

'One of the best ways to encourage students to think positively about mathematics is to get them talking with people who are at the next step of learning or using mathematics. For example, students at sixth-form colleges can encourage GCSE students; undergraduates can encourage A level students; postgraduates or alumni can encourage mathematicians and outreach people to get involved!

Outreach to Schools

The difficulty is that finding political will and funding to link three, four or more different organisations in a chain of positive mentoring can be tricky: someone needs to lead on the project and keep things going. It's probably in a strong place to do this, but it's not always easy to advertise in managing it and for sources of funding to be readily available.'

'It has been great to see students come in to see the prospect of doing it. In the session they discussed mathematics and finally to be involved in the careers event at the end of the day.'

A Good Practice Guide

by the idea of More Maths Grads. I really enjoy maths and am interested in taking it further. Before I went I was sort of worried about taking it further because I didn't want it to ruin my enjoyment of it if I did something to do with it as a job. But after talking to you, the idea's really starting to appeal. The way you were so passionate about it really engaged me, and has really encouraged me to think seriously about taking maths as a further option, so thank you.'

in their work and help in preparing for exams. Sometimes they found it easier to ask me for help than to ask the teacher



More Maths Grads was a three-year project funded by the Higher Education Funding Council for England to develop, trial and evaluate means of increasing the number of students studying mathematics and encouraging participation from groups of learners who have not traditionally been well represented in higher education.

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Acronyms Used in this Guide

CRB	Criminal Records Bureau
HEFCE	Higher Education Funding Council for England
ISA	Independent Safeguarding Authority
KS	Key Stage
MMG	<i>More Maths Grads</i>
NCETM	National Centre for Excellence in the Teaching of Mathematics
PSI	Statisticians in the Pharmaceutical Industry
STEMNET	Science, Technology and Mathematics Network

Introduction

This guide arises from the *More Maths Grads* project, which was funded by the Higher Education Funding Council for England (HEFCE) and delivered by teams in three areas, the West Midlands (led by Coventry University), East London (Queen Mary, University of London), and Yorkshire & the Humber (University of Leeds), for the three years 2007–9, while Sheffield Hallam University undertook a national study to assess the higher education curriculum and to try to increase the scope of mathematics courses to allow real choice for a wide range of students. Part of the *More Maths Grads* project was devising and delivering outreach to school students. *More Maths Grads* tested a number of forms of outreach to schools. Many of the schools with which the project worked had low participation rates in higher education, but the project also worked with high-achieving schools. *More Maths Grads* dealt with all ages from Year 7 to A level. The feedback from school students and their teachers showed this to be a great success and it is the experience gained on this part of the project that provides most of the evidence for success*. While the MMG teams developed new materials of their own (for details see the *More Maths Grads* and Maths Careers websites www.moremathsgrads.org.uk and www.mathscareers.org.uk respectively), they also used the fruits of earlier efforts from other groups, particularly the FunMaths Roadshow (www.maths.liv.ac.uk/lms/funmaths) and the National Centre for Excellence in the Teaching of Mathematics (NCETM) (www.ncetm.org.uk). There is plenty of readily available material which could be used for outreach and those intending to start outreach do not have to reinvent everything for themselves; indeed, such a course of action might divert attention from the other aspects of setting up a programme of successful outreach.

This guide is not intended to be prescriptive. Different materials, styles and presenters will appeal to different audiences or to those in different circumstances; what is a success in one situation may be less beneficial in another. The guide is intended to show what has worked in *More Maths Grads*, with some evidence of that success in the form of comments from school students and their teachers, and to give examples to colleagues of what might be done, some experience of how to find suitable partners and engage the audiences, and suggestions of sources of materials and help. Individual colleagues will need to decide in the light of their audiences' needs and circumstances what is best in their own cases.

Acknowledgments

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'It was challenging but fun.'

School student on the Cryptic Challenge session run by Yorkshire & the Humber More Maths Grads

*78% of school students considered the *More Maths Grads* visits to schools (workshops and other activities) to be very appropriate to their needs and a further 22% considered them appropriate.

16% of teachers strongly agreed and 56% agreed that the activities had helped them raise attainment levels in mathematical sciences, while 33% strongly agreed and 53% agreed that the activities had helped them raise aspirations relating to mathematical sciences.

75% of school students considered the ambassadors' support to be very appropriate and 25% appropriate.

Starting outreach



Before starting a programme of outreach there are some immediate questions to answer.

Why?

There has been concern in recent years about the decline in the proportion of young people studying mathematics, in school, college or higher education (here, and throughout, we include statistics within the broad term mathematics). The report in 2004 of Professor Adrian Smith's inquiry into mathematics chronicled this and noted some causes: lack of awareness of the usefulness of and the breadth of careers involving mathematics, perception by school students of how interesting, or not, the subject is, and the supply of well qualified and enthusiastic teachers, to name but three*. Smith found that 'there is relatively little current, systematic interaction between mathematics departments in higher education and schools and colleges**' and recommended various means of improving this situation, in particular, closer working between mathematics departments in higher education and schools. In the time since that report circumstances have not lessened the competing pressures on schools and university academic departments, nor has the need for outreach found by Professor Smith's inquiry disappeared. It is more important than ever that outreach to schools by higher education is well targeted and best that it draws on existing experience. As society comes to realise that mankind cannot live by banking alone, now may be a good time to extend our outreach..

*'A great day that all the pupils loved.
Very engaging activities.'*

Teacher's comment on Mystery at the University

Although there are, as ever, pressures to do myriad other things in addition, the benefits to a mathematics department of devoting some of its efforts to outreach are substantial. If the school students who form the audience are from groups which participate less than the average in higher education, then convincing some that higher

education (and mathematics) are for them will result in extra students in higher education. Outreach to this group has the advantage that it may be possible to cooperate with other (funded) providers as part of a Widening Participation activity. Where those in the audience find that mathematics is more interesting or applicable than they thought or that it leads to more appealing and varied careers than they were aware of, then more of these school students are likely to continue with the subject in preference to some other discipline than would have done without their discovery of the interest and utility of mathematics. Simply enlarging the pool of people wishing to study mathematical subjects in higher education is clearly good for the discipline and will allow the sector as a whole to recruit more suitable students than it might otherwise do. This should itself eventually feed back in the form of better recruitment of mathematics teachers and, in turn, more potentially interested students. There is more to it than this rather altruistic view, however, since those recruited to mathematical disciplines by outreach activities are likely to regard the people who interested them in higher mathematics with some favour and any department that stimulated this interest must have gained some competitive advantage. This may allow the department concerned to select more able or more committed students than it would otherwise have been able to do. On a personal level, convincing people that mathematics is interesting and useful is in itself rewarding, particularly if it involves some who already had a wish to study mathematics but feared that it did not lead to a range of careers that interested them.

There is a perceived problem in some quarters of some students having 'drifted' into university, rather than going there knowing what they want to achieve from it. Clarifying the benefits of studying mathematics and the scope of the subject and of higher education may help school students make more informed choices.

Everyone in higher education knows that more outreach should be done. This guide suggests that some should be done by all higher education departments, that success is attainable and that there will be direct benefits to the departments which get involved. To use a catch phrase from many years ago: you know it makes sense. Now go and do something about it!

*Making Mathematics Count, The Report of Professor Adrian Smith's Inquiry into Post-14 Mathematics Education, February 2004, The Stationery Office Ltd., 2004. Available online at www.mathsinquiry.org.uk/report/MathsinquiryFinalReport.pdf

**Smith report p134

Who?

The people involved in outreach must be temperamentally suitable, have enough time to devote to it, and have enough support available, perhaps in the form of student ambassadors. It may be necessary for some or all of those involved to be checked by the Independent Safeguarding Authority (which works with the Criminal Records Bureau); see the Advice section for more about this.

Good communicators are essential. It is crucial that presenters are aware of the level of the mathematical skills of the audience, so that they are stretched rather than overwhelmed. To make sure the presenters do know their audience they, or perhaps the organisers, need to check with their audience's teachers.

Research students finishing PhDs, particularly in applied mathematics or statistics, but also other mathematical topics where the students can be clear about the external impact of what they have been doing, are potentially good candidates for delivering sessions. They need to have the required communications skills, but they can show that mathematics is a live subject, not just one invented by the ancients and pursued only by middle-aged men. It can, however, be difficult to use them as they may be under pressure to complete their theses. As ever, the presenters must be aware of the mathematical level of the audience as a presentation at too high a level may deter rather than attract the audience.

Which schools?

The schools involved in *More Maths Grads* were chosen with the help of the Higher Education Funding Council for England (HEFCE) 'Aimhigher' coordinator in each of the chosen areas, as the project was intended to focus on widening participation. The 'Aimhigher' coordinator talked to local sources on mathematics such as the LEA advisor and the local teachers' mathematics centre, and liaised with the mathematics coordinator for specialist mathematics schools.

'It has been great to work with the schools. Sometimes when students came in to a maths workshop they groaned at the prospect of doing maths but as these students participated in the session they discovered that they were actually enjoying mathematics and finding it interesting. It has been a real privilege to be involved in this change of attitude.'

Dr Ruth M Holland, More Maths Grads, University of Leeds

Widening access and improving participation in higher education are a crucial part of HEFCE's mission and one of its strategic aims, with an associated funding stream. HEFCE aims to promote and provide the opportunity of successful participation in higher education to everyone who can benefit from it. HEFCE regards this as vital for social justice and economic competitiveness. Under-representation of some groups of people in higher education is closely connected with broader social issues of equity and social inclusion. (For advice from HEFCE see its paper *Higher education outreach: targeting disadvantaged learners*, HEFCE paper 2007/12, May 2007, available on the website www.hefce.ac.uk.)

What?

Obviously, one possibility is to present some mathematical topic which will engage those in the audience and ideally inspire them. This needs care and discussion with the schools involved. It is usually best if presentations can relate to everyday culture, perhaps by using characters the school students will know of as examples, or perhaps things like the mathematics of a sports stadium, designing a bungee jump, dance making or the mathematics of card tricks. We all have our interests, but they are usually initially sparked by some 'fun' aspects or a fascination with the topic – only later do we realise that a 'serious' interest may involve some less appealing aspects (or 'hard work'). Mathematics is no exception: to engage those not already committed to something we need to start with something appealing, in short, with fun.

The focus of an event need not be its mathematical content, however, and careers or the uses of mathematics are useful topics, particularly as many school students are unaware of the breadth of career opportunities available to those with a mathematical background. As well as careers information and examples of the industrial use of mathematics, including Maths at Work conferences, and enrichment through presentations of aspects of the subject, it is possible to organise industrial placements for school students.



Where?

In school or at university? The choice will determine what is possible. It can often be difficult to arrange for school students to go to activities outside their school. Schools have to provide supply cover at school for the teachers who accompany their students and make suitable arrangements for their supervision and safety. For large events it may be feasible to take school students out of school, but for smaller ones it may be easier to organise the event in the school. If school students are to attend an event at university the question of transport must be raised and agreed, including an understanding of who is going to arrange it and pay for it. As with most things, this should be discussed with the schools involved to find what is most appropriate.

'There are lots more things I have learned from today. You can use maths which you don't usually think of.'

Student on Year 12 Maths at Work day

Possible activities



Enrichment and enhancement

Individuals may wish to devise their own materials but, for those just starting, it may be better to use existing successful material until experience has been gained of what produces the best response from the audiences. Clearly the individual presenter may be more comfortable, and correspondingly more successful, with some topics than others, but it is more important that the topics presented suit the audiences. To be sure of this, there is no substitute for discussion with the teachers at the schools involved beforehand. Some sample lists of materials from *More Maths Grads* are given in the Appendices.

The mathematics needs to be accessible, interactive and not perceived as appealing only to 'geeks'. A multidisciplinary activity can overcome some school students' limited appreciation of the applicability of the subject. It is an advantage if it relates, perhaps quite loosely, to the mathematics being studied by the school students. It is worth emphasising, where appropriate, the creativity needed in doing and applying mathematics.

Traditional lectures are not sufficiently compelling for those who are not already committed to the subject. This observation should be no surprise as it is consistent with recent findings on improving learning in higher education*, which place emphasis on active learning. In cases where outreach is aimed at appealing to those who do not see the interest or utility of mathematical subjects the need to engage the audience actively is even more acute. Sessions where some mathematical topic is presented, with the audience being required to engage with it by carrying out some activities, have been found productive by the project. *More Maths Grads'* experience suggests that there should be no more than about ten minutes talking before the audience engages in some 'hands-on' activity. A slick presentation will not compensate for a lack of this activity by the audience. The topics need to be well chosen. Topics used by *More Maths Grads* included the mathematics of magic, the mathematics of sports stadiums, quadratic equations and football, Galileo and the path of a football (or a bullet), cryptography and 'How not to get conned' (from K'nex Technology Challenge).

The MMG materials are available on the *More Maths Grads* and Maths Careers websites (www.moremathsgrads.org.uk and www.mathscareers.org.uk respectively). In addition, all higher education mathematics departments should have received *More Maths Grads in a Box*, a collection of resources useful for outreach activities. There is very useful careers material in the DVD *What's the Point of Maths?* which has been circulated to schools and further education colleges. Other excellent materials are available from the FunMaths Roadshow (www.maths.liv.ac.uk/lms/funmaths) and the National Centre for Excellence in the Teaching of Mathematics (NCETM) (www.ncetm.org.uk). Another good source is STEMNET (www.stemnet.org.uk). For the younger groups the firm K'nex (www.knex.com) supplies various model kits which could form the basis of some mathematics, the sophistication depending on the stage the audience has reached. As its name suggests, the NRICH project website (<http://nrich.maths.org/public/>) also has good enrichment material.

*John Biggs, Teaching for Quality Learning at University, Society for Research into Higher Education/Open University Press, 1999.

Careers promotion

Many school students (and a large number of teachers) are only vaguely aware of the range of career opportunities available to a mathematical graduate or of the ways in which the discipline is used in the real world. This can be a great inhibition to those who enjoy mathematics but imagine that continuing with the subject might restrict their career opportunities. Making school students aware of the range and interest of jobs which use mathematics is at least as important as enriching the mathematics these students know. Career-focussed events can be very large: the Maths at Work days in Yorkshire and the Humber attracted well over five hundred visitors.

Contributions from industry are important, to allow the audience to encounter real people who can speak from first-hand experience. Even where careers are not the main focus of an event it may be useful to contact individuals through STEMNET (www.stemnet.org.uk) and seek some career profiles as illustrations. PSI (Statisticians in the Pharmaceutical Industry) also provided some useful input to *More Maths Grads*. Care needs to be taken with industrial speakers. Some of them may not have been in a school since they were a student and things may have changed quite a lot since then. Speakers need to be tactfully briefed about the reception that a two-hour talk is likely to receive.

'I didn't know so many jobs include maths.'

Student on Year 12 Maths at Work day

Large scale fairs are a good place to promote the message about the range of careers that rely on mathematics. They can be 'cost effective' in that they provide the opportunity to contact large numbers of people in a relatively short space of time. The disadvantage is that many of the contacts are quite superficial. Many such events are already well established and it is much better (and less work) to have a stall at one of these than trying to set up your own event.

Maths at Work days are a different kind of careers-focussed event. These have proved to be particularly successful, with most days for one hundred Year 10 or 12 students being over-subscribed. The days had one-hour workshops for Year 12 events and shorter interactive workshops for Year 10. The format was to have four companies from different sectors showing how mathematics is useful in their area. Suggestions are to use PSI, banks, accountants and engineers, while other contributing firms include GCHQ, Rolls Royce and ASDA. Among less obvious choices Coca Cola and the RAF have given good material. It is important to have a diverse range of companies and, for instance, only to have one financial company at each event. Use personal contacts in the company where possible, otherwise some large companies have an education officer or person involved with corporate and social responsibility who should be the first point of contact. Sometimes links were made with companies through meeting them at undergraduate careers fairs held at the university.

One such occasion split the students into four groups and rotated them around four workshops: a cryptography workshop; a pharmaceutical statistics workshop run by GlaxoSmithKline statisticians as part of their work for PSI (Statisticians in the Pharmaceutical Industry); an exploration of jobs in the financial sector; and a speed dating session involving a mathematics postgraduate student and professionals from the science, engineering and finance sectors. This example was in the week that Lehman Brothers filed for bankruptcy so finance was particularly topical!

The NCETM has a collection of video clips entitled '*Maths in Work*' which have been produced in collaboration with the *More Maths Grads* Project (www.ncetm.org.uk/resources/11329).



School student placements

Apart from the placement of undergraduate ambassadors in schools, *More Maths Grads* helped organise industrial placements for school students as part of the Nuffield Science Bursary scheme*. The placements lasted for four to six weeks in the school summer holidays. This was generally very successful, for much the same reasons that school placements benefit students in higher education. Before *More Maths Grads* there had been only one or two mathematics placements in the UK annually but *More Maths Grads* organised sixteen a year. In places where there are suitable industries, this is something that mathematics departments in higher education could follow up, although the effort involved can be significant.

Revision conferences

These were large events, usually in a university, as that location can help demystify universities for those who know little about them. They have the advantage that school students can see a short-term gain for their forthcoming exams. Having such an event at a university may help school students become aware of the possibility of progress to higher education, especially if they see the student ambassadors as role models they might follow.

'I had not heard of the scheme before, but thought it was a fantastic opportunity to give my students an insight which they could not get in any other way. I was invited to participate in the scheme by More Maths Grads. We were really grateful, we managed to get three placements. Two of our students went to Rolls Royce – there is no better place to give students experience of real mathematics. As staff, we sometimes lose touch with applications of the subject. Being aware of the jobs there is crucial to us.'

Martyn Rice, Head of Mathematics,
Coventry Blue Coat Church of England
School and Music College.

*See www.nuffieldfoundation.org/go/grants/nsbsc/page_394.html for details of Nuffield Science Bursaries.

Student ambassadors



Students in higher education can be effective as ambassadors in a number of ways, partly because school students usually find it easy to talk to ambassadors. Within the *More Maths Grads* project some were put on a ten-week placement in a school, with a role essentially that of a teaching assistant. These ambassadors had a teacher as mentor, and there was effective liaison between the sponsoring higher education department and the mentor. Some of these students were offered a second placement if the first was beneficial. This is effective for higher education in the sense that successful ambassadors gain a great deal of confidence as well as direct experience of schools, which may confirm their thoughts of entering the teaching profession, or in some cases allow them to realise that it is not the career for them. They can act as role models for school students and convince those who had not aspired to higher education that they should, and show them that those who enter higher education are no different from themselves. Some teachers see such ambassadors as useful channels for modernisation, in that their views will generally be those of a later generation than the teachers with whom they work. The ambassadors on these long placements may be part of a module at their home university which carries normal academic credit, although others carry it out as volunteers. Whilst many such schemes offer payment to the ambassadors, the increasing culture of volunteering amongst students may mean that, even if funding is not available, it may still be possible to organise this kind of activity.

There are several existing schemes for student ambassadors. The Undergraduate Ambassadors Scheme (UAS) provides a framework for a degree programme module awarding academic credit to science, technology, engineering and mathematics undergraduates working with teachers in local schools. The Student Associates Scheme, run and funded by The Training and Development Agency for Schools (TDA), organises placement of university students with schools on a regular basis, to allow them to discover what teaching is really like, work alongside experienced teachers and develop new skills. There is a tax-free bursary of around £40 for every day spent in school or college during the scheme, which is open to students registered on degrees and postgraduate programmes. There are also ambassadors appointed under the general 'widening participation' banner as part of universities' widening participation activities. While these

schemes all have rather differing aims, it is best to work in cooperation with them; there is no point in unnecessary duplication of effort. This may require some discretion as some of the widening participation activities, in particular, involve partnerships of several bodies, so that recruiting to a particular university, rather than to higher education in general, may be inappropriate.

The use of student ambassadors and university staff has the merit that they are seen to have some credibility in the school students' eyes by being attached to a university. That 'credibility' may mean that school students react differently compared with the way they would react to the same things said by their regular teachers. Much of the material used in *More Maths Grads* could have been delivered by good school teachers, but other pressures, particularly those of the additional non-mathematical responsibilities that good teachers acquire, often deny teachers the time to devise and deliver such material.

In other cases ambassadors visited schools for one-off sessions or acted as assistants and liaison with the school students on events organised outside school. The West Midlands *More Maths Grads* found that a ratio of one ambassador to about eight school students for hands-on sessions worked well.

A weekly hour when all the ambassadors can meet to exchange experiences has proved useful.

At most *More Maths Grads* activities school students generally worked in groups, with the ambassadors helping the various groups. The audiences were found to prefer being in groups and, in any case, the ability to work in a group is a useful skill to acquire.

'It made me realise that I would rather teach at secondary school than at college, which is what I initially wanted to do. It is great to have this experience if you are thinking about going into teaching and it looks really good in interviews for PGCEs.'

Student taking undergraduate module involving placement in school as an ambassador

Measuring success

Given the pressures on higher education to deliver many things, it is obviously important to know that any activity which makes claims on academics' time is successful and uses that time effectively. Formal quantitative measures of success, such as increasing the proportion of school students who continue with mathematics to A level or beyond, require proper statistical analysis, and in any case involves a delay until there has been enough time for the desired effects to have happened. Those who devote much resource to outreach may, however, wish to collect baseline data before the outreach begins, to be followed up with later results in order to carry out a formal analysis of results.

For more immediate feedback capable of influencing the following year's work, which may be particularly important when innovations are being introduced, it is best to ask the school students and their teachers for their views on their experience of what has been done. This can be done either through the traditional end-of-event questionnaires (which, bearing in mind the present-day tendency towards 'questionnaire fatigue', should be as short as practicable – an example of the

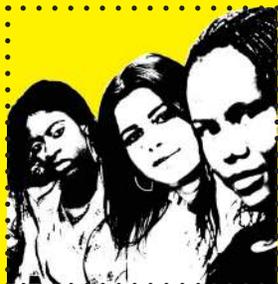
kind of questionnaire used by *More Maths Grads* can be found in Appendix 2) or through focus groups. Teachers' views will start from a different standpoint from that of their students and they may be able to give an informed opinion of the effectiveness of what was done. The views of student ambassadors, if used, should also be sought, as school students may be more forthcoming to ambassadors than to figures in authority. Questions should cover topics such as interest, appropriateness, perhaps how it relates to the mathematics the students have studied, the effect on the students' likely future interest in mathematics or appreciation of the usefulness of the subject, as well as their views on how successfully the session was delivered. This information will normally be enough to form a reasonable impression of the success of the various activities, and to obtain suggestions of how aspects could be made more appealing or useful to the audience. Experience suggests that the traditional questionnaires, along with a short period at the end of the activity in which students are given time to complete them, will gain the highest response rate. On-line sampling of views generally has a much lower response.

'I was walking about the careers event at the Benn Hall, and was really interested by the idea of More Maths Grads. I really enjoy maths and am interested in taking it further. Before I went I was sort of worried about taking it further because I didn't want it to ruin my enjoyment of it if I did something to do with it as a job. But after talking to you, the idea's really starting to appeal. The way you were so passionate about it really engaged me, and has really encouraged me to think seriously about taking maths as a further option, so thank you.'

Year 10 student at Rugby High School



Advice



If it is to be successful, outreach can be a lot of work and must be done well. Teachers at the schools involved must be able to see the value of what is to be done. In this sense it is essential to bring the teachers on board first. School teachers are generally good at noticing that something has not engaged their students and, if this happens, they will not be interested in the future.

By common agreement among the *More Maths Grads* teams, the biggest challenge is getting the teachers and school administration on board. All found that, to be effective, the activities need to be matched to the schools and their students, so it is essential to make personal visits to the schools beforehand. However, contact must first be made. Contact with the Head of Department and Head Teacher are a necessary formality, but may not always be successful on their own. Once a link has been made with a school it is often best if there is a named individual in addition to the head of department with whom to communicate by email or phone. Local education authorities (LEAs) can be helpful in suggesting schools to contact, and may be useful in spreading the word when there is a successful activity. Some LEAs' mathematics consultants may be able to suggest the right teacher to contact within a particular school. Schools seeking to create or renew specialist status may be more receptive than others. Teachers are, however, continually deluged with unsolicited mail. Experience has shown that envelopes with hand written addresses have a higher success rate of being opened and read than ones with more formal computer-printed labels. Generally speaking, telephoning teachers is not a good policy unless prearranged. Email has the advantage that it will wait until the teacher concerned is no longer engaged with his or her students.

'School students gained support in their work and help in preparation for exams. Sometimes they found it easier to ask me for help than to ask the teacher as they could relate to me more. A lot of students asked about university and maths at higher levels and I tried to promote further education to them.'

Student ambassador

- It is important to engage partner schools early and to match the materials delivered, and perhaps the student ambassadors used, to the schools involved. Those involved should be sensitive to the constraints imposed by school timetables, examinations and holidays, as well as national curriculum requirements. If there is already a relationship with the school then it is often the school which makes contact to book workshops. Often schools try to book in activities at the start of term for the rest of that term with popular times being just before half-term and before the main holiday.

- Schools require much more notice in order to arrange a trip out of school. For example, *More Maths Grads* would advertise a March Maths at Work day in December and have schools booked in by January. Some schools now require trips out of school to be planned a year in advance so that they can be scheduled in the school calendar. Basically, the more advanced the organisation, the better – but contact should be made in the run-up to the event to ensure that everything is still in place. For events in university there may, of course, be local timetabling constraints which demand early booking of rooms and facilities.

- There needs to be clear agreement with teachers as to who does what. In general *More Maths Grads* teams found that where the event was in school the outsiders needed to comply with the local norms (e.g. dress code). Where a teacher brings his or her students to an event outside school, it should be agreed in advance with the school that it is the teacher's responsibility to keep behaviour in order. For some residential conference events at university school students signed a code of behaviour. What is most appropriate in a particular case should be discussed with the school beforehand. For Maths at Work days it may be worth emphasising to the teachers that they are in charge of their students' behaviour and reminding them that the workshops are being run by industrial presenters who often do not have experience of working with school groups.

It is essential to work with the teachers in preparation, to ensure anything done by outsiders fits with what the school students are being taught, and that they can relate to anything new. In this sense higher education partners need to find a good, interested member of staff in each of the schools with which they are to work to be the liaison between the school and higher education. Without this, things are hardly possible. Those with experience put it more bluntly: if you cannot set up a good liaison 'Don't flog a dead horse'. Brief advice is to know the audience, know the school, and prepare. It is easy to burn the contact 'bridges' with teachers if outreach is poorly received. Competitions and quizzes work well if the format allows them to be fitted in to the activities, for example, where work is done in parallel by several teams of school students.

Organisers need to discuss what is required from any industrial contributors involved beforehand. Remember to arrange for breaks, not just for front-line presenters, but also for those who are to be consulted by students, as at a careers fair. The industrial contributors are often being asked to do things outside their normal range of activity and need to be properly acknowledged and generously thanked for this. Industrial contributors may not be aware of school students' expectations and the forms of learning they are used to.

For occasions where the presentation is mathematical, having a stock of career profiles as posters, for discussion in a foyer or similar informal location, may be useful. The NCETM has a collection of video clips entitled 'Maths in Work', produced in collaboration with *More Maths Grads*, which could be similarly useful. (www.ncetm.org.uk/resources/11329)

Training student ambassadors

The ambassadors need to be selected carefully, more or less as if they were applying for a job, which, depending on the format in which they are used, it effectively is. They should be selected not just for their ability to carry out the tasks directly involved, but also for their suitability as a role model for the school students whom the activity is aimed at influencing. The set of ambassadors should, if possible, reflect the diversity of the audiences with whom they are involved.

Training with *More Maths Grads* usually consisted of one session in which the ambassadors were given some advice on communication and child protection issues and were made aware of the needs of the schools to which they were going. This part needs substantial input from the teacher(s) from the school(s) involved and may be very practical; teachers are the best people to train them on how to deal with school students, and on specific matters relating to their particular school. If the ambassadors are to be helpful in day-to-day lessons the training should set out the expectations of the school and how the ambassadors can be useful in the school. Where they are to be used in one-off visits to schools there still needs to be input from a teacher about dealing with school students but also in this case from those presenting the sessions in which the ambassadors will take part.

'The main thing gained by the school students from my presence was the extra help and attention they received. Also many viewed me as a mentor, who can assist them in the choices of subjects for A levels, and give them an insight on university life and maths as a degree.'

Student ambassador

Criminal Records Bureau and Independent Safeguarding Authority

Criminal Records Bureau (CRB) checking of those working with children or other vulnerable people has been in force for several years, but is on the point of changing as this guide is being written. The Independent Safeguarding Authority started work in 2009 but new employees and those changing jobs in regulated activity do not need to start applying for ISA registration until July 2010 while ISA registration does not become mandatory for these people until November 2010. Other staff will be phased into the scheme from 2011. The best advice is to consult the schools involved on what is required, and to do this well in advance, as if registration or checking of the staff or ambassadors is required time has to be allowed for this to happen.

CRB checks are required if either someone will be left alone with under-18 students (this usually does not apply to ambassadors in schools), or if they will get to know students on a one-to-one basis over a period of time (which does apply to some ambassadors). Hitherto a CRB check has not been normal unless a student is helping on a defined programme, since there was a six- to eight-week delay in having it arranged. Student ambassadors on modules involving placement in school have all had CRB checks; student ambassadors helping with open days have not needed them.

Most ambassadors do not assist school students on their own as there is always a teacher present. They do not necessarily need to have CRB checking or ISA registration, but this should be confirmed with the schools involved. Some schools will not allow visitors into school who have not been CRB checked. Those who are going to be in one-to-one contact with school students or work with them regularly should be CRB checked or ISA accredited. It may be simplest to ensure that all ambassadors or student hosts are CRB checked or ISA accredited, although whether this is practicable will depend on circumstances. If industrial presenters are STEM ambassadors (through STEMNET) they will have been CRB checked.

The detail of this may change once the ISA is fully functioning. Those organising outreach should check the current guidelines to ensure that people have been registered with ISA or cleared through CRB checks where appropriate.

'One of the best ways to encourage students to think positively about mathematics is to get them talking with people who are at the next step of learning or using mathematics. For example, students at sixth-form colleges can encourage GCSE students; undergraduates can encourage A level students; postgraduates or alumni can encourage undergraduates; and mathematicians and outreach projects can encourage everyone to get involved! The difficulty is that finding political will and funding to link three, four or more different organisations in a chain of positive mentoring can be tricky: someone needs to lead on the project and keep things going. Universities are probably in a strong place to do this, but they need to develop expertise in managing it and for sources of funding to be made readily available.'

Dr Vivien Easson, *More Maths Grads*, Queen Mary, University of London

Appendix 1 – More Maths Grads activities

Events in Schools – Workshops

Paper Imagination

Duration: 1–2 hours
Number of students: 20–30
Age group: Years 7 or 8

Students work together to make three-dimensional shapes using paper and simple origami, while investigating some of their mathematical properties.

Mathematical Trickery

Duration: up to 1 hour
Number of students: maximum 30
Age group: Years 7 to 9

Students learn how a range of card tricks and number puzzles rely on mathematics to work.

Fractals

Duration: 1 hour
Number of students: maximum 30
Age group: able Year 10 to Year 13

Fractals are found in all sorts of places, from clouds and coastlines to the humble fern. Students will find out about these objects and have a go at constructing them while looking at some of their surprising mathematical properties.

Cryptic Challenge

Duration: 1–2 hours
Number of students: 20 plus
Age group: Can be modified to suit students from Years 7 to 11

Depending on the age group, students will learn about some different types of codes, competing in groups to crack the hidden messages. They will soon see that maths is right at the heart of this exciting topic.

FunMaths Roadshow

Duration: 90 minutes
Number of students: maximum 60
Age group: Years 7 to 13

This challenge uses materials from the FunMaths Roadshow which has been running since 1998 and was created by the Liverpool Mathematical Society. It consists of fun problem-style activities which the students complete in pairs as they move around. The problems range from easy right through to some quite challenging ones and the idea is that students do as many as they can.

If it is run in school, we would like to have older students from higher up the school to man the activities and help the younger students with the problems. Alternatively we can host this event at the university.

(FunMaths Roadshow resources also exist for primary school Years 3 to 6.)

A Maths Whodunnit

Duration: 2 hours
Number of students: maximum 30
Age group: Years 7 to 9

Only maths can solve the mystery as students work together in teams to find out whodunnit.

Kitchips

Duration: 40–60 minutes (extendable)
Number of students: maximum 30
Age group: Years 9–11 (KS3 Level 5–7)

Kitchips is a project with cross-curricular links. Students choose where to work in a fully-fledged business environment developing pet foods. With colleagues they solve real issues and examine the maths required to make decisions and do analysis in departments from marketing through to human resources.

more maths grads is a three-year project funded by the Higher Education Funding Council for England to develop, trial and evaluate means of increasing the number of students studying mathematics and encouraging participation from groups of learners who have not traditionally been well represented in higher education.

Polypaperhedra

Duration: 40–60 minutes (extendable)

Number of students: Maximum 30

Age group: Years 7–10

Understanding polyhedral shapes can help find a cure for cancer or create the next Hollywood blockbuster. A practical session investigating some of their properties of two- and three-dimensional shapes using nothing more than paper, thread and simple origami.

Public Enemy Number 10110111

Duration: 40–60 minutes (extendable)

Number of students: negotiable

Age group: Years 10–13

Digital information is everywhere: iPods, computers, the internet and mobile phones all rely on codes. In this workshop we explain how binary numbers work and look at the maths which keeps your credit card details secure against hackers. Find out how it all works.

Air Miles

Duration: 30–40 minutes

Number of students: negotiable

Age group: Years 10–13

How would you plan the holiday of a lifetime? Visit nine world destinations and try to find the cheapest route! Students work in groups and try to solve this version of the well-known Travelling Salesman Problem. Companies are using versions of this problem daily. We look at the inspiration from diverse fields such as evolutionary theory, the physics of heating glass to steel and jazz music!

Sequences

Duration: 30–40 minutes

Number of students: negotiable

Age group: Years 11–13

1, $\frac{1}{2}$, $\frac{1}{4}$, ... What comes next? What do you get if you add up the infinite sequence of these numbers? Sequences were first studied by the Greeks 2500 years ago. Today we find sequences hidden in fractal design, in financial markets, in biology, in hairdressing and in music compression for iPods. We ask students to resolve Zeno's Paradox and to complete our challenge.

Maths At Work days (school version)

Duration: 1–2 hours

Number of students: 30–40

Age group: Year 10

Students participate in practical workshops led by a mathematician working in industry.

Maths of Dance Making

Duration: 2 hours

Number of students: 20–30

Age group: Years 8 or 9

Students engage in a practical workshop incorporating concepts from pure mathematics such as geometry in their routines.

Appendix 1 – More Maths Grads activities

Events at University – Workshops

Maths in Higher Education Experience Day

Duration: either a half or a full day of activities
Number of students: 15–30
Age group: All years

This visit can be tailored on request to include a range of activities. These could include a sample lecture, a hands-on workshop, a tour of the campus and a more general activity relating to higher education

Maths at Work day (Year 10)

Duration: a full day of activities
Number of students: 100 (maximum of 25 per school)
Age group: Year 10

Four different employers are present at this event which is designed to show students how maths is used in the workplace. Students move round a series of hands-on workshops from a range of different companies who all value well developed maths skills.

Sample Year 10 'Maths at Work' day programme
(four 45-minute workshops)

9:30	Registration
9:40	Welcome/Introduction
9:55	Session 1
10:40	Change over
10:45	Session 2
11:30	Break
11:45	Session 3
12:30	Lunch and Quiz
13:15	Session 4
14:00	Plenary session
14:30	Close

All students attend every session. The industrial presenters each run their sessions four times and in groups of 25 the students participate in each in turn.

Maths at Work day (Year 12)

Duration: a full day of activities
Number of students: 100 (maximum of 25 per school)
Age group: Year 12

Four different employers are present at this event which is designed to show students how maths is used in the workplace. Students move round a series of hands-on workshops from a range of different companies who all value well developed maths skills.

Sample Year 12 'Maths at Work' day programme
(four 1-hour workshops)

9:30	Registration
9:40	Welcome/Introduction
9:55	Session 1
10:55	Break
11:10	Session 2
12:10	Lunch and Quiz
13:00	Session 3
14:00	Change over
14:05	Session 4
15:05	Plenary session
15:30	Close

All students attend every session. The industrial presenters each run their sessions four times and in groups of 25 the students participate in each in turn.

Building A Rover (also suitable for school delivery)

Duration: 1 hour
Number of students: 30–40
Age group: Years 9 or 10

Students work in teams to design a Mars rover.

Mechanics days (Year 12)

Duration: a half day of activities
Number of students: 5 per school
Age group: Year 12

Students will rotate around a series of experiments which demonstrate mechanics in action. No prior knowledge of mechanics is assumed.

Mechanics in Action

Duration: 2.5 hours
Number of students: 20
Age group: Years 7 or 8

Engage in practical workshops and interactive sessions to discover how mathematics influences all of our lives every day! Students explore mechanics through practical activities and hands-on sessions.

Good mechanics resources used at the mechanics events above:

- The Leeds Mechanics Kit, a Mechanics in Action resource available from Unilab Limited
- 'Mechanics in Action' by Mike Savage and Julian Williams, Cambridge University Press (1990)

Maths Fun Day

Duration: a full day of activities
Number of students: 100 (maximum of 25 per school)
Age group: Year 9

Students work together in groups on a series of hands-on activities including Maths Trail, Maths of Paper Folding and Who Wants to be a Millionaire.

'I hope with the help of the project I implemented, that the school students I worked with have academically moved up. In addition I hope that talking to these students and informing them that university is achievable has raised their aspirations.'

Student ambassador

Careers awareness

Speed dating session at a careers-focussed event

Five to seven tables, each with four or five chairs; five to seven professionals or student ambassadors from different backgrounds (e.g. a forensic scientist, a postgraduate mathematician, an investment banker, a statistician, a careers adviser, etc.), one at each table, with two to four students or teachers at that table. A whistle, gong or buzzer was pressed every five minutes, signifying that the students should move to the next table. We found it best to keep professionals at their own table so they can lay out any props or leaflets. The professionals should be ready to give a 30-second spiel about who they are or who they are representing. Students and teachers are encouraged to ask any questions they like.

Maths in Your Career ; a Career in Maths?

Duration: 40–60 minutes
Number of students: negotiable
Age group: Year 11–13

Who uses maths in their career? The question should really be: who doesn't? Just think of actuaries, biologists, cancer researchers, detectives, engineers, fund managers, geneticists, hairdressers, investment bankers, x-ray technicians, yoga instructors, zoologists Good mathematical skills improve your earning potential and your career opportunities. Light relief is provided by digressions into the maths of the national lottery, a game of spot-the-celebrity and everyone's favourite mathematician, Homer Simpson.

Why do a Maths Degree?

Duration: 40–60 minutes
Number of students: negotiable
Age group: Year 12

A general talk outlining the benefits of studying maths at degree level and the wide variety of career routes that open up to maths graduates. This event would be delivered in cooperation with Queen Mary's outreach officer Laura Jackson. If more time is available then this talk can be made part of a longer workshop covering interactive activities, depending on venue and numbers. Possible activities include Air Miles or Public Enemy Number 10110111.

See also:

Maths at Work days (page 00)
What Can You Do With Maths? (page 00)
Why do Maths A level? (page 00)

*'Good to see the maths they knew
could be used in everyday activities.'*

Teacher's comment on Maths at Work

Teacher enrichment / CPD events

Residential conference

Duration: Annually for 2 days

Number of teachers: 95

Various workshops and plenary session to enrich maths teaching.

Workshops

Duration: 3 hours, three times a year

Number of teachers: 50

Workshops on various topics to enrich maths teaching.

.....

Talks

What Can You Do With Maths?

Duration: 30 minutes

Number of students: negotiable

Age group: Years 10 or 11

A general talk outlining the benefits of studying maths at A level with a particular look at the variety of degree courses and careers available.

Why do Maths A level?

Duration: 20–30 minutes

Number of students: negotiable

Age group: Years 10 or 11

A general talk outlining the benefits of studying maths at A level with a particular look at the variety of degree courses where students are advantaged when they have a good understanding of maths.

Appendix 2 - Sample feedback sheets

Name				
School Name				
School Year				
Gender	<input type="checkbox"/> Male	<input type="checkbox"/> Female		
Ethnicity	<input type="checkbox"/> White – British	<input type="checkbox"/> Black/Black British – Caribbean		
	<input type="checkbox"/> White – Irish	<input type="checkbox"/> Black/Black British – African		
	<input type="checkbox"/> White – other	<input type="checkbox"/> Black/Black British – other		
	<input type="checkbox"/> Asian/Asian British – Indian	<input type="checkbox"/> Chinese		
	<input type="checkbox"/> Asian/Asian British – Pakistani	<input type="checkbox"/> Any other ethnic group		
	<input type="checkbox"/> Asian/Asian British – Bangladeshi	<input type="checkbox"/> Not known		
	<input type="checkbox"/> Asian/Asian British – other	<input type="checkbox"/> Do not want to say		
If you are of mixed heritage please tick all that apply.				
The following questions are about how you found the workshop. Please circle your answer				
Was it understandable?				
<i>Yes</i>	<i>No</i>	<i>Some of it</i>		
Comments...				
Was it interesting?				
<i>Very interesting</i>	<i>Interesting</i>	<i>OK</i>	<i>Not very interesting</i>	<i>Not interesting at all</i>
Comments...				
Did you enjoy it?				
<i>A lot</i>	<i>Quite a lot</i>	<i>OK</i>	<i>A little</i>	<i>Not at all</i>
What did you enjoy?				
(continued overleaf)				
Could the workshop be improved?				

<i>Yes</i>		<i>No</i>		
If yes, how could it be improved?				
Do you feel you have learned anything new about mathematics from today's activity?				
<i>A lot</i>	<i>Quite a lot</i>	<i>A reasonable amount</i>	<i>A little</i>	<i>Nothing at all</i>
Has the event changed the way you think about mathematics or those who use mathematics?				
<i>Yes</i>		<i>No</i>		
Is this change:				
<i>Positive</i>		<i>Negative</i>		
Comments...				
Following this event, would you like to know more about mathematics and what you can do with it?				
<i>Yes</i>		<i>No</i>		<i>Maybe</i>

Any other comments?

You may not need to collect names and ethnicity information if all you wish do is evaluate the event itself.

Teacher feedback

As part of the evaluation of the *More Maths Grads* Project we are required to report on such things as the number of times individuals have interacted with the project. This means that we need to collect a limited amount of personal information (such as your name). This personal information will only be used for the purpose of compiling evaluation reports and will not be disclosed in a form that enables you to be identified.

Name				
Position				
School Name				
What do you feel about the organisation of today's event?				
<i>Excellent</i>	<i>Good</i>	<i>Satisfactory</i>	<i>Less than satisfactory</i>	<i>Poor</i>
Comments....				
Was the project offered at the appropriate level and suitably tailored for the curriculum?				
<i>Yes</i>		<i>No</i>		
Comments....				
How useful did you find the activities offered to your students?				
<i>Very useful</i>	<i>Useful</i>	<i>Satisfactory</i>	<i>A little useful</i>	<i>Not useful at all</i>
Comments...				
Do you think the students gained any additional skills or knowledge as a result of working on this project?				
<i>Yes</i>		<i>No</i>		
If yes, what?				
Do you think it is likely to raise their aspirations towards studying mathematics further?				
<i>Yes</i>		<i>No</i>		
Comments...				
Could this project be improved?				
<i>Yes</i>		<i>No</i>		
If yes, how?				

Appendix 3 - Organisations involved in outreach

Aimhigher

Website: www.aimhigher.ac.uk/sites/practitioner

Aims: To widen participation in higher education by increasing awareness, aspirations and attainment among under-represented groups of students.

Activities offered:

Campus visits
Mentoring
Master classes, including subject enrichment or revision sessions
Student ambassadors
Information, advice and guidance (IAG)
Summer schools and HE-related residential experiences
School or college based interventions

STEMNET

Website: www.stemnet.org.uk

Aims: To increase opportunities for young people through Science, Technology, Engineering and Mathematics (STEM). To encourage awareness of the relevance of STEM in the lives of young people and also the career possibilities. To encourage industry to target their efforts to encourage more students to engage in STEM.

Activities offered:

STEM ambassadors (Industrial partners)
After-school science and engineering clubs (ASSECs)
Brokerage of STEM enhancement and enrichment

The Royal Institution of Great Britain

Website: www.rigb.org

Aims: To connect people of all ages with the world of science.

Activities offered:

Online resources and activities
Talks and visits to the institution
Masterclasses in mathematics

Smallpeice Trust

Website: www.smallpeicetrust.org.uk/

Aims: To provide exciting programmes to promote engineering careers to young people.

Activities offered:

STEM sessions in schools
Four-day residential engineering courses at universities

Nuffield Foundation

Website: www.nuffieldfoundation.org/ (Foundation site)
www.nuffieldcurriculumcentre.org/
(Curriculum Centre site)

Aims: To provide independent funding for research and development in education, law, science and social policy.

Activities offered:

Science Bursaries for Schools and Colleges
Online resources

Nrich

Website: <http://nrich.maths.org>

Aims: Part of the Millennium Maths Project. Aims to enrich the experience of the school mathematics curriculum for all learners through challenging and interesting activities.

Activities offered:

Free enrichment material for all school levels
Online and face-to-face support
Professional development courses for teachers

Researchers in Residence

Website: www.researchersinresidence.ac.uk

Aims: To engage young people with contemporary research in order to stimulate their interest in national shortage subjects such as physical sciences.

Activities offered:

Funded placements in local schools for PhD students

Ogden Trust

Website: www.ogdentrust.com/

Aims: To encourage and promote the teaching and learning of physics.

Activities offered:

Sponsorship of students at sixth form and undergraduate level
Sponsorship of programmes supporting school science teaching
Sponsorship of students wishing to become teachers of physics



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'One of the best ways to encourage students to think positively about mathematics is to get them talking with people who are at the next step of learning or using mathematics. For example, students at sixth-form colleges can encourage GCSE students; undergraduates can encourage A level students; postgraduates or alumni can encourage undergraduates; and mathematicians and outreach projects can encourage everyone to get involved! The difficulty is that finding political will and funding to link three, four or more different organisations in a chain of positive mentoring can be tricky: someone needs to lead on the project and keep things going. Universities are probably in a strong place to do this, but they need to develop expertise in managing it and for sources of funding to be made readily available.'

'It has been great to work with the schools. Sometimes when students came in to a maths workshop they groaned at the prospect of doing maths but as these students participated in the session they discovered that they were actually enjoying mathematics and finding it interesting. It has been a real privilege to be involved in this change of attitude.' 'I was walking about the careers event at the Benn Hall, and was really interested by the idea of More Maths Grads. I really enjoy maths and am interested in taking it further. Before I went I was sort of worried about taking it further because I didn't want it to ruin my enjoyment of it if I did something to do with it as a job. But after talking to you, the idea's really starting to appeal. The way you were so passionate about it really engaged me, and has really encouraged me to think seriously about taking maths as a further option, so that **great students** gained support in their work and help in preparation for exams. Sometimes they found it easier to ask me for help than to ask the teacher

