathematics was 20%.

A-level
The first significant coursework in Mathematics A-level began in 1990 with the approval of MEI Structured Mathematics; SEAC (the pre-cursor to QCA) insisted on a minimum of 20% coursework assessment. By 1993, when all A-level syllabuses were resubmitted, the "minimum" had become a "maximum" of 20%. Since then, the tendency has been for coursework to be reduced at A-level.

The SMP 16-19 syllabus included coursework as an integral part of the learning and assessment process; some units included more than one piece of coursework. Prior to the Curriculum 2000 changes, 20% of the marks for the SMP A-level were for coursework. Directly following Curriculum 2000 changes, all Mathematics A-level specifications for teaching in England contained some coursework.

A 100% coursework Mathematics A-level ran for about 4 years from 1989 under the umbrella of RAMP (Raising Achievement in Mathematics Project) and was moderated and ratified by the Oxford exam board.

FSMQ
Free Standing Mathematics Qualifications were introduced from 1998 to encourage students to include learning appropriate mathematics in their studies. Many of the Freestanding Mathematics Qualifications have a 50% coursework requirement. The portfolio allows the assessment of whether students are able to apply their mathematical knowledge and skills to real-life situations.

The current situation

All GCSE Mathematics specifications contain two pieces of coursework, each worth 10% of the final assessment:

- A data handling task
- An investigational task set in the context of number and algebra *or* shape, space and measures

This is to be discontinued for first teaching from 2007 but no alternative suggestions have yet been published.

The current situation at A-Level is as follows:

- The Edexcel A-level specification has no coursework.
- The OCR A-level specification has no coursework
- The AQA specification has optional coursework in S1, S2, M1 and M2 (worth 25% of the module if the coursework option is chosen).
- The WJEC specification has no coursework.
- The CCEA specification has no coursework.
- The MEI A-level specification has coursework in the following units, counting for 20% of the assessment of the unit:
    - C3, Methods for Advanced Mathematics (taken by all students studying A-level Mathematics)
    - Numerical Methods (taken by some students studying AS or A-level Further Mathematics)
    - Differential Equations (taken by some students studying AS or A-level Further Mathematics)

Thus, at A-level, the MEI specification is the only one to have retained compulsory coursework.

For A-levels in some subjects, for example Geography or Psychology, coursework comprises a unit on its own, allowing for skills from a number of units to be applied in one piece of work and ensuring that a reasonably substantial amount of time is spent on the coursework; this approach also allows the coursework grade to be published separately. Having a coursework unit was tried in various mathematics syllabuses but take up was never high so it was discontinued. All present A-level Mathematics coursework is part of a unit; this allows the application of a clearly defined area of mathematics.

Coursework review

The Smith report
In February 2004, the Smith report[2] stated that:
"Many respondents have expressed serious doubts about the value of GCSE mathematics coursework, in particular the data-handling component."

The report recommended:
"…an immediate review by the QCA and its regulatory partners of the quantity of coursework in GCSE mathematics and, in particular, the data handling component,.."[3]

QCA's coursework review
QCA published "A review of GCE and GCSE coursework arrangements" in November 2005[4]. The foreword states:
"The review's findings confirm the value of coursework in many subjects. However, the report recommends that the assessment arrangements – including the role of coursework – for all qualifications should be kept under regular review. It also notes concerns raised by teachers about coursework in mathematics. The regulatory authorities will take full account of these concerns in their current development work on future mathematics specifications."

In the main body of the report, it can be seen that these concerns relate to coursework in mathematics GCSE, not A-level, and, specifically, to the data handling coursework component at GCSE.
"The open-ended nature of the data handling exercise at GCSE left some candidates frustrated: there was no sense of completion since the exercise lent itself to continual development. The significant written element in this exercise was felt to disadvantage the candidates who were good at mathematics but poor at written English. The investigational project for mathematics coursework did, however, elicit some favourable comments from teachers and candidates alike."

QCA's consultation
More recently, QCA conducted a consultation on GCSE coursework in order to formulate appropriate advice on the way forward. This has culminated in the announcement by the Secretary of State, in September 2006, that GCSE Mathematics coursework will be discontinued.

Reasons for Coursework

The decision to discontinue coursework in GCSE Mathematics was based on a number of concerns. These are considered in detail later in this paper, in the section headed: "Practical difficulties with coursework". However, it is also crucially important to consider why coursework was introduced in the first place and to ensure that there is a reasonable prospect of the intended learning outcomes being achieved by whatever replaces it.

Appropriate assessment
Coursework can assess particular skills and topics that are, by their nature, unsuitable for assessment within a timed examination but are, nonetheless, important aspects of the specifications. The following skills are currently being (or have recently been) assessed by coursework in mathematics:

- Investigation (GCSE MA1)
- Problem solving (nearly all coursework)
    - Mathematical modelling (MEI A-level Differential Equations, Mechanics, Decision Mathematics)
    - Use of the full Statistical Investigative Cycle including sampling and data collection (GCSE and A-level Statistics)
- Mathematical use of ICT (MEI A-level C3, Numerical Methods)

Real-life situations
Even students who are proficient at using mathematical techniques do not always appreciate that they are widely used in real-life and may find it difficult to make decisions about when it is appropriate to use which technique. This cannot be properly assessed in an examination, as the opportunity to think round a problem is severely curtailed and the opportunity to seek advice is non-existent.

Communication
The mathematical communication that takes place in an examination is solely written and, at GCSE, usually very structured. Coursework allows the opportunity for students to discuss their work with each other, with the teacher and other people, to reflect on appropriate ways to communicate their findings and to refine their work; this is more akin to the ways they will communicate in the workplace.

Positive achievement
Some students find it difficult to demonstrate positive achievement in timed, written examinations. This may be for a variety of reasons such as lack of confidence, learning difficulties, disability or long-term illness. These students are sometimes able to produce coursework of which they can be justifiably proud.

Excitement
Mathematics coursework can be an opportunity for genuine personalised learning, where students use their mathematics to find out something that is of personal interest to them. Where this has happened, students have become involved with their work, they have seen the relevance and power of mathematics and they have produced excellent work, which they and their teachers remember for years to come. This experience fosters much-needed positive attitudes to mathematics.

Why has GCSE Coursework not succeeded?

If coursework in GCSE Mathematics had consistently fulfilled the promise outlined above, teachers would have campaigned for its retention. In order to ensure that future assessment yields better results, there needs to be an understanding of what went wrong.

Relationship with desired outcomes

The way in which coursework is assessed affects the way students and teachers work on it and the way in which they perceive it. This can be most clearly seen by contrasting GCSE data handling coursework with the Statistics 1 coursework from the Curriculum 2000 MEI A-level specification; in both of these students choose an investigation, collect and analyse data and interpret the results. Marking criteria for these two pieces of coursework are presented in Appendix A and Appendix B.

- The GCSE data handling coursework is awarded a mark out of 8 in each of three strands. In the second strand, the phrase: "*techniques of at least the level detailed in the handling data paragraph of the grade description for grade ...*" was widely interpreted by examination boards, and understood by teachers, to mean that higher marks are dependent on using more advanced techniques. This, together with the requirement that these techniques should be relevant to the original problem often undermined the whole planning process. Instead of starting with a problem and asking what techniques were needed, people usually began with the techniques and then tried to find something to do with them. Consequently, the task of the GCSE mathematics teacher became that of ensuring that the students provided evidence of jumping over the highest possible hurdle rather than ensuring that they got the maximum educational benefit from the work.
- By contrast, the MEI A-level Statistics 1 coursework was awarded marks for the quality of the investigation and its write-up; there was no obligation to use "more difficult" techniques to gain a higher mark. Consequently, teacher input was focused on enabling students to apply appropriate mathematics successfully.
- The GCSE coursework marking criteria mirror the Targets and Tariffs[6] approach to GCSE grading with grades related to level of content rather than successful completion of the task. This has resulted in teachers guiding students to choose tasks which will enable them to use "high grade content"; these are often based on artificial data which are of no interest to the students.
- By contrast, the MEI A-level Statistics 1 coursework gave credit to students who were able to explain why their investigation was worth doing. This encouraged students to investigate something that they felt was worthwhile and fostered an understanding of the full scope of statistics.

The GCSE data handling mark scheme encourages starting with a list of techniques to be used and finding a problem to fit whereas the MEI A-level Statistics 1 mark scheme encouraged starting from a problem to be solved and using the appropriate techniques to tackle it. The latter allowed coursework to succeed in its educational aims.

Although the investigational coursework at GCSE is marked using a scheme in three strands, like the data handling coursework, the same difficulties have not resulted. Most students were working with tasks provided by the awarding bodies which all lent themselves to making and justifying generalisations and finding algebraic formulae. Consequently, there was a clearer path of progression through the task.

The criteria used for marking GCSE Mathematics coursework make it almost impossible for students to achieve their potential in it without considerable teacher guidance; this has led to many of the other problems and difficulties with coursework. The mark scheme, rather than the coursework itself, is the major reason why GCSE coursework, and, particularly, the data handling task, was so unsuccessful**.**

Teacher attitudes
When coursework was first introduced into GCSE Mathematics, there was interest in the educational benefits of an investigational approach. However, some teachers were sceptical about the possibility of students "discovering mathematics for themselves" and unwilling to introduce coursework until it became compulsory.

Effective teachers use a variety of methods to encourage interest and understanding but the current high-stakes results culture in education encourages less confident teachers to "teach to the test". The amount of step-by-step guidance for coursework that has been given by some teachers has diminished the potential educational value of it.

Consistency of assessment
Experienced teachers are usually able to place completed work in rank order of merit; an appropriate mark scheme should allow the rank order of marks to be the same as the rank order of merit. An appropriate mark scheme should also allow teachers with less experience to award marks commensurate with the quality of the work. The association between content, rather than quality, and marks for GCSE coursework has sometimes caused confusion about whether a piece of work merits a particular mark or not.

Choosing coursework
All GCSE specifications have the same coursework requirements. However, the pressure to improve results has led to increasing guidance from awarding bodies and the use of a small pool of tasks exacerbates problems arising from the use of formulaic tasks and increases the possibility of plagiarism and inappropriate help.

Practical difficulties with coursework

In addition to difficulties arising from the design of GCSE coursework, there have been a number of more practical problems that, taken together, have given it a bad name.

Teacher overload
Marking coursework is time-consuming for teachers, especially because of the need to match externally set criteria. In addition, many teachers spend considerable time marking work, advising on redrafting and then remarking the redrafts; this can be a significant source of teacher stress and is likely to be more pronounced in schools where the pressure to achieve results is highest. Student and/or parental expectations that the teacher will provide sufficient guidance to ensure a high grade add to the pressure.

This pressure can be reduced by clear marking guidelines, which are shared with, and understood by, students so that they can take increased responsibility for their own work. The mark scheme needs to be appropriate to the coursework task and to support its overall aims. Although the general criteria for GCSE coursework can be shared with students, it is doubtful whether they have the mathematical sophistication and experience to understand what they mean.

Student overload
Students undertaking large numbers of substantial pieces of coursework often find it difficult to manage their time effectively; this is likely to be more pronounced as final deadlines approach. This is clearly an issue at GCSE, where students can take 10 or more subjects but could also be an issue for some students at A-level, depending on their combination of subjects.

The pressure can be reduced by well-defined pieces of coursework with a clear purpose and a definite end-point. In GCSE Mathematics coursework, there is always the temptation to try to make the work more sophisticated in order to achieve a higher mark; this often results in students attempting to use complicated mathematical techniques but sometimes doing so inappropriately and failing to gain any extra marks for their extra effort.

Assistance from outside
Some students receive guidance from parents, other family members or paid tutors; this is difficult to police and it is clear that some students are at an advantage compared to others. The nature of coursework encourages dialogue between student and teacher and between student and student. Provided that the final write-up is the student's own work, this discussion should be seen as a normal part of the learning process and encouraged. Students should learn and gain ideas from such in-school dialogue; this helps to level the playing field for those who do not receive assistance at home. The on-going discussion that has taken place often assists the teacher in judging whether the final work reflects the student's own understanding.

Plagiarism
The increased use of the internet has led to worries that students may download and submit work which is not their own. The use of suitable software can identify such plagiarism, leaving the internet as a resource for research, provided that it is properly acknowledged in the finished work. Researching a topic is a useful skill for later life and, hence, one that we would wish to encourage in our students, along with the understanding of the difference between learning (which may include quoting selectively from other people's work) and copying wholesale.

What should happen next?

GCSE
While the forthcoming disappearance of mathematics coursework at GCSE overcomes some difficulties, it also raises a number of questions.

- What is the best way to assess, and encourage the development of, the skills we want our young people to acquire?
- How can changes to the assessment system support improved mathematics education, rather than being made piecemeal to "fix" a problem?
- Should the means of assessment that replaces GCSE coursework be subsumed within existing examination papers or separated in some way?

Relying entirely on assessment by examination removes the possibility of students considering a problem over an extended period of time, researching it, discussing it and using ICT when appropriate.

It could be argued that removing assessment of coursework is not the same as removing coursework because teachers will still do things that are educationally valuable. It is, however, difficult to see how teachers will find the time to devote to extended tasks in a pressurised curriculum, where targets and results are of prime importance, unless some credit is given for it.

We want young people to be able to use mathematics, to communicate effectively and to enjoy learning; the current coursework regime at GCSE has not succeeded in achieving this. Only a fully informed, and carefully thought through, alternative can improve matters.

A-level

Coursework at A-level is different from coursework at GCSE and it would be wrong to allow a simplistic, "Coursework is bad", way of thinking to affect future decisions about A-level Mathematics. It is essential that the able and motivated students who make up the A-level cohort have a rich experience of mathematics, that they are able to solve problems and apply mathematics appropriately.

The reduction of coursework in the various Mathematics A-level specifications is partly a result of competition between the syllabuses; "no coursework" is advertised as a key feature on some of them. This is likely to appeal for reasons outlined under "Teacher overload" and "Student overload", particularly if experience with GCSE coursework has not been satisfactory. The alternative to unsatisfactory coursework need not be "no coursework".

Advertising a specification as containing "no coursework" should be as unthinkable as advertising a meal containing "no vegetables". However, the negative effects of the current coursework regime at GCSE will have to be overcome first.

In conclusion

Assessment is important, not just as a means of measuring whether students have acquired the knowledge and skills that we wish them to, but also as a means of showing that these are valued. Assessing what is most important, rather than what is most easily measurable, can be difficult and needs to be carefully thought through to ensure that one set of problems is not replaced by a different set of problems.

"Mathematics equips learners with a uniquely powerful set of tools to understand and change the world. These tools include logical reasoning, problem-solving skills and the ability to think in abstract ways. Mathematics is important in everyday life, many forms of employment, science and technology, medicine, the economy, the environment and development, and in public decision making. Different cultures have contributed to the development and application of mathematics. Today, the subject transcends cultural boundaries and its importance is universally recognised. Mathematics is a creative discipline. It can stimulate moments of pleasure and wonder when a learner solves a problem for the first time, discovers a more elegant solution to that problem or suddenly sees hidden connections."

(National Curriculum, 1999)[5]

Many students' experience of mathematics in school falls short of the vision described above. The last 15-20 years in mathematics education have been characterised by increasing amounts of regulation and guidance; there is no evidence to suggest that this has resulted in either more positive attitudes towards mathematics or an increase in the ability of school leavers to use mathematics effectively.

A feature of the increased regulation has been the reduction in the variety of permitted assessment models, often to just one. This contrasts with the situation some years ago, where different approaches to assessment were allowed and, indeed, encouraged; it was acknowledged that they would provide information about what works well and what does not, and also that a variety of approaches was healthy.

We now find all students being forced into untested models of assessment, in which their teachers have no confidence. We need greater variety, and freedom for teachers to choose the approach that is best for their students. And we need proper evaluation of whether the intended aims are being achieved, of whether our young people are receiving a better, and more appropriate, educational experience.

Appendix A – coursework assessment sheet for MEI Statistics 1

MEI STRUCTURED MATHEMATICS
STATISTICS 1 (2613)
COURSEWORK ASSESSMENT SHEET: DATA EXPLORATION

TASK: Candidates will carry out an investigation of their own choice, collecting a sample of at least 50 items of single variable data which they will describe and interpret in a written report.

Domain	Mark	Description	Comment	Mark
Aim	1	The aim of the investigation is stated in clear English and there is a convincing explanation of why the investigation is worth doing.		
Data Collection	1 1	The population is defined and there is a clear explanation of the sampling method used and how efforts were made to ensure that the data are of good quality. The data are neatly and concisely presented.		
Displays	1 1	The diagrams are appropriate for the data, and there are no undue duplications. The diagrams are drawn and labelled correctly with suitable scales and titles.		
Analysis	1 1 1	The calculations are substantially correct and there are no obvious omissions. Answers are rounded appropriately. Calculations are attempted that are suitable for analysing the data. The methods used (i.e. spreadsheet or calculator) are clearly indicated. No calculations are included that are of no relevance, and there are no undue duplications.		
Interpretation	1 1 1	Conclusions are drawn which relate to the aim of the investigation. The candidate indicates clearly what has been discovered. The candidate demonstrates why the data were worth collecting and the implications of the conclusion in relation to the population.		
Accuracy and refinements	1 1	The report includes a sensible discussion of the possible sources of error and the restriction imposed by the source of the data and the method of collection. The report includes a discussion of how the quality of the work could be improved.		
Oral communication	2	Presentation ☐ Interview ☐ Discussion ☐	Please tick at least one box and give a brief report	
			TOTAL	15

Half marks may be awarded but the overall total must be an integer.
Coursework should be available for moderation by OCR.

Appendix B – coursework assessment criteria for GCSE data handling

Specify the problem and plan

Mark	Mark description
1-2	Candidates choose a simple well-defined problem. Their aims have some clarity. The appropriate data to collect are reasonably obvious. An overall plan is discernible and some attention is given to whether the plan will meet the aims. The structure of the report as a whole is loosely related to the aims.
3-4	Candidates choose a problem involving routine use of simple statistical techniques and set out reasonably clear aims. Consideration is given to the collection of data. Candidates describe an overall plan largely designed to meet the aims and structure the project report so that results relating to some of the aims are brought out. Where appropriate, they use a sample of adequate size.
5-6	Candidates consider a more complex problem. They choose appropriate data to collect and state their aims in statistical terms with the selection of an appropriate plan. Their plan is designed to meet the aims and is well described. Candidates consider the practical problems of carrying out the survey or experiment. Where appropriate, they give reasons for choosing a particular sampling method. The project report is well structured so that the project can be seen as a whole.
7-8	Candidates work on a problem requiring creative thinking and careful specification. They state their aims clearly in statistical terms and select and develop an appropriate plan to meet these aims giving reasons for their choice. They foresee and plan for practical problems in carrying out the survey or experiment. Where appropriate, they consider the nature and size of sample to be used and take steps to avoid bias. Where appropriate, they use techniques such as control groups, or pre-tests of questionnaires or data sheets, and refine these to enhance the project. The project report is well structured and the conclusions are related to the initial aims.

Collect, process and represent data

Mark	Mark description
1-2	Candidates collect data with limited relevance to the problem and plan. The data are collected or recorded with little thought given to processing. Candidates use calculations of the simplest kind. The results are frequently correct. Candidates present information and results in a clear and organised way. The data presentation is sometimes related to their overall plan.
3-4	Candidates collect data with some relevance to the problem and plan. The data are collected or recorded with some consideration given to efficient processing. Candidates use straightforward and largely relevant calculations involving techniques of at least the level detailed in the handling data paragraph of the grade description for grade F. The results are generally correct. Candidates show understanding of situations by describing them using statistical concepts, words and diagrams. They synthesise information presented in a variety of forms. Their writing explains and informs their use of diagrams, which are usually related to their overall plan. They present their diagrams correctly, with suitable scales and titles.
5-6	Candidates collect largely relevant and mainly reliable data. The data are collected in a form designed to ensure that they can be used. Candidates use a range of more demanding, largely relevant calculations that include techniques of at least the level detailed in the handling data paragraph of the grade description for grade C. The results are generally correct and no obviously relevant calculation is omitted. There is little redundancy in calculation or presentation. Candidates convey statistical meaning through precise and consistent use of statistical concepts that is sustained throughout the work. They use appropriate diagrams for representing data and give a reason for their choice of presentation, explaining features they have selected.
7-8	Candidates collect reliable data relevant to the problem under consideration. They deal with practical problems such as non-response, missing data or ensuring secondary data are appropriate. Candidates use a range of relevant calculations that include techniques of at least the level detailed in the handling data paragraph of the grade description for grade A. These calculations are correct and no obviously relevant calculation is omitted. Numerical results are rounded appropriately. There is no redundancy in calculation or presentation. Candidates use language and statistical concepts effectively in presenting a convincing reasoned argument. They use an appropriate range of diagrams to summarise the data and show how variables are related.

Interpret and discuss results

Mark	Mark description
1-2	Candidates comment on patterns in the data. They summarise the results they have obtained but make little attempt to relate the results to the initial problem.
3-4	Candidates comment on patterns in the data and any exceptions. They summarise and give a reasonably correct interpretation of their graphs and calculations. They attempt to relate the summarised data to the initial problem, though some conclusions may be incorrect or irrelevant. They make some attempt to evaluate their strategy.
5-6	Candidates comment on patterns in the data and suggest reasons for exceptions. They summarise and correctly interpret their graphs and calculations, relate the summarised data to the initial problem and draw appropriate inferences. Candidates use summary statistics to make relevant comparisons and show an informal appreciation that results may not be statistically significant. Where relevant, they allow for the nature of the sampling method in making inferences about the population. They evaluate the effectiveness of the overall strategy and make a simple assessment of limitations.
7-8	Candidates comment on patterns and give plausible reasons for exceptions. They correctly summarise and interpret graphs and calculations. They make correct and detailed inferences from the data concerning the original problem using the vocabulary of probability. Candidates appreciate the significance of results they obtain. Where relevant, they allow for the nature and size of the sample and any possible bias in making inferences about the population. They evaluate the effectiveness of the overall strategy and recognise limitations of the work done, making suggestions for improvement. They comment constructively on the practical consequences of the work.

Appendix C – MEI Experience of Coursework at A-level

MEI has run extensive CPD to help teachers to fully understand the educational and assessment aims of coursework; this has been very valuable for many teachers, enabling them to reflect on the nature of mathematics and how best to teach and assess it.

Pure Mathematics

MEI have never had genuinely Pure Mathematics coursework at A-level. The limited number of suitable tasks, all of which have known solutions, made syllabus designers wary of introducing it, even though they would have wished students to have experience of investigational work at this level.

This meant there was something of a discontinuity from GCSE, where investigational coursework has been in existence for over fifteen years and has allowed candidates to explore a situation mathematically, making connections between diagrammatic representations, algebraic formulae and the original situation. MEI have tried to make up for this in their text books and published materials but many teachers do not conduct the available investigations with their classes.

Statistics

This was a requirement of the MEI A-level in the past. At one time there was coursework in Statistics 1, 2 and 3. The Statistics 1 coursework concentrated on the use of the Statistics Investigative Cycle; this worked well and was undoubtedly valuable. The Statistics 2 coursework was similar to this but using bivariate data. Arguably, this provided no additional information as bivariate techniques were covered in the examination and the Statistics Investigative Cycle had been covered in Statistics 1 coursework. It threw up mathematical problems concerning the use of random and non-random variables, which was good for teachers' understanding but a nightmare for moderators.

The Statistics 3 coursework required students to carry out a hypothesis test for real. At the time, many students ended their A-level with Pure Mathematics 3 and Statistics 3 and the coursework was often rushed with the test being carried out on quite trivial hypotheses. This piece was the first of the statistics coursework to be cut, followed by Statistics 2. Although the Statistics 1 coursework was successful, and many teachers liked it, it became untenable when the data handling coursework came in at GCSE since the two were similar and often done within a few months of each other.

At GCSE, the data handling coursework has been problematic due to the way in which the work is marked. The contrast between the approaches at GCSE and A-level has been considered under the heading "Why has GCSE Coursework not succeeded?" The S1 coursework tested, and gave credit for, students' decision making. For instance, in S1 coursework a candidate had to make a decision about the appropriate way of displaying data; a correct decision received credit; in GCSE, credit is only given if the chosen means of data display is considered hard enough.

Mechanics
This was a requirement of the MEI A-level in the past. There were originally two pieces of coursework in Mechanics 1: one modelling and one experimental. The two were often hard to distinguish and so were soon rolled into one. There was also coursework in Mechanics 2 and Mechanics 3, covering the same skills but with increasingly sophisticated content available. Mechanics 3 coursework was dropped but the tasks for Mechanics 1 and Mechanics 2 continued for some time. There is evidence to suggest that, while some candidates produced work of a high standard, showing that they had understood the basic principles and been able to apply them successfully, this was not the case for candidates in all teaching groups. Professional guidance and training of teachers was particularly important for this coursework to be successful.

Differential Equations was originally part of the Mechanics suite of modules and the coursework there continues to foster understanding of rates of change.

Differential Equations
Uniquely, the MEI specification has a unit devoted entirely to differential equations. This has quite a high uptake, mainly among A2 Further Mathematics candidates. It is a popular and worthwhile unit with many of the students going on to university courses in mathematics, engineering or science. This unit allows them to gain a real understanding of an important area of mathematics. In designing this unit, MEI were concerned that students should see at first hand how differential equations model many real life situations; the coursework requirement gives students just that experience. This has been, and continues to be, a very successful piece of coursework with many students producing excellent work.

Numerical Methods
This is a requirement of the MEI modules C3 and Numerical Methods. In C3, candidates solve equations by three different numerical methods; they are expected to use ICT appropriately, to find solutions to a given degree of accuracy, to consider when and why the methods may not work and to compare methods of solution for ease of use and efficiency. They need to make decisions about how to use the methods of solving equations; for example, in C3 coursework, when using the Newton Raphson method they have to choose a suitable starting value, deciding whether it is close enough. This is an essential part of the process and, if it is not examined, then a crucial part of the understanding is not being tested. In a typical examination question on the Newton Raphson method, students are asked to do some algebraic manipulation to achieve the iterative formula, and then are told "starting with $x = \ldots$"; thus, the decision making process is not tested in examinations.

In Numerical Methods, candidates investigate a problem which is suitable for numerical solution, using one of the methods in the specification. They are expected to use a computer to develop a solution which is both efficient and accurate. The coursework allows candidates to use ICT appropriately and efficiently and, hence, to understand more fully the differences between numerical methods and algebraic methods. The spreadsheet work being done by students is impressive; this would be lost if coursework were removed.

Decision Mathematics

The process of following the modelling cycle was seen to be so integral to the whole of Decision Mathematics that for the first few years of MEI Structured Mathematics the whole unit was tested by coursework; this worked reasonably well but with only a small number of students taking it. As the number of students grew, the amount of coursework was reduced, due to practical and administrative problems, finally settling at 20%. Many students produced high quality work and increased their understanding as a result of the coursework. However, it was particularly prone to plagiarism and the quality was very centre dependent. These problems could have been overcome but, due to time pressure in the AS year of the Curriculum 2000 syllabus, all AS coursework was dropped from the 2004 revision.

References

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2. Report of the *Post-14 Mathematics Inquiry*, Chair Professor Adrian Smith, 2004

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4. *A review of GCE and GCSE coursework arrangements*, QCA, 2005

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6. *Targets and Tariffs* is a confidential document used by awarding bodies.