International comparative study in mathematics teacher training

Enhancing the training of teachers of mathematics

Professor David Burghes

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Welcome to the Centre for Innovation in Mathematics Teaching (CIMT)

CIMT is a self-financing centre in the Faculty of Education at Plymouth University. It was set up some 25 years ago, initially at the University of Exeter, with a research and development focus, aiming to support and help teachers of mathematics to implement good practice, based on international work.

It moved to the University of Plymouth in July 2005, based initially at the Rolle Campus at Exmouth and subsequently moving to a dedicated new building for the Faculty of Education on the campus of Plymouth University. CIMT has recently been joined at the Faculty of Education by the Royal Statistical Society's Centre for Statistical Education and these two centres are co-located to provide a thriving, innovative and enterprising facility for

pedagogical research and development in the mathematical sciences.

In the past two decades CIMT has undertaken two major international longitudinal studies, namely the Kassel Project (mathematical progress in cohorts of pupils in 15 countries in their last three years of compulsory education) and the IPMA Project (mathematical progress of pupils in the first five or six years of school) both aiming to make recommendations for good practice in mathematics teaching and learning. The dissemination phase for UK schools of both of these projects is through the Mathematics Enhancement Programme (MEP), the resources all being freely available at the CIMT website: http://www.cimt.plymouth.ac.uk

The views and opinions expressed in this publication are those of the authors and do not necessarily represent the views of CfBT Education Trust.

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About the international comparative study in mathematics teacher training

The aim of this study, funded by CfBT, was to seek an understanding of good practice in the training of (primary and secondary) teachers of mathematics. It is based on evidence from a variety of mathematically high performing countries around the world, and used a longitudinal study to provide recommendations for effective training.

The following reports and resources are available from **www.cfbt.com/evidenceforeducation** or by contacting **research@cfbt.com**

- International comparative study in mathematics teacher training (2008)

- International comparative study in mathematics teacher training: Recommendations for initial teacher training in England (2011)

- Enhancing the training of teachers of mathematics: Full report (2011)

- Appendix documentation: audits and mark schemes, and responses on each question

Foreword by Professor David Burghes

There has never been a more important time for nations, whether established or developing, to ensure that their young people have confidence and capability in mathematics in this increasingly technological world.

This can only happen if they have a workforce of teachers who are themselves confident and competent and indeed enthusiastic for mathematics. This starts in the primary phase of education, where a mathematical foundation should be put in place to be built on in the secondary and tertiary phases.

For this to happen, trainees to the profession need to be well-qualified and good communicators of mathematics; this is true not just for secondary mathematics teachers but, crucially, for primary teachers, who in England, all teach some mathematics. Their role is pivotal in that they are influencing the mathematical progress of young children at the start of their formal learning of mathematics and where, in an ideal situation, they will have the opportunity to pass on their expertise and their excitement for the subject.

This research seeks to understand both the mathematical strengths of our trainee teachers and their attitudes towards mathematics through a comparative study in both primary and secondary in 10 countries worldwide. It provides evidence of the mathematical prowess of trainee teachers in these countries and makes recommendations for changes to the training models for future teachers, with the aim of improving the teaching and learning of mathematics of future generations.

David Burghes, Project Director

CfBT Education Trust

Executive summary

The aim of this research was to seek an understanding of good practice in the training of primary and secondary teachers of mathematics, based on evidence from a variety of mathematically high performing countries around the world. The countries that participated were: England, Finland (primary only), Hungary, Czech Republic, Ireland (primary only), Russia, China, Japan, Singapore (secondary only) and Ukraine.

In each of the participating countries samples of between 100 and 200 trainee teachers in both the primary and secondary sectors completed an 'audit' of both their mathematical skills and knowledge (part A) and their understanding of mathematical concepts (part B).

The research found that at the primary level, Japan significantly outperformed all other countries. China and Russia also performed above the average for the participating countries. This was true of both skills and knowledge questions and mathematical concepts questions, although there is evidence that the high performing countries are indeed pulling away more on the higher level questions. The Czech Republic had the lowest mean score overall, and specifically for primary trainees' skills and knowledge questions, obtained just 21.5 out of 40, a phenomenon that could be linked to the social and economic prestige of the teaching profession in the Czech Republic which is noted as being particularly low. England and Finland had the lowest scores in questions about mathematical concepts (6.6 and 6.8 out of 20 respectively); this serves as a useful reminder that this study does not seek to prove any specific link between mathematics teacher trainees' ability and student ability (Finland was ranked first in the most recent TIMSS data).

At the secondary level, Russia had the highest overall mean, with 34.7 questions correct out of 40, closely followed by China (33.8) and Japan (33.5). As with the primary sample, this was true in both skills and knowledge questions and mathematical concepts questions, although Japan marginally outperformed China on the concepts questions. Hungary achieved the lowest overall mean of 24.9. Looking specifically at the knowledge and skills questions, the countries are closely bunched: out of the 20 questions, England had the lowest mean of 14.1 whilst Russia had the highest at 17.3. These are the responses to the relatively straightforward questions on concepts that were also taken by the primary participants. We would expect the secondary trainees to do well on this part of the audit. For the mathematical concepts part of the audit, there are more significant differences between countries, with China, Japan, Russia, Singapore and Ukraine all performing far more strongly than England, Czech Republic and Hungary. Hungary had the lowest mean score of 10.1 out of 20 and Russia performed best with a mean score of 17.4 out of 20. England had the highest range of all the participating countries, showing that there is a great variation in that sample; perhaps as expected, Japan had the smallest range.

Comparing performance of primary against secondary Japan demonstrated a particularly unique similarity between the primary and secondary samples. A more typical result is that primary performance has much greater variation than that of the secondary sample, with some primary trainees at a very high standard but some quite the reverse. This is likely to be due to Japan's unique university entrance examination where both primary and secondary trainees are selected according to entrance exam scores that includes mathematics.

1. Project aims and methodology

We used the words 'good practice' as we recognised that teacher training is subject to a great deal of variation both within and between countries.

1.1 Aims

The aim of this research, funded by CfBT, was to seek an understanding of good practice in the training of (primary and secondary) teachers of mathematics, based on evidence from a variety of mathematically high performing countries around the world, and using a partly longitudinal study to provide recommendations for effective training.

We used the words 'good practice' as we recognised that teacher training is subject to a great deal of variation, both within and between countries. The processes used for teacher training vary considerably from country to country; we were keen to identify what we could all agree to be good practice, whatever the context or culture.

1.2 Methodology

The evidence to meet the research aims above was obtained by the implementation of a two-year longitudinal research study for which we selected a sample of trainees, primary and secondary, on the main routes into teaching in each participating country.

Samples consisted of between 100 and 200 trainee teachers in both the primary and secondary sectors in their last year of training in each of the participating countries.

The information sought from the trainees included (* means computer-based):

(a) mathematical audit* at the start of the last year of the training course

(b) personal details*, including attitudes towards mathematics and teaching

(c) questionnaire* on aspects of their training, including school-based work

(d) progress report on training, including interviews with a sub-sample of trainees, teacher trainers and school mentors.

Full details of these test instruments can be found at: **cfbt.com/evidenceforeducation**

We also observed and interviewed a significant proportion of the sample in order to gain more understanding of the data collected and to help clarify aspects of current good practice in each country. Individual trainees have, where possible, been tracked into their first year of teaching, where we have gained evidence as to what is the most effective support given to new teachers to improve their retention rate in teaching.

The information from all countries was processed at CIMT with meetings of all the project co-ordinators (after Year 1 and Year 2 of the project. We obtained agreement, based on the evidence collected and on the experiences of the country co-ordinators, on some of the key factors that constitute (and under what conditions) good practice for the training of teachers of mathematics in both the primary and secondary sectors.

Some of the comparative data is summarised in **Section 2** whilst recommendations for good practice in ITT are given in **Section 3**.

The structure of the audits was:

Primary

Part A: 40 marks on relatively straightforward skills and knowledge questions, e.g.:

- What is the value of 5^5?

- What is the lowest common multiple of 40 and 140?

- Simplify as far as possible 8x + 3y – x + 3y

Part B: 20 marks on mathematical concepts and understanding, e.g.:

- Factorise $x^2 - 7x + 12$

- A bag contains 5 red, 4 blue and 3 white counters. Counters are taken out in succession and not replaced. What is the probability of obtaining two red counters for your first two choices?

- There is a large number of 5 different kinds of sweets in a bag. What is the least number you must take from the bag (with your eyes closed) to make sure that you get at least 3 of the same kind?

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- The price of a television was increased by 20%. In a sale, its new price was reduced by 20%. How does this price compare with the original price?

Secondary

Part A: This is identical to Part B on the primary audit, e.g.:

- Factorise $x^2 - 7x + 12$

- A bag contains 5 red, 4 blue and 3 white counters. Counters are taken out in succession and not replaced. What is the probability of obtaining two red counters for your first two choices?

- There is a large number of 5 different kinds of sweets in a bag. What is the least number you must take from the bag (with your eyes closed) to make sure that you get at least 3 of the same kind?

- The price of a television was increased by 20%. In a sale, its new price was reduced by 20%. How does this price compare with the original price?

Part B: 20 marks on more advanced mathematical topics, e.g.:

- If $x^2 + 6x - 3 = (x + a)^2 + b$ calculate the values of a and b.

- The equation of two lines are $y + 3x - 6 = 0$ and $y - 7x + 5 = 0$. Which of the statements below is true?

  A: The two lines are parallel

  B: The two lines are perpendicular

  C: The two lines both have positive gradients, but are not parallel

  D: The two lines both have negative gradients, but are not parallel

  E: None of the above is true

- How many solutions does the equation below have in the interval $0 \leq \theta \leq 360°$?
  $8 = 2 + 5\sin 3\theta$

- Differentiate $1n(2x)\ 1n(2x)$ with respect to x

In both cases, the audits were designed to be completed in one hour (for the online version, participants were timed-out after one hour). This did not seem to be an issue and it appears that the participants had in nearly all cases completed all that they could do within the hour.

The audits, together with the mark schemes, are given in full in Appendix 1 for primary and Appendix 2 for secondary.

The responses on each question are also given in full in Appendix 3 (primary) and Appendix 4 (secondary). The Appendices to the report can be found at: **cfbt.com/evidenceforeducation**

1.3 Participating countries

The following countries participated with acceptable samples: England, Finland (primary only), Hungary, Czech Republic, Ireland (primary only), Russia, China, Japan, Singapore (secondary only) and Ukraine. These countries were chosen either on account of their strong track record in mathematics or because they exhibit interesting and relevant practice. Between them, they exhibit a variety of methods for teacher training. Australia also participated in some aspects of the project, but not with sufficient data to include in this report.

Each country had a co-ordinator with a background in mathematics teacher training, in both the primary and secondary sectors. Typically, the co-ordinators were front line teacher trainers with good access to other teacher training institutions and to schools used for teaching practice.

At the first meeting of the international co-ordinators, at the beginning of May 2007, agreement was sought on the format and content of the audits and questionnaires and other aspects of the methodology. The second meeting was held in October 2008, where we had our first chance to consider the available data and to discuss our recommendations for good practice. The third and final meeting of the international co-ordinators was in November 2009, when we considered more information from the participating countries as well as recommendations for the support of Newly Qualified Teachers (NQTs) in their first year of teaching.

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2. Comparative data analysis

> *So, we do need to treat the results with caution, but nevertheless they do provide interesting comparisons and looking at the responses on some on the individual questions is of particular interest.*

In this section, we summarise the main data set for the audits. The interpretation of the more qualitative data across countries is less consistent that that of the audits, where we can be assured that, even with translations, the questions have an identical meaning. Indeed, most of the audit questions are straightforward, unambiguous and consistent after translation.

The audits undoubtedly stress procedural rather than conceptual mathematics. There are two reasons for this; the first being the requirement of marking online and the second being on the consistency of the questions after translation. Here we have gone for simplicity for the sake of consistency and reliability rather than complexity.

We also need to be aware that the samples, although in all cases of a reasonable size, are only samples from the institutions that have taken part in the project. That is, they do not necessarily provide an accurate sample for the whole country. In some of the countries, there is also the issue of ethics: for example, in England, all participants were volunteers and could walk away from the project at any time. So, we do need to treat the results with caution, but nevertheless they do provide interesting comparisons and looking at the responses on some on the individual questions is of particular interest.

We also provide a comparison between primary and secondary trainees as there were core questions undertaken by both samples; some of the country reports have highlighted this.

2.1 Primary audit data[1]

The easiest way to give a quick overview of the responses is to look at the comparative box and whisker plots for the participating countries. These are given below. The data can of course be interpreted in a number of ways, but the main conclusions would appear to be:

- Japan significantly outperforms all other countries

- China and Russia perform above the average for the participating countries

- the performances of England, Hungary, Finland and Ireland are all similar

- England and Ukraine have a relatively high spread compared to China, Ireland and Russia, showing the wide variation in performance between the participating trainee teachers in the samples.

Figure 1: Country Primary Results
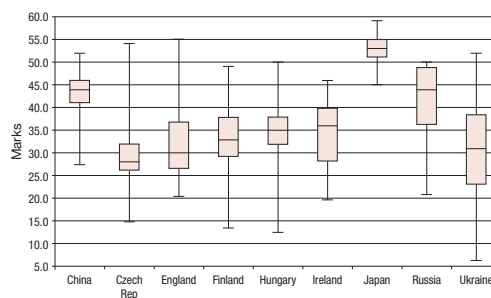
The box and whisker plots (Figure 1 above) are for the full primary audit; performance on the component parts A (Figure 2 below) and B (Figure 3 on page 12) are given in the form of bar charts, based on the mean score and with standard deviations given in brackets. What is clear from the bar charts is that the distribution between the countries on each part is similar despite the different types of questions on each part. As with the full audit, Japan, Russia and China perform above the average for the participating countries in part A, scoring a mean of 36.9, 30.5 and 30.1 respectively within the 40
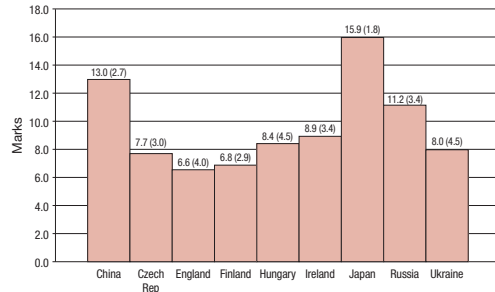
Figure 2: Primary Audit Part A

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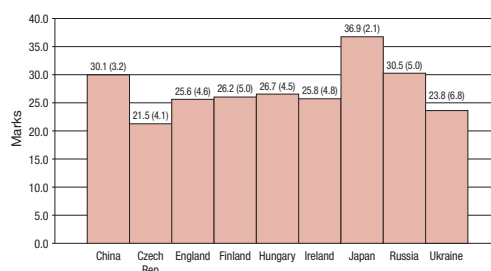
[1] Note, Singapore did not participate in this section of the audit

Figure 3: Primary Audit Part B

- There is little difference between the medians and quartiles of Czech Republic, England and Hungary

- England has the highest range of all the participating countries, showing that there is great variation in the sample; perhaps as expected, Japan has the smallest range.

Figure 4: Country Secondary Results

questions. The Czech Republic has the lowest score for this part with a mean of 21.5 out of 40.

Part B again highlights the high performing countries of Japan, China and Russia pulling away from the other participating countries to a greater degree. England has the lowest score of the participating countries for part B with a mean of 6.6 correct answers from 20 questions. Finland has the second lowest score with a mean of 6.8 out of 20. George Malaty, author of the Finland study, reports that this reveals some interesting facts about primary education teacher students in Finland; he explains that although primary trainees in Finland include some of the best achievers in secondary school matriculation examinations, this does not relate to an interest in mathematics. Dr Malaty explains that only 25 per cent of students in his sample had taken 'advanced level' matriculation examinations in mathematics and only 'advance level' graduates would be able to answer the type of questions that were posed in part B of the audit. Speaking more generally, he notes that *'students who studied mathematics at the 'advanced level' and have a genuine interest in mathematics, in general, do not apply either for primary teacher education study or for mathematics teacher education study'*.

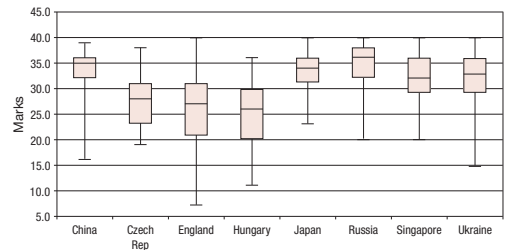## 2.2 Secondary audit data[2]

The overall data for the participating countries is given in the box and whisker plots in Figure 4.

Again the overall trends are clear, namely:

- China, Japan, Russia, and Ukraine outperform the other countries

As with the primary data, we now give the performance on the two parts of the audit. This provides some interesting comparisons as on part A (Figure 5 below) the mean scores of the countries are closely bunched: out of the 20 questions, England had the lowest mean of 14.1 whilst Russia had the highest at 17.3. These are the responses to the relatively straightforward questions on concepts that were also taken by the primary participants. We would expect the secondary trainees to do well on this part of the audit.
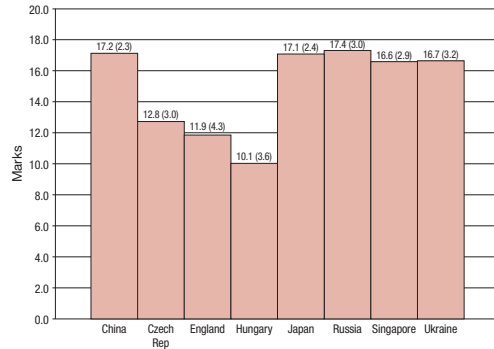
Figure 5: Secondary Audit Means (Part A)
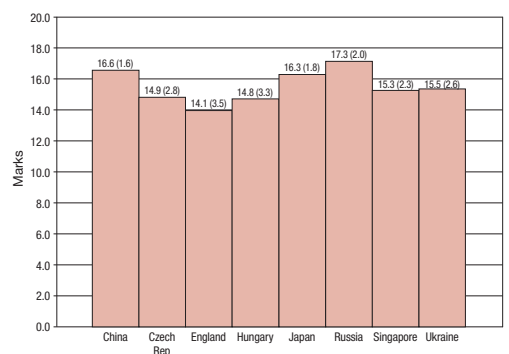
On part B (Figure 6 on page 13), the more advanced mathematical questions, there are more significant differences between countries, with China, Japan, Russia, Singapore and Ukraine all performing far more strongly than

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[2] Note, Finland and Ireland did not participate in this part of the audit

Figure 6: Secondary Audit Means (Part B)

England, Czech Republic and Hungary. Hungary has the lowest mean score of 10.1 out of 20. As with part A, Russia performs best with a mean score of 17.4 out of 20.

For those countries that participated in both the primary and the secondary audits (England, Hungary, Czech Republic, Russia, China, Japan, and Ukraine), the format of the audits also gave us a chance to compare performance for all samples. The results are in fact more interesting country by country and this is produced in Figure 7 below for the contrasting countries, Japan and Ukraine.

Figure 7: Japan and Ukraine primary v secondary comparison on common questions
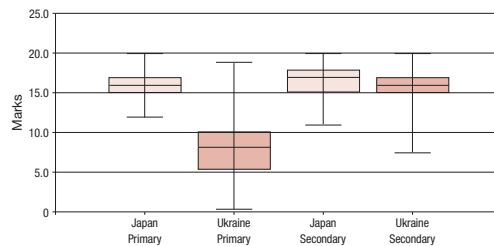
Note here the great similarity between the primary and secondary samples: Japan is quite unique in this. A more typical result is that of Ukraine where the 'box' is in a significantly different position and the primary performance has much greater variation than that of the secondary sample, with some primary trainees at a very high standard but some quite the reverse. Explaining this difference, Masataka Koyama, author of the

Japanese report, comments that Japanese *'primary and secondary trainees are very different from the participants in other countries'* and attributes this to Japan's *'unique university entrance examination… [where] primary and secondary trainees are selected by each university according to their entrance exam scores, including mathematics. As a result, we have similar trainee teachers in terms of their performance level on upper secondary school mathematics'.*

2.3 Attitude responses[3]

We have also observed and interviewed a significant proportion of the sample in order to gain more understanding of the data collected and to help clarify aspects of current good practice in each country.

Of particular interest was the length of time the trainees intended to remain within the teaching profession. In all the countries that addressed this question, there was a difference in response between primary trainees and secondary trainees. In general, primary trainees seemed more committed to a career in teaching. For example, in China, one of the highest performing countries in our audit, the modal response was 'working lifetime' with just over 50 per cent of their secondary sample and two thirds of their primary sample giving this answer. This may be because their subject specific skills are more limited than their secondary counterparts and therefore they may find it harder to find jobs in different industries. The most alarming example of this phenomenon was in the Czech Republic where more than 15 per cent of secondary trainees reported that they intend to teach for only the first year after graduation (during this time they will seek better paid work), and a further 20 per cent had already decided (before graduation), that they will never teach. It should be noted however that this was not the same with primary trainees in the Czech Republic. Miroslav Bělík and Tomáš Zdráhal, who led the study in the Czech Republic, determined that *'the social and economic prestige of the teaching profession in the Czech Republic compares with other countries*

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[3] Note, Finland and Japan did not participate in this part of the data collection

> *Across the participating countries, geometry appeared to be the subject where trainees reported their greatest lack of confidence; other particular areas of concern for trainees included statistics and probability.*

participating in this project at the lowest level', but that there are a wide variety of differences between the degree programmes for primary and secondary teacher training programmes, *'and therefore also students'*. A similar pattern was also observed in Ukraine where over 15 per cent of secondary trainees said that they will not teach at all, although the situation is more positive in primary schools The study leader in Ukraine, Sergey Rakov, reports that *'this illustrates a big problem with the prestige of the teaching profession'* evidenced by low salaries and under-resourced schools. Hungary was the only country where more secondary trainees (32 per cent) than primary (16 per cent) expected to stay in the teaching profession for the rest of their working lives.

Across the participating countries, geometry appeared to be the subject where trainees reported their greatest lack of confidence; other particular areas of concern for trainees included statistics and probability. Regarding the trainees' main concerns about teaching more generally, most countries identified a variation between primary and secondary trainees, as would perhaps be expected.

In nearly all countries that collected attitude data, trainees agreed that the key qualities of an effective mathematics teacher included 'excellent subject knowledge', with being 'well prepared' and 'explaining clearly' also ranked as important.

3. Recommendations for initial teacher training

For trainee teachers of mathematics in the primary sector we would recommend the study of mathematics up to their entry into teacher training, rather than stopping mathematical study at age 16.

Our recommendations, based on the international evidence, are framed in six overlapping interest areas; these recommendations for good practice are not country-specific but are what we consider to be good practice in any context or culture.

3.1 Mathematical ability of trainees

It is comparatively easy to audit the mathematical knowledge of the participating trainees but it should be stressed that, in the time that we allowed for this audit (one hour), there was a limit to the coverage of topics in mathematics and some topics have been omitted which might be central to a particular country's mathematical curriculum. Having said this, the questions were agreed by all participating co-ordinators and do provide a fair reflection on mathematical skills and knowledge.

The primary audits showed the success of China, Japan and Russia in both parts of the audit. The other countries, England, Finland, Czech Republic and Hungary, had similar performance profiles, although having a number of mathematics specialists in the England sample might have enhanced the England position (the concept of mathematics specialists does not exist in the other countries). The secondary audits show very similar results here, except that the first tier of countries now includes Singapore alongside China, Japan and Russia but there is little difference between the second tier of countries, England and Hungary.

The authors' discussions, based on both the audits and our combined observations, lead us to the conclusion that:

A pre-requisite to be an effective teacher of mathematics, is that you are confident and competent in mathematics at a level significantly above that at which you are teaching; you should be aware of the mathematics you are preparing your students for in later years and understand the concepts that underpin mathematics.

This is just a pre-requisite for effective mathematics teaching. There are many other attributes needed by an expert teacher, including, for example, a love of the subject, good communication skills, liking and understanding young learners etc.

3.2 Length of training and level of award

The Bologna Declaration for three (undergraduate) plus two (Master's Level) year courses is having an impact on all countries in this study. One country, Czech Republic, already has this system in place so that the teaching profession is a Master's level profession for all teachers. Here the 3 + 2 years are normally sequential, although the Master's degree is very much school-based, with trainees spending time in schools experimenting and evaluating.

This contrasts with other countries, for example, China, for which a Master's degree level qualification would be very much the exception. England (as with other countries) is in a state of flux with moves to encourage, although this is not compulsory, newly qualified teachers (and others) to be working towards a higher degree known as the Masters in Teaching and Learning (MTL).

Given the variation in current practice across countries, we have based our recommendations on what we think is common sense, namely:

Three-year undergraduate degree in mathematical sciences for secondary mathematics teachers and one-year teacher training course (or equivalent) PLUS part time modular study during first school post (but with significant release time) at Master's level with the intention of completing the masters degree within three to four years and with enhanced pay for each module completed successfully.

For trainee teachers of mathematics in the primary sector we would recommend the study of mathematics up to their entry into teacher training, rather than stopping mathematical study at age 16.

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> *University Practice Schools should play a significant role in the training of teachers and in this way fully integrate theory and practice.*

3.3 Balance between theory and practice

This was one area that alarmed us, as many of the England trainee teachers interviewed stated that they considered there to be a lack of relevance between the theoretical studies undertaken (and set as reading) in the training institution (we will call this the university in what follows) and the practical implications for school-based work. The two worlds did not seem to meet except in countries that based much of their training in University Practice Schools (UPS) such as China, Czech Republic, Hungary, Russia and Japan.

It should be noted that UPSs are specifically designed to be used for:

1. Teacher trainees' first observations of expert teachers.

2. First teaching block (with trainee teachers working in groups of four or six).

3. Regular school-based work for the university tutor to enable them to keep their own practice up-to-date and relevant as well as providing demonstrations for the trainees.

4. Experimental projects, run by the university or government, designed to enhance practice.

These state schools have to be appropriately funded and might be owned or run by the university; they are very much akin to the model of University Practice Hospitals in the Health Service in the UK for the training of doctors and nurses. So our recommendation is:

> University Practice Schools should play a significant role in the training of teachers and in this way fully integrate theory and practice.

3.4 School-based work and assessment

Again we saw great variation in practice with some trainees spending about two thirds of their final year in school and teaching almost a full timetable, whilst in other countries trainees taught far fewer lessons but were able to observe and reflect on a range of lessons taught by others.

This second group of countries essentially use a Lesson Study model in which a group of trainees and one expert teacher or mentor (or their university tutor) plan, observe and evaluate a series of lessons. We would recommend that all countries should base their training around University Practice Schools, and for these UPSs to be used both for trainees' first observations of expert teachers and for trainees' first school practice. We are also convinced that trainees working in groups of four or six gain far more than in single placements as they provide constant opportunities for collaboration and observing and reflecting on mathematics teaching from other trainees and expert teachers. Their final practice could be in a normal school, either on their own or in pairs. Hence we recommend:

> Use lesson study as the main concept for school-based work, where trainees cannot only teach and gain from peer and mentor review but also gain much from observing and reflecting on their peers' teaching.

Assessment also shows great variation, with some countries marking each lesson with scores of 1, 2, 3, 4 with 4 the failed grade, and completing their training with an examination lesson. It has to be noted, though, that with this type of training model, most inadequate trainee teachers realise their weaknesses and withdraw from the course rather than be failed.

At the other extreme, in England there is a criterion-based methodology but this degenerates to a tick box mentality. What we recommend is to take the best from each model:

> Use about five or six overarching criteria for effective teaching, which are continuously assessed throughout the school-based work with regular and consistent feedback.

3.5 Role of university tutors

Yet again there is great variation in practice across countries. In England, for example, the university tutor's role is mostly focused on quality control of the schools being used for school practice. Other consultants are also often employed to undertake the quality control of school-based work. In Hungary though, there are joint university/UPS appointments and the university tutors teach regularly in school.

It will come as no surprise that we see this second approach in which the university tutor has a crucial role, both in university sessions and in school-based work, as an effective way forward. This ensures that the tutors themselves can remain expert teachers and continue to practise and enhance their teaching skills, with opportunities to innovate and evaluate innovations.

Too often, university tutors in teacher training can become remote from schools and the issues in classrooms if they are not in constant and regular contact with schools. Just observing their trainee teachers is not sufficient; they need to be teaching or innovating and still, in some way, working with the learners in school. You need to contrast this with the medical profession in which the consultants in charge of training, are still in the front line with patient care etc. So, we recommend:

> University Practice Schools should be used for university tutors to teach on a regular basis, put on demonstration lessons for their trainees and work collaboratively with school staff, innovating and experimenting to enhance teaching and learning.

3.6 Support for newly qualified teachers (NQTs)

Getting through a teacher-training course is in itself a daunting task but this is relatively easy compared to experiences in the first year of teaching. Again it is no surprise (see the country reports) that the support given varies enormously – not just across countries but also within countries.

Some countries ensure that newly qualified teachers are given help and support from school mentors, the training university, and the local education authority and, for example, have a significantly reduced timetable of teaching in their first year. But this is far from the norm and many NQTs were critical of the lack of support given and were just left to 'sink or swim'. Indeed the poor retention rate in some countries, notably England, can at least in part be blamed on the lack of suitable support in school. Hence our recommendation is:

> NQTs should have a significantly reduced timetable, enabling them to have time for lesson preparation, reflection, working with expert teachers (through a lesson study model) and with university staff on practical work contributing to modules in a Master's Degree; this should continue for at least three years, with a gradual increase in teaching time.

4. Final remarks

"...mathematics is such a key subject for education in all countries in this increasingly technological world..."

This is the final report for this CfBT-funded research into mathematics teacher training. We hope that we have provided interesting and relevant data and recommendations to help not just the participating countries, but other countries who seek to improve their model of teacher training in mathematics. You will see from the country reports that this project has raised awareness of the issues in many of the participating countries and we hope that our collective conclusions can be of help in finding more effective ways of training future teachers.

Much of what we have concluded is not mathematics-specific but mathematics is such a key subject for education in all countries in this increasingly technological world that we make no apology for stressing this subject.

Finally, as project director, it has been a real pleasure to work with this international team, who have worked long and hard with no financial reward. I am sure I speak for all my colleagues in saying that our motivation comes from working collaboratively together to help improve teacher training in mathematics.

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