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Charlie Stripp

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## The Further Mathematics Network

Providing access to AS/A level Further Mathematics qualifications for all, promoting mathematics and enriching the mathematical experience of students and teachers at KS4 and sixth form level.

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Charlie Stripp  
The Further Mathematics Network  
Mathematics in Education and Industry (MEI)  
charlie.stripp@mei.org.uk

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### Introduction

Mathematics in Education and Industry's (MEI) Gatsby-funded pilot project 'Enabling Access to Further Mathematics', which ran from 2000 to 2005 [1], showed that it was possible to make Further Mathematics tuition available to all students, even when it could not be offered directly by a student's own school or college. As part of its response to the Smith Inquiry Report, 'Making Mathematics Count' [2], the DfES is now funding MEI to set up and manage a national 'Further Mathematics Network', modelled on this pilot.

The Further Mathematics Network (FM Network) is now making it possible for suitable sixth formers across England to study Further Mathematics and is helping to promote mathematics widely in schools and colleges. Universities now have a major role to play in ensuring it fulfils its potential to improve standards in pre-university mathematics and encourage more students to take Mathematics and strongly mathematics-related degrees.

### What are the aims of the Further Mathematics Network?

The Further Mathematics Network has a three point mission statement. It aims to:

- give every student who could benefit from studying Further Mathematics the opportunity to do so.
- work to increase the number of students studying AS/A-level Mathematics and Further Mathematics.
- provide training and support to teachers of AS/A-level Mathematics and Further Mathematics.

How the FM Network achieves these aims is discussed in the section on what the FM Network does.

### How was the Further Mathematics Network set up?

The Further Mathematics Network was launched early in 2005 through three launch events organised by MEI in London, Manchester and Reading. Following the launch events, expressions of interest were invited from schools, colleges, local authorities and universities who wished to be involved in setting up one of 46 local 'Further Mathematics Centres' (FM Centres), roughly one per local Learning and Skills Council sub-region. Local meetings of these interested parties were then organised all over the country. At these meetings, those who wished to be involved were invited to work

together to submit a single collaborative proposal to set up and run their local FM Centre. Institutions were not invited to compete for the privilege of becoming the FM Centre. The FM Centres each have a regional identity (the 'South East London FM Centre or the Hertfordshire FM Centre rather than the 'Grange Hill FM Centre, or the 'University of XYZ FM Centre'), and involve institutions working co-operatively. Inviting local competition would have been destructive and counter-productive.

The setting up of the Network is now complete, well ahead of schedule, with 46 FM Centres covering the whole of England. This means that all students who could benefit from studying Further Mathematics are now able to do so, whether or not their own schools or colleges are able to offer Further Mathematics on their timetables.

### Operational structure

#### National structure

Each of the 46 FM Centres has a local Manager who is employed by a local fund holder and typically works to a half-time contract. Local tutors and administration support are also employed through the local fund holder. The fund holders can be universities, schools, colleges or local authorities, depending on what was agreed locally. Universities form the largest group, with 22 university fund holders.

The FM Network has a Central Team employed by MEI with 8 full-time equivalent staff. It provides national training and leadership for the Network as a whole. The Central Team and Centre Managers meet three times a year at national FM Network conferences that focus on ensuring good practice and sharing and discussing developments and ideas. Regional meetings of neighbouring FM Centres are held each term and each FM Centre management committee meets each term. These regular meetings, both local and national, help to ensure that each FM Centre Manager is properly supported and that the FM Network has a coherent national identity.

The map in Fig 1 indicates the 46 FM Centre fund holders, spread across the whole of England. The FM Centres must operate within many different local circumstances, from the most urban to the most rural, from regions where sixth form education is dominated by grammar schools, to others where the state schools are mainly 11 – 16 and almost all sixth form education takes place in colleges. The FM Network is set up to allow the FM Centres to operate flexibly, to enable them to work effectively with their local schools and colleges.



Fig 1 - Map showing the distribution of the Further Mathematics Centres

#### How does an FM Centre work?

Each FM Centre manager works to a local Management Committee, which normally includes representatives from local schools, colleges, universities and local authorities (see Fig 2). It also includes a fund holder representative and a member of the MEI Central Team (generally 6 – 10 people). The make-up of the local management committees means that each FM Centre has a proper understanding of the local provision of mathematics education and can direct its activities to meet local circumstances.

All local schools and colleges are encouraged to register with their local FM Centre. In exchange for registering

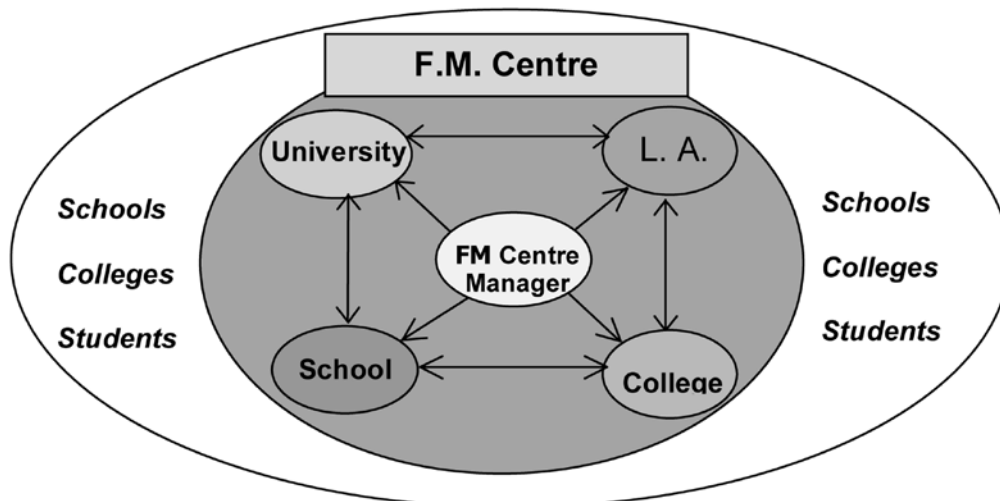


Fig 2 - Diagram to show the collaborative structure of a Further Mathematics Centre

(which is free), they receive free access to extensive online teaching and learning resources and support and advice on teaching Further Mathematics. They are also kept informed of the activities of their local FM Centre.

### **What does the Further Mathematics Network do?**

#### **Direct support for the teaching and learning of Further Mathematics**

The Further Mathematics Network supports ALL Further Mathematics teaching; it provides free resources and advice to schools and colleges that are able to teach Further Mathematics and it also provides Further Mathematics tuition for students whose own schools and colleges cannot offer it. Sometimes tuition is shared between a student's own school or college and the local FM Centre. Schools and Colleges are funded by the Learning and Skills Council (LSC) for the AS/A level qualifications taken by their students. When Further Mathematics tuition is provided by a FM Centre, the students' schools and colleges pay the FM Centre from the LSC funding they receive for their students' Further Mathematics qualifications. FM Network tuition charges are set so as to make them cost-neutral to schools and colleges. Currently about 1000 students who would not otherwise have access to Further Mathematics are receiving tuition through the FM Network.

#### **Online Resources**

The FM Network, through MEI, provides extensive on-line resources for teaching and learning Further Mathematics. Each of the four English awarding bodies' specifications are supported (Edexcel, AQA, OCR and OCR(MEI)). The resources are available to all students who are tutored through the FM Network and to all schools and colleges who have registered with their local FM Centre (currently over 1100), regardless of whether they are teaching Further Mathematics themselves or are having students tutored through their local FM Centre.

#### **Mathematics events for local schools and colleges**

The FM Centres are all involved in running revision days and enrichment events. These are often held at local universities.

Revision days are organised to support students' examination preparation for standard AS/A level Mathematics units, as well as Further Mathematics units. Leading up to the unit examinations this January, FM Network revision days were attended by about 2500 sixth form students. Extensive resources for revision days are provided through the Central Team. The days have been well received and have helped to give FM Centres credibility with their local schools and colleges. The days also provide informal professional development for teachers.

The FM Centres also run enrichment events for Key Stage 4 students (several of which have attracted well over 200 students) and for sixth formers. The FM Network has built

up excellent contacts with national enrichment providers such as the Royal Institution, NRich and the United Kingdom Mathematics Trust. The strong links we have developed with local universities' mathematics departments also provide excellent opportunities for enrichment events. The networks developed by FM Centres between their local schools and colleges mean the FM Network is ideally placed to organise and promote such events nationally. At these events, as well as engaging students in exciting, interesting and entertaining mathematics, AS/A level Mathematics and Further Mathematics are promoted, along with mathematics-related degree courses and careers opportunities. These events have received excellent feedback from both students and teachers. We believe that promoting mathematics in this way really contributes to inspiring students to take mathematics in the sixth form and to then go on to take STEM degrees.

#### **Professional development of teachers**

The activities of the FM Centres provide many opportunities for informal professional development of teachers. Revision days are often attended by teachers accompanying their students and feedback suggests that many teachers find them very useful. Teachers who attend Further Mathematics classes organised by the FM Centres are made to feel welcome and FM Centre Managers are always willing to give free advice to teachers.

The FM Network Central Team is actively involved in an MEI pilot professional development course 'Teaching Further Mathematics'. This course is designed to help existing teachers of A level Mathematics to gain the knowledge and confidence necessary to teach Further Mathematics. The first cohort of teachers is now most of the way through the course, which is proving very successful.

The FM Network is already working with the National Centre for Excellence in Teaching Mathematics (NCETM) and plans to expand its professional development activities, specialising in supporting teachers of AS/A level Mathematics and Further Mathematics.

#### **How does the tutoring work?**

##### **Tutors**

Tutors can be drawn from a variety of backgrounds; school teachers, college lecturers and university lecturers are all involved, including some who are now retired from mainstream teaching.

##### **Face-to-face tutorials and supported independent study**

Students being tutored through the Network receive an average of about 1.5 hours tutor contact time per week, though this varies according to local circumstances. A traditionally-taught Further Mathematics student would receive about 4.5 hours class contact time each week in-house. This means the FM Network tuition has to be very focused and efficient. Study outside the classroom,

structured through the use of the online resources and textbooks, with email support available from tutors between classes, is vital.

FM Network classes take place in a variety of settings, depending on what will work locally. Sometimes students from neighbouring schools and colleges get together in one school or college for their classes; sometimes tutors travel to meet students; sometimes students travel to their local university for classes. Often several different arrangements happen within the same FM Centre. It is vital that the provision is flexible enough to meet local needs.

### Remote tuition

In order to improve its overall provision, the FM Network is developing methodologies for providing remote tuition. This will be particularly useful for remote rural locations and for high level units that are not taken by many students. We are currently piloting online tuition and feel confident that it will become an integral part of our provision.

### Revision days

Leading up to examinations, the FM Centres run intensive revision days, often held in local universities. These are opened up to all students in the area for a small fee (usually less than £20 per student for the day).

### Is it working?

#### Results

Students tutored through the FM Network have received excellent results when compared with those achieved by students taught Further Mathematics in traditional classroom settings. The ‘blended learning’ approach of focused tutorials, well-structured independent study using online resources and textbooks, together with intensive revision days has proved effective. Many students have reported that the independent learning skills developed by studying through the FM Network have proved useful to them at university.

#### Numbers

As a result of its successful pilot and start-up phase, the Network has already achieved one of its major goals, reversing the long-term decline in the numbers taking AS/A level Further Mathematics.

Since 2004, AS level Further Mathematics numbers have risen by 58% and the knock-on effect is now being felt at full A level Further Mathematics, with numbers rising by 22.5% in academic year 2005/6. These were by far the largest percentage rises for any AS/A level subject. Now that the Network is operating throughout England, this summer’s figures are predicted to be even higher. Table 1 shows the increases in numbers for Further Mathematics in England (where the Further Mathematics Network is operating), compared to Wales and Northern Ireland (where it is not).

|                       | A level FM increase | AS level FM increase | Proportion of A level Maths taking A level FM |
|-----------------------|---------------------|----------------------|---|
| England               | 23.5%               | 25.1%                | 1 in 7  |
| Wales and NI combined | 4.6%                | 12.7%                | 1 in 14                                       |

Table 1 - Numbers for Further Mathematics in England increasing compared to Wales and Northern Ireland

The increases in Wales and Northern Ireland can be attributed to the re-structuring of the Further Mathematics specification for first teaching from September 2004, which allows an AS in Further Mathematics to be studied alongside AS Mathematics in year 12, making AS Further Mathematics both more accessible and easier to timetable [3]. However, we believe that the far higher increases in England provide strong evidence of the positive effect the FM Network is having. The increased numbers are only in part due to the students we are actually tutoring. We believe the most significant factor in the increase is our work in promoting Further Mathematics and supporting its teaching. This has resulted in more schools and colleges offering Further Mathematics in-house and those that already teach Further Mathematics making it available to a wider range of students.

### What are the implications for universities?

The FM Network is giving students from even the most disadvantaged schools and colleges the opportunity to study for Further Mathematics qualifications. More students studying Further Mathematics means more students who are better prepared for Science, Technology, Engineering and Mathematics (STEM) degrees at university. The work we are doing to promote mathematics also encourages more students to apply to study for mathematics and mathematics-related degrees.

In the past, when Further Mathematics was only offered by a minority of schools and colleges, universities felt that they could not ask for Further Mathematics qualifications as this would discriminate unfairly against the majority of students who were unable to access them. That is no longer the case. Further Mathematics is now genuinely available to all sixth formers.

Another factor is that before the changes to AS Further Mathematics in 2004, Further Mathematics at both AS and A level was rather difficult, suitable for only elite A level Mathematics students. AS Further Mathematics is now accessible to a far wider range of students; it has a greater emphasis on broadening and reinforcing, alongside its traditional functions of deepening and stretching. Teachers report that weaker A level Mathematics students who study for an AS Level in Further Mathematics also improve their A level Mathematics grade; for example, a student who might have been expected to achieve a grade C in A level

Mathematics may well achieve a B in A level Mathematics alongside a C or D in AS level Further Mathematics taken in year 13. This means AS level Further Mathematics is an ideal option for any A level Mathematics student who wishes to go on to study for a STEM degree at university. The stretch and challenge for the elite is still provided by going on to the full A level in Further Mathematics in year 13, which is just as demanding as ever.

A few university departments, mainly some medical schools, have excluded Further Mathematics from their offers, but by doing so they are discouraging students from starting to study it in year 12. An effect of the change to AS level Further Mathematics is that, because it is a broadening option, many students can and do complete it in year 12, at a time when they have not finally decided on their university course, knowing that it will be of benefit to them for any mathematics-related degree. This means that it is now completely inappropriate for any university department to exclude AS level Further Mathematics from its offers. This practice closes down students' options at a time when they may still wish to change their minds about their final choice of degree.

Universities can now begin to ask for Further Mathematics again, confident that students can access tuition, either through their own school or college, or through the FM Network. We must break the cycle of lack of demand from universities leading to schools and colleges feeling that they have no obligation to offer Further Mathematics to their students.

### What should universities do?

There are two courses of action that would help to ensure that the FM Network can fulfil its potential to encourage more students to pursue mathematics and related subjects at university and raise the standard of mathematics of new undergraduates.

1. All Mathematics and mathematics-related departments in universities (engineering, sciences, computing, economics, etc.) should build strong links with their local Further Mathematics Centre(s).
2. All Mathematics and mathematics-related departments should review their admissions policies and, if they are not already encouraging students to take Further Mathematics qualifications, they should reconsider. Not all departments will feel themselves in a position to make Further Mathematics a requirement, but two effective strategies are:
  - a. Stating explicitly in prospectuses that Further Mathematics will be useful to students intending to take mathematics-related degree courses.
  - b. Including Further Mathematics in 'alternative' offers, e.g. B in A level Mathematics plus C, C in two other A levels

or  
B in A level Mathematics plus C in AS Further Mathematics, plus C, E in two other A levels

Several university departments are now doing one or both of these things (they were first suggested in *MSOR Connections* Aug 2004 [3]). We also know of cases where a small bursary is being offered to students with a Further Mathematics qualification. The time is now right for all universities openly to encourage sixth formers to study Further Mathematics.

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### Conclusion

Through the FM Network, the school and college sector has addressed the issue of access to Further Mathematics tuition and is doing much to promote mathematics in schools and colleges throughout England. This provides a fantastic opportunity to really improve the standard of pre-university mathematics. Demand from universities can really help to make this happen.

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