

# IN-SERVICE PROFESSIONAL DEVELOPMENT FOR TEACHERS OF PRE-UNIVERSITY MATHEMATICS.

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This paper is practice-oriented.

## Abstract

The 'Teaching Advanced Mathematics' (TAM) course of in-service professional development offers teachers of secondary school mathematics of students up to age 16, the opportunity to acquire the subject knowledge and pedagogical skills to teach A level Mathematics. This is the post-16 pre-university course in mathematics for students in England.

TAM is a pilot course offered through four universities and centrally managed by MEI. It is a 16 month course and requires a substantial amount of private study. Extensive support is provided to participants, through sessions at university, web-based resources, weekly lessons using an on-line virtual classroom and by e-mail. Throughout the course, participants learn A level mathematics and practice teaching it. They receive supportive school visits. Typically nine days are spent at university focusing on mathematics pedagogy and related research, with associated assignments, leading to the award of a Postgraduate Certificate.

Course participants, their colleagues and the independent evaluation team have reported significant on-going progress in terms of participants' enhanced subject knowledge and teaching skills at all levels of the secondary curriculum. This paper reports on the design and structure of the pilot course, the experiences of participants and the outcomes as evidenced by the evaluation team and others.

The independent evaluation has provided the course managers with evidence that TAM is successfully meeting its objectives and is highly regarded and valued both by its participants and their teaching colleagues. The course has potential for development in other countries where there is a shortage of suitably qualified mathematics teachers.

## Background

There is a well-publicised shortage of specialist teachers of mathematics in England, see ACME (2002), Smith (2004) and DfES/DTI (2006). In response to the Smith Report, the UK government set up the National Centre for Excellence in the Teaching of Mathematics (NCETM) with a brief to coordinate the national provision of professional development. Both the Smith Report and the NCETM highlighted a gap in the provision of professional development available to mathematics teachers. There was a clear need for a course of sustained professional development to allow teachers of secondary school mathematics to extend their subject knowledge and deepen their understanding of the associated pedagogy.

In 2003, Mathematics in Education and Industry (MEI), an independent UK curriculum development body with many years' experience of providing professional development, designed the "Teaching Advanced Mathematics" (TAM) course together with the University of Warwick. The TAM course was aimed at teachers who are competent to teach students up to age 16, to the GCSE qualification in England, who wished to develop the depth of

knowledge, skills and understanding of mathematics and its pedagogy to teach A-level mathematics with confidence. (See Porkess (2003) for information relating to the structure of A level Mathematics.) In June 2004, with funding from the Gatsby Charitable Foundation, the pilot phase was initiated with twenty teachers enrolled on the course. Due to demand, the course is now offered through four universities in England, supporting approximately 70 teachers per year. Successful completion of the TAM course leads to a Postgraduate Certificate in A level Mathematics Pedagogy, which constitutes one third of a Masters degree.

### **Theoretical Framework**

In 2002, leading practitioners and experts in the field of mathematics education in England met to establish the principles of good practice for the professional development of mathematics teachers. These were reported by Advisory Committee on Mathematics Education (ACME (2002)) and informed the design of the TAM course as delineated below.

- Collaboration : In TAM this is between MEI, universities and schools
- Targeted provision : TAM aims to support teachers with the necessary experience who wish to develop their teaching to a higher level
- Use of non-teaching time : The TAM course includes giving participants time away from the pressures of the classroom
- Sustained CPD : the TAM course lasts for 16 months, with a total of 3 years support
- Teacher ownership : The TAM course has built-in flexibility giving teachers the opportunity to choose areas of study outside a common core
- Independence : funding from the Gatsby Charitable Foundation allowed MEI to design the TAM course without externally imposed constraints
- Deepening subject knowledge : the TAM course assumes knowledge of GCSE and allows teachers to deepen their knowledge into A level and, if required, beyond.

In this way, the course design benefits from being based on well established, effective principles.

### **Evaluation**

During the pilot phase, course development has been influenced by the findings of the external evaluators, the Curriculum, Evaluation and Management Centre (CEM) at Durham University. They have adopted a mixed methods research approach which has included

questionnaires, interviews with participants, their colleagues and students, observations of lessons and observations of university-based sessions. They have followed participants through the course and monitored their progress for one year after completing the course.

The evaluation has been an integral part of the pilot phase, and the evaluators have produced regular reports as the pilot has progressed for the TAM Steering Committee, which is made up of members of MEI, the Gatsby Charitable Foundation and the four participating universities. The evaluators have been formative in their evaluation offering suggestions and recommendations for course improvement that have been responded to by the Course Manager and University providers. In the six interim reports (between 2005 and 2007), there is much evidence from the participants that they have enjoyed the course and got a great deal from it in terms of building their knowledge and confidence to teach mathematics to A level mathematics students. CEM will present their final report in August 2008.

Further research is currently being undertaken by the NCETM as part of their Researching Effective CPD in Mathematics Education (RECME) project and Jill Adler, using the QUANTUM research methods (Adler (2006)).

### **Questions to be answered during the pilot phase**

In designing the programme, we aimed to answer two questions:

- Given the restrictions on teachers' time, is it viable to run a sustained course of professional development to equip non-specialist teachers with the skills to teach A level Mathematics with confidence?
- Can a 16-month course set teachers on a route of continuing professional development giving them the independence to acquire further knowledge and pedagogical skills?

The evidence from the course participants, their colleagues, the course evaluators and the course providers, clearly indicates that the answer to both of these questions is 'Yes' and that the existing course, as described below, is highly successful in achieving its aims.

### **The Course Structure**

The main features of the course are as follows.

- It is a 16-month course that runs from June one year to September of the following year, thereby incorporating two summer holidays, each of approximately six weeks duration. This gives time for participants to work uninterrupted for a substantial period of time away from the pressure of the school environment (researching assignments and studying mathematics) enabling them to focus on the course requirements.
- Approximately nine days are spent at the university, focussing on the subject content of A level Mathematics, its pedagogy and related issues such as student misconceptions, assessment, ICT, the role of proof in mathematics and mathematical modelling. Participants are challenged to think about mathematics in a way that takes them beyond the comfort zone of typical A level textbooks. Course leaders facilitate discussion on aspects of pedagogy such as the use of questioning, student-centred activities and differentiation and set associated assignments in the form of essays and classroom-based research, leading to the award of a Postgraduate Certificate.
- The course requirements involve a substantial amount of private study. This is demanding on the time of participants, but the evaluation reports that the majority of the participants respond positively to this, and benefit from the personal development involved in learning to manage their study time effectively against family and work related commitments.
- Extensive support is provided to help participants learn the content of the four Core Mathematics modules and their chosen area of applied mathematics. This support is provided through drop-in sessions at the University, web-based resources in the form of teaching materials such as lesson plans, interactive ICT resources, active learning resources and enrichment materials, by e-mail and through weekly on-line lessons using the Elluminate virtual classroom .
- Throughout the course, all participants teach A level Mathematics to 16–19 year old students and receive at least two supportive school visits. Participants are observed teaching their students in their own classroom, with the lesson videoed, and then given feedback as to how their preparation and delivery of a lesson might be improved.

From the moment of course enrolment, participants benefit from the three-pronged collaborative support of MEI, their university and their school/college.

1. The TAM course is centrally managed by MEI through the appointed Course Manager who brings coherence to the course at the various universities around the country at which it is offered, to the benefit of all participants. MEI ensures that high quality on-line resources are available to participants at all centres to support their learning and teaching of A level Mathematics. In addition, MEI provides participants with all the support they need in terms of acquiring subject knowledge, understanding its place within the wider framework of Mathematics and experiencing a range of effective ways of teaching it. The purpose-written, web-based resources, on-line lessons in a virtual classroom and regular e-mails give teachers a focus and structure to their independent studies. The school visits, undertaken by MEI and the university course tutors, give participants one-to-one advice, support and ideas for use in their own classrooms.

2. The university introduces participants to the research underpinning the teaching and learning of A level Mathematics. The university-based study days allow MEI and the course leaders at the universities to model good practice, to discuss the major issues related to teaching at this level and provide any other face-to-face support as required by individual participants. The university designs the course assessment, accredits the work at postgraduate level and provides further options for participants to continue their studies at Masters level for those who wish to complete a higher degree qualification.

3. Schools and colleges support the participants by providing them with the teaching experience required in order to be able to put into practice the skills they are gaining from the course and by releasing them for the university-based days. Where possible, colleagues with experience of teaching A level Mathematics provide daily face-to-face support as required. In this way, the course provides many of the participants with a new direction in their teaching careers and is a gateway to further professional development. This is evidenced in the six interim reports produced so far by the external evaluators.

### **Patterns of delivery**

During the pilot phase, the TAM course has continually evolved. Improvements have arisen as a consequence of the collaborative work between the universities and MEI and in response to the feedback from participants. In particular, the independent feedback provided by the evaluators, through interviews with course participants, has resulted in specific improvements to the course design. These included redesigning the assessment to make it more accessible to participants, developments in the way participants are supported both face to face and on-line

and changing the way in which participants study applications of mathematics. The latter has included using national experts as consultants to deliver specific university study days.

Whilst all four universities have broadly similar modes of delivery, the universities themselves are independent awarding bodies whose requirements for accreditation and certification differ, so local courses must meet the requirements of the university at which they are based. The flexibility in the programme has allowed each university to design a distinct way of assessing the course. This has included essays on aspects of A level Mathematics pedagogy, 'classroom based enquiry' involving research into an issue of the participant's choice, and mathematical investigation in which participants reflect on the process of working on mathematics and the implications this has for their teaching.

### **Lessons learned from the pilot**

The motivation for enrolling on the course differs between participants, but for all, the important thing was to develop their knowledge of mathematics and teaching skills to enable them to teach at A level.

The evaluation team have found that most participants see the university assessment as relevant to their professional lives, and so chose to complete the assignments required to qualify for the Postgraduate Certificate, even when this was not their intention at the outset. For some participants the qualification was seen as an important aid in seeking promotion in their career, whereas for others this wasn't an issue.

It has been important to get the balance right on the university study days between devoting time to mathematics and its pedagogy whilst also ensuring the University's requirements for what constitutes an academic course at this level are met. The feedback from the participants as evidenced in the evaluation reports gives a clear indication that the balance achieved meets their needs and expectations.

A mixture of after-school, half-day, full day and Friday-Saturday university tuition sessions have been trialled and the latter have been by far the most successful. These are now used at all the universities. In responding to the questionnaires from the independent evaluators, participants report to benefiting from the more intense focus this provides and feel that the compromise between their own time and school time is appropriate. Nevertheless, many prospective course participants report that their schools are not prepared to release them for

university study days in term time due to the associated costs of providing supply teachers and consequently they cannot enrol on the course. In the proposed expansion, from four universities in the pilot phase to ten participating universities throughout England, we are recommending that the schools and colleges of participants receive funding to meet these costs and so recognise their contribution in tackling the national shortage of well-qualified mathematics teachers.

### **Course Outcomes**

Whilst on the course, participants develop their understanding of Mathematics to a much greater depth. This has a positive effect on their teaching at all levels from typically age 11 upwards, thus enabling them to present a joined-up view of mathematics throughout a student's time at secondary school. The participants develop a greater appreciation of mathematics pedagogy and acquire the motivation to continue their professional development in mathematics education beyond the completion of the TAM course.

The resources and pedagogy that participants are introduced to whilst on the course are shared with their teaching colleagues in their schools and colleges and, as a result, there is a substantial improvement in the general standard of mathematics teaching at all levels.

Many of the participants were originally trained in specialisms other than mathematics, in which there is no shortage of teachers. In changing career to become mathematics teachers, capable of teaching to A level, they represent an additional, and cost-efficient, way of increasing the number of well-qualified mathematics teachers, thus making a significant contribution to the supply of mathematics teachers nationally. It is planned for the TAM course to be expanded to be offered at 10 universities in England with about 200 participants a year. It is believed that the TAM model could be adapted to help the supply of teachers of mathematics in other countries where there is a shortage.

### **Conclusion**

- The pilot course has shown that TAM is an appropriate model for professional development.
- The main obstacle to course recruitment is lack of funding in schools for supply teacher cover so that they can release teachers for university study days. It is

important that the money going into schools for professional development is ring-fenced so that teachers can access this support. Clearly many teachers wish to do so.

- Central management of the course through MEI has proved crucial in ensuring that high quality, but economically viable, resources are available to all participants both on-line and at study days and that good practice is shared between the course providers
- The course benefits from the collaborative expertise offered by both the universities and MEI. The university provides up-to-date knowledge of research into pedagogy and has the authority to award postgraduate qualifications. MEI provides recognised expert classroom teachers and examiners to support participants and expertise in producing on-line resources. This collaboration has proved highly effective in meeting the needs of teachers. The independent evaluation by CEM is evidence that the course is successful.

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