RESEARCH PAPER

International comparative study in mathematics teacher training

Recommendations for initial teacher training in England

Professor David Burghes

CfBT Education Trust

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Since we were founded, we have worked in more than 40 countries around the world. Our work involves teacher and leadership training, curriculum design and school improvement services. The majority of staff provide services direct to learners: in nurseries, schools and academies; through projects for excluded pupils; in young offender institutions and in advice and guidance centres for young people.

We have worked successfully to implement reform programmes for governments throughout the world. Government clients in the UK include the Department for Education (DfE), the Office for Standards in Education, Children's Services and Skills (Ofsted), and local authorities. Internationally, we work with educational ministries in Dubai, Abu Dhabi and Singapore among many others.

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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 on the CIMT website: **http://www.cimt.plymouth.ac.uk**

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About the authors

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David Burghes has been Professor of Mathematics Education at the University of Plymouth in the UK since 2005.

He was previously Professor of Education at the University of Exeter, where he founded the **Centre for Innovation in Mathematics Teaching**. The Centre was set up to provide help and support to mathematics teachers around the world through research, development, evaluation and dissemination of good practice in mathematics teaching and learning.

He has directed three international longitudinal comparative projects concerned with making recommendations for enhancing the teaching and learning of primary and secondary mathematics and the teacher training of mathematics teachers.

He is passionate about enhancing mathematics teaching for all pupils and students, whatever their ability, and sees mathematics as a lively, relevant and interesting topic to study at all levels.

Russell Geach
Centre for Innovation in Mathematics Teaching (CIMT), University of Plymouth

Russell Geach has been a research officer in CIMT for more than six years; he was appointed web master four years ago and undertakes the data analysis for projects at CIMT.

As well as being a trained teacher, he has developed the skills to produce online interactive resources for mathematics and much of the recent innovative work on the CIMT website has been due to him. He is currently working with both Ukrainian and Hungarian programmers on enhancements to the website.

Acknowledgements

This report is based on the participation of the named countries and crucially on the work of our country co-ordinators and the participating trainee teachers. We are grateful for the time and effort made by the co-ordinators, who were often required to translate and reproduce the audits and questionnaires in their native language as well as to encourage trainee teachers to participate in the project at a time often of great stress for them. We hope that we will be able to use the data and information wisely to help improve and enhance teacher training in the participating countries.

We are also grateful for the contributions made by our colleagues, Margaret Roddick and Rob Smith, in the early stages of this project; the success of the methodology owes much to their tenacity and persistence as we were translating the proposed project into reality.

We are also grateful to our teacher trainers in England who helped us to achieve the goal of obtaining good size samples and contributed to our discussions on the issues in mathematics teacher training.

Finally, we are very grateful to CfBT Education Trust for providing us with the opportunity to undertake this important and relevant research.

About the international comparative study in mathematics teacher training

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 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)
- Enhancing the training of teachers of mathematics: Full report (2011)
- Enhancing the training of teachers of mathematics: Report synthesis (2011) – available in English and Arabic
- Appendix documentation: audits and mark schemes, and responses on each question

Section 1: Introduction to project (ICSMTT)

“The methodology used for teacher training is very different in countries around the world but we are determined to pick out what we can all agree to be good practice, whatever the context and culture.”

Aims

The aim of this proposed research, funded by CfBT, is to seek an understanding of **good practice** in the training of (primary and secondary) teachers of mathematics in a variety of countries around the world and, using the longitudinal study, provide recommendations for effective training.

We have used the words ‘good practice’ as we recognise that teacher training is subject to a great deal of variation both inside and between countries. The methodology used for teacher training is very different in countries around the world but we are determined to pick out what we can all agree to be good practice, whatever the context and culture.

Methodology

We will provide the evidence to meet the research aim above by implementing a two-year longitudinal research study, for which we have selected a sample of trainees on each of the main routes into teaching.

We have sampled and tracked about 200 trainee teachers in each of a number of countries (in both the primary and secondary sectors) in their last year of training and have selected, where appropriate, different training routes and different locations in each country for an in-depth study. The total number of trainees in all the countries that participated was about 1,400.

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 all 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 on our project website at: **http://www.cimt.plymouth.ac.uk/icsmtt**

You will not be able to use the online audits and questionnaires but you will be able to see the non-interactive versions. These will also be reprinted in the appendices to this report (these are published as a separate document and available at **www.cfbt.com/evidenceforeduction**).

In England, nearly all of our sample used the online versions but in non-English speaking countries, the information was collected from paper-based audits and questionnaires and the data was input for comparative analysis.

We have also observed a significant proportion (about 10% for England) 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.

We will also have some evidence on the retention rate of trainees into their first year of teaching and, in particular, evidence as to what is the most effective support given to new teachers to improve their retention rate. This will be reported on in the final report of the project.

The information from all countries was processed at CIMT. This was followed by a meeting of tutors of trainees in the English sample and then a meeting of project co-ordinators from all the countries, with a view to obtaining agreement on what constitutes (and under what conditions) good practice for the training of teachers of mathematics in both the primary and secondary sectors.

This report details the recommendations for good practice. These recommendations have been discussed and agreed in principle with the international co-ordinators but CIMT is ultimately responsible for both the data analysis and the interpretation of the available data. This report also focuses on the implications of these recommendations for **England**.

The first year of the project was 2007/08, following the cohort that had started their last year of training in September 2007. (For PGCE trainees, this is of course the only year of their training.) We have followed some of this sample through to their first year of teaching in 2008/09.

Section 2: Participating countries

"These countries were chosen either on account of their strong track record in mathematics or because they exhibit interesting and relevant practice."

The participating countries were:

England	Russia
Ireland	China
Finland	Japan
Hungary	Singapore
Czech Republic	

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.

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.

The first meeting of the international co-ordinators took place at the beginning of May 2007; agreement was sought on the format and content of the audits and questionnaires. 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 took place late in 2009. We will be providing, in the final report, more information from the participating countries and recommendations for support of Newly Qualified Teachers (NQTs) in their first year of teaching.

Section 3: Issues considered

"The lack of progress is certainly not helped by having, in the primary sector, many teachers who are not as well qualified in mathematics as those in other countries…"

Mathematics education continues to be an area of concern to the UK and indeed other countries. Despite numerous projects and initiatives in the UK, including the Government's National Numeracy Strategy and a similar Secondary Strategy, the mathematical progress of children and students is not matching that of our economic competitors. There is some evidence of advancement,[1] but many are more dubious about progress.[2]

The lack of progress is certainly not helped by having, in the primary sector, many teachers who are not as well qualified in mathematics as those in other countries, whilst in the secondary sector, we have suffered and continue to suffer from a very transient workforce. This is illustrated by the fact that in a six-year period, we train a completely new cohort of secondary mathematics teachers!

So although attracting creative and talented new entrants to the profession is important, it is equally important that the retention rate of competent new teachers is improved. Research evidence from a number of countries highlights the fact that it takes about five years for a teacher to reach their potential in the classroom, yet the majority of our secondary mathematics teachers have left the profession well before that time.

In the **first year** of this project, we aimed to gain insight into:

- initial level of mathematical skills and understanding
- attitudes to mathematics and its teaching
- length of training and level of award
- balance between theory and practice in training
- school-based work and its assessment
- role of the university tutor.

We report in **Sections 5** and **6** on our main findings related to these issues and we make recommendations for good practice that relates to these areas of interest.

In the **second year** of this project, we aimed to gain insight into:

- support and help given to newly qualified teachers
- retention rate of creative and talented teachers.

We report on our findings and recommendations in these areas of interest in our final report.

[1] Managing NLS/NNS Intervention Programme at: **http://nationalstrategies.standards.dcsf.gov.uk/node/85339**
[2] Cambridge Primary Review at: **http://www.primaryreview.org.uk**

Section 4: Data analysis (primary and secondary)

> *"What is more important even than the extent of knowledge or competence is that the mathematics is understood in depth."*

In this section, we will summarise the main data set for the audits. We do have other interesting data but it is more applicable to the individual country reports, which are presented in the final report of this project. The interpretation of the more qualitative data across countries is less consistent than that of the audits, where we can be reassured that, even with translations, the questions have an identical meaning. Indeed, most of the audit questions are straightforward and unambiguous and are entirely consistent after translation. So we do think that we are comparing like with like in these questions.

The audits undoubtably 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 translated into a number of languages. There is much debate about subject knowledge for effective teaching (see for example, Triosh and Even,[3] Steinbring[4]) whilst the Williams Review[5] states:

> *'What is more important even than the extent of knowledge or competence is that the mathematics is understood in depth.'*

Here we have gone for simplicity rather than complexity, for the sake of consistency and reliability.

We also need to be aware that the samples, although in all cases 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 participating, there is also the issue of ethics and, for example, in England, all participants were volunteers and could walk away from the project at any time. For England, we do not think that for our secondary sample that this made much difference and most students who were asked did indeed participate. There were though more concerns about the primary sample, where many volunteered and later, or after looking at the online audits, decided not to participate. This resulted in our sample having about 30% specialising in mathematics (and likely to have A Level mathematics qualification or its equivalent) and this is more than the national figure (thought to be about 10%), so we do need to treat the results with caution. Nevertheless they do provide an interesting comparison 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 that both samples undertook. The structure of the audits was:

Primary

Part A: 40 marks on relatively straightforward skills and knowledge questions

Part B: 20 marks on mathematical concepts and understanding

Secondary

Part A: This is identical to Part B on the primary audit

Part B: 20 marks on more advanced mathematical topics

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 appeared that the participants had in nearly all cases completed all that they could do within the hour.

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[3] Tirosh, D. & Even, R. *Teachers' Knowledge of Students' Mathematical Learning: An Examination of a Commonly Held Assumption* Part of the Cambridge Seminar Series, 2007–08 at: **http://www.maths-ed.org.uk/mkit/Tirosh%20Nuffield%20Jan%202007.pdf**

[4] Steinbring, H. *Changed Views on Mathematical Knowledge in the Course of Didactical Theory Development – Independent Corpus of Scientific Knowledge or Result of Social Constructions?* Contribution to the Cambridge Seminar Series, 2007–08 at: **http://www.maths-ed.org.uk/mkit/Steinbring%20Nuffield%20Jan%202007.pdf**

[5] Williams, P. *Independent Review of Mathematics Teaching in Early Years Settings and Primary Schools: Final Report* (2008) at: **http://publications.teachernet.gov.uk/eOrderingDownload/Williams%20Mathematics.pdf**

"...performance on the component Parts A and B are given in Charts 2 and 3. What is clear from the bar charts is that the distribution between the countries is very similar despite the different types of questions on each part."

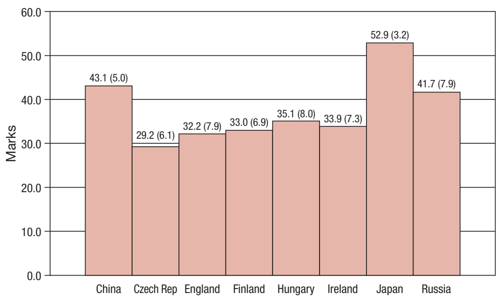
The audits, together with the mark schemes, are given in full in **Appendix 1** for primary and **Appendix 2** for secondary.

The responses on each question are also given in full in **Appendix 3** (primary) and **Appendix 4** (secondary) and we comment on some specific questions on the following pages. Teacher trainers who might like to use our audits with their trainees can copy the audits as a paper copy but please contact CIMT if you would like to use the online version (it is freely available).

Primary audit data

The easiest way to give a quick overview of the responses is to look at the bar chart for the participating countries. This is given below in Chart 1.

Chart 1: Primary Audit Means



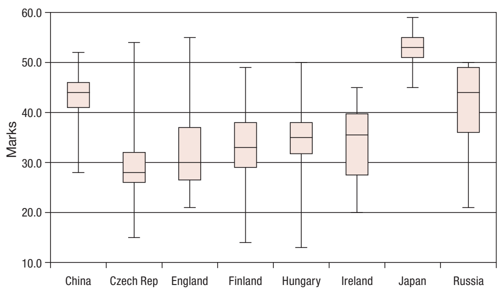
The two figures at the top of each column give the mean score for each country sample and the standard deviation of those scores. For example, the **China** sample has a mean score of 43.1 and standard deviation of 5.0 whereas **England** has a mean score of 32.2 and standard deviation of 7.9.

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.
- **England** has a similar performance to **Czech Republic**, **Hungary**, **Finland** and **Ireland.**
- **England** has a relatively high standard of deviation compared to **China**, **Ireland** and **Russia**, showing the wide variation in performance between the participating trainee teachers in our sample.

The box and whisker plots for this data show these trends with clarity. This is shown in Figure 1.

Figure 1: Country Primary Results



From this data, but noting the caveats given earlier, we can at least conclude that **England** is not out of line with some of the other countries but is significantly outperformed by **Japan**, **Russia** and **China**.

The bar chart (Chart 1) and box and whisker plots (Figure 1) are for the full primary audit; performance on the component Parts A and B are given in Charts 2 and 3. What is clear from the bar charts is that the distribution between the countries is very similar despite the different types of questions on each part.

Chart 2: Primary Audit Means – Part A

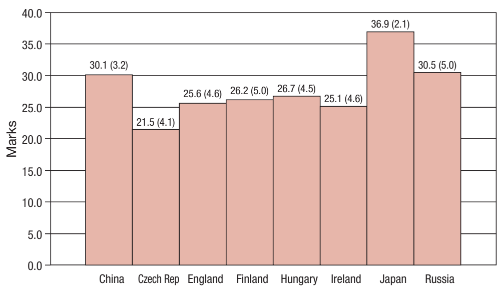


Chart 3: Primary Audit Means – Part B

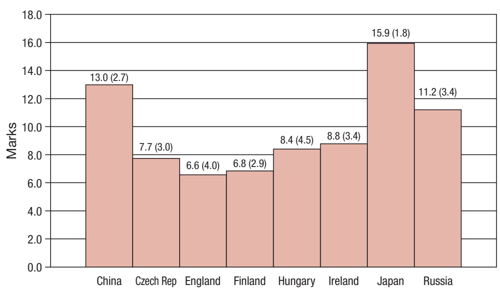


Table 1: Primary Audit Means – Part A questions								
Country	**China**	**Czech Rep**	**England**	**Finland**	**Hungary**	**Ireland**	**Japan**	**Russia**
What is the value of 2^5?	90.0	50.0	50.0	84.7	93.8	68.2	92.0	92.5
What is the lowest common multiple of 40 and 140?	83.8	51.1	20.0	1.5	58.3	36.4	90.7	77.4
Simplify as far as possible $8x + 3y - x + 3y$	97.5	55.4	70.0	80.2	97.9	81.8	100	96.2

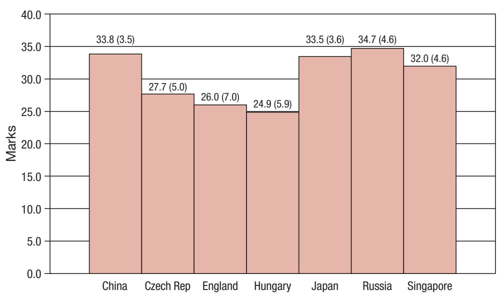
Table 2: Primary Audit Means – Part B questions								
Country	**China**	**Czech Rep**	**England**	**Finland**	**Hungary**	**Ireland**	**Japan**	**Russia**
Factorise $x^2 - 7x + 12$	73.8	27.2	46.7	6.1	20.8	54.5	98.7	79.2
A bag contains 5 red, 4 blue and 3 white counters. Counters are taken out in succession and not replaced. What is the probability of obtaining two red counters for your first two choices?	23.8	34.8	16.7	12.2	0.0	22.7	85.3	37.7
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?	0.0	39.1	23.3	13.7	56.3	18.2	1.9	3.8
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?	61.5	20.7	26.7	67.2	20.8	54.5	85.3	41.5

Whilst detailed responses to questions are given in Appendix 3, we have summarised the results for a number of the questions in Table 1 and Table 2 above.

Secondary Audit Data

The overall data for the participating countries is given in Chart 4 below.

Chart 4: Secondary Audit Means



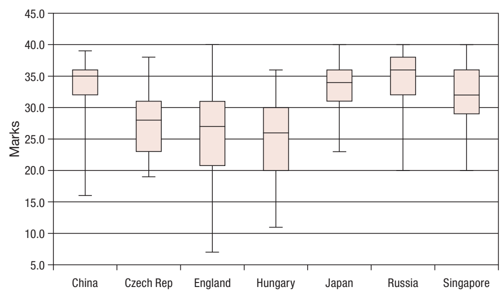
Again the overall trends are clear, namely:

- **China**, **Japan**, **Russia** and **Singapore** outperform the other three countries.
- There is little difference between the performance of **Czech Republic**, **England** and **Hungary**.
- **England** has the highest standard deviation of all the participating countries, showing that we have great variation in our sample; perhaps as expected, **China** has the smallest variation.

These trends are obvious from the box and whisker plots for this data. This is shown in Figure 2 below.

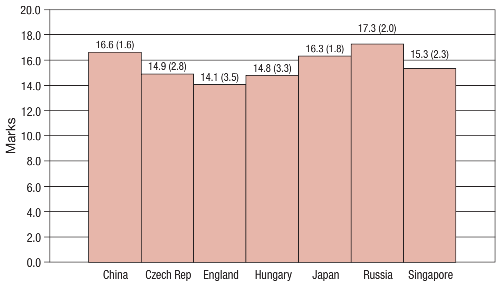
Again, we can be reassured that **England** is not disgraced here, although it could clearly do much better. It should also be noted that the Hungarian sample does include some potential middle school teachers rather than all secondary, so this might explain their surprisingly low performance.

Figure 2: Country Secondary Results



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 (Chart 5) the mean scores of the countries are closely bunched. These are the responses to the relatively straightforward questions on concepts that were also taken by the primary participants. You would expect the secondary trainees to do well on this part of the audit.

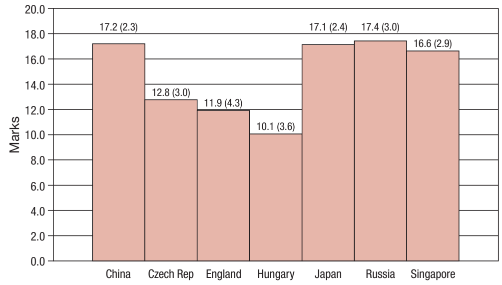
Chart 5: Secondary Audit Means – Part A



On Part B (Chart 6), the more advanced mathematical questions, there are more significant differences with **China**, **Japan**, **Russia** and **Singapore** all performing far more strongly than **England**, **Czech Republic** and **Hungary**. It is important to note this characteristic and we have summarised below the responses to some of these questions that indicate the weakness of the **England** sample.

Particular question responses from Part A and Part B questions are given in Table 3 below and Table 4 on page 13.

Chart 6: Secondary Audit Means – Part B



The format of the audits also gave us a chance to compare primary and secondary performance for all samples. The results are summarised in Chart 7.

Chart 7 is for the complete samples (i.e. all countries) for primary and secondary trainees and only summarises what we would expect to happen; that is, there is a significant difference between the primary and secondary performances on these common questions.

Chart 7: Primary v Secondary on common questions

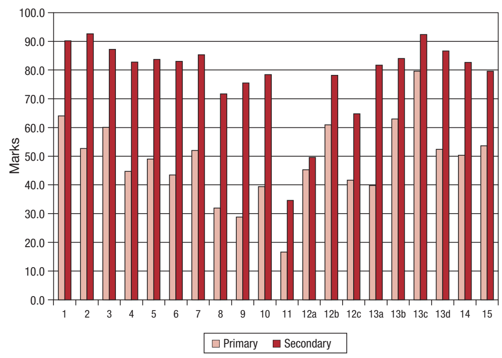


Table 3: Secondary Audit Means – Part A questions							
Country	**China**	**Czech Rep**	**England**	**Hungary**	**Japan**	**Russia**	**Singapore**
Factorise $x^2 - 7x + 12$	97.5	71.4	83.3	57.6	98.6	51.6	97.2
A bag contains 5 red, 4 blue and 3 white counters. Counters are taken out in succession and not replaced. What is the probability of obtaining two red counters for your first two choices?	78.3	80.2	74.1	24.7	88.5	70.3	85.1
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?	43.5	69.0	25.9	43.5	13.4	52.7	19.1
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?	28.3	71.4	62.0	87.1	68.9	84.6	52.5

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The results are in fact more interesting country by country and these are produced for the seven countries that participated in both the primary and secondary projects.

Table 4: Secondary Audit Means – Part B questions

Country	China	Czech Rep	England	Hungary	Japan	Russia	Singapore
If $x^2 + 6x - 3 = (x + a)^2 + b$ calculate the values of *a* and *b*.	97.5	71.4	83.3	57.6	98.6	51.6	97.2
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	100	77.8	61.1	52.9	84.2	83.5	87.2
How many solutions does the equation below have in the interval? $0 \leq \theta \leq 360°$? $8 = 2 + 5\sin 3\theta$	66.3	52.4	27.8	9.4	68.9	57.1	54.6
Difference ln$(2x)$ with respect to x	98.9	54.8	60.2	16.5	78.0	82.4	80.9

The question that has an almost similar performance was Question 12(a), namely:

Mark the statement 'Quadrilaterals tessellate' as

A: always true

B: sometimes true

C: never true

This though is partly due to only a small percentage of trainees getting this correct.

The results are in fact more interesting country by country and these are produced below for the seven countries that participated in both the primary and secondary projects (see Figures 3 to 8).

Russia is much what you would expect with the secondary data significantly higher than the primary data. The maximum score is 20 and it is clear that most of the secondary trainees scored highly on these common questions (see Figure 3 below).

Japan is quite unique with very little difference between the two plots and very little variation between the trainees' ability compared with other countries (see Figure 4 below).

Hungary is much as expected with significant differences between primary and secondary cohorts in the project (see Figure 5 on page 14).

For England (see Figure 6 on page 14), this is what you might expect although there are

Figure 3: Russia Primary v Secondary comparison on common questions

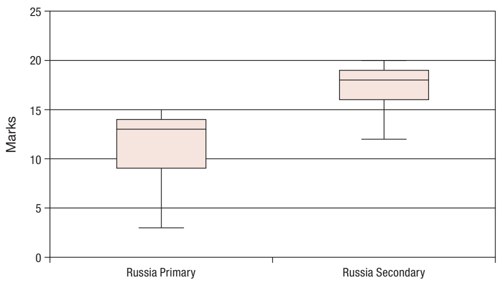


Figure 4: Japan Primary v Secondary comparison on common questions

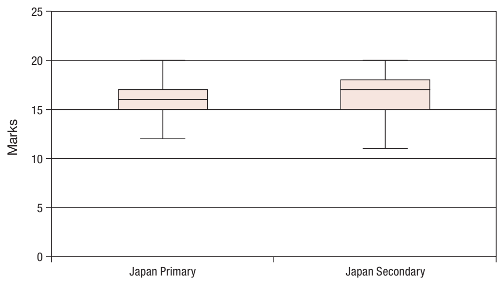


Figure 5: Hungary Primary v Secondary comparison on common questions

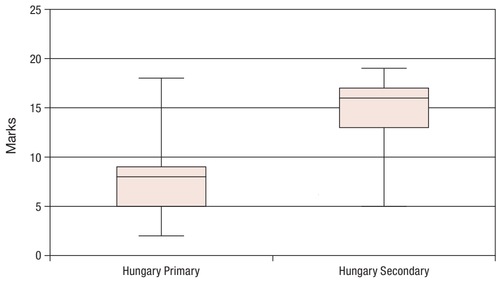


Figure 7: Czech Republic Primary v Secondary comparison on common questions

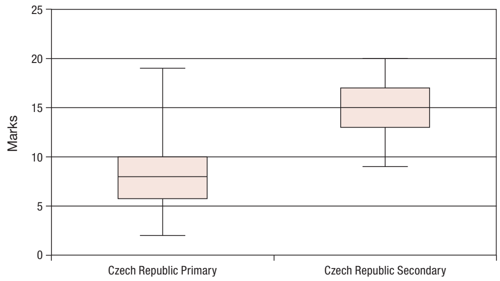


Figure 6: England Primary v Secondary comparison on common questions

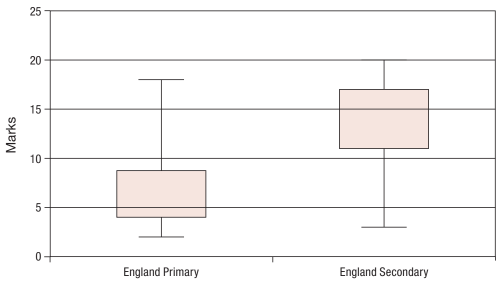
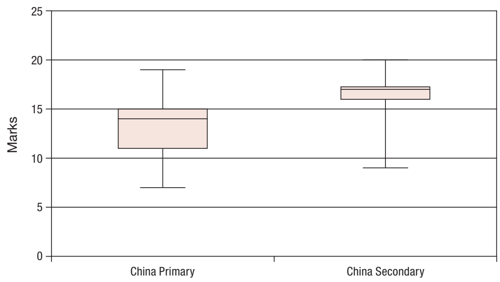


Figure 8: China Primary v Secondary comparison on common questions



clearly a minority of talented mathematicians entering primary teaching but with a very long tail for the secondary trainees.

No surprises for the Czech Republic (see Figure 7) with a contrasting performance between primary and secondary cohorts. This is more akin to Japan but with slightly more variation and with the primary cohort not achieving as highly as the secondary cohort (see Figure 8).

Section 5: Attitude questionnaire

> *"Clearly the expectation does not match up to the reality that the modal length of time is about three to four years in mathematics teaching."*

Not all country samples completed the attitude questionnaire so we only give here the results for the **England** secondary sample, see Chart 8 below. They do make interesting reading with useful pointers to how teacher trainers should enhance their courses.

In this question, we asked the trainees what they thought were the most important attributes for an effective mathematics teacher. The modal attribute was *Explains Clearly* and this has been also found in surveys that we have undertaken with younger pupils (age 12 and 13).

We also asked the trainees what topics they most feared. We were surprised at first with this data as *Geometry* and *Statistics* were the most popular choices rather than *Algebra*, which most seemed confident with. This might be because the mathematics taken in their degree had emphasised algebraic topics rather than geometric concepts but their lack of confidence with statistics was harder to explain, see Chart 9.

We also asked the trainees to give the main concerns about mathematics teaching that they hoped would be addressed by their training course and, perhaps not surprisingly, the highest concern, *classroom management*, was generic and not specific to mathematics, see Chart 10.

We also asked our sample how long they expected to be in the profession. We were amazed that *Working Life* was by far the most popular choice. Clearly the expectation does not match up to the reality that the modal length of time is about three to four years in mathematics teaching. It does though show that the trainees are mostly dedicated to teaching and have high expectations of the contributions that they expect to make, although the reality is that most of them will not be in teaching after a few years. This does lead us to question what happens to these trainees over the next few years which results in such a poor retention rate in English schools, see Chart 11.

Chart 8: Attributes of an effective Mathematics Teacher

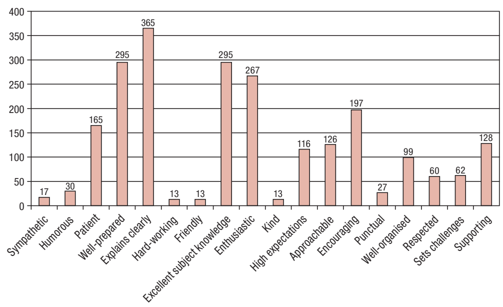


Chart 10: Trainees' main concerns about maths teaching that they hope will be addressed by their training course

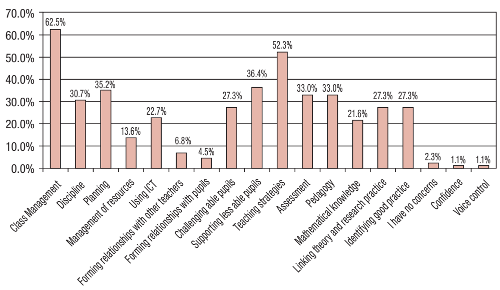


Chart 9: Topics in which trainees did not feel confident

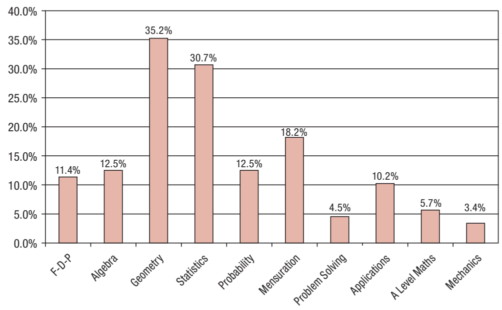
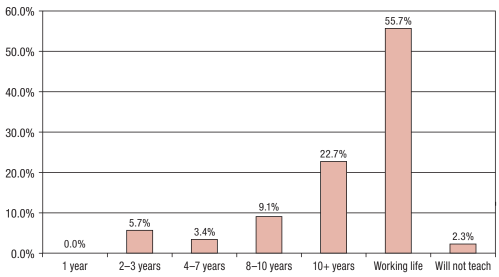


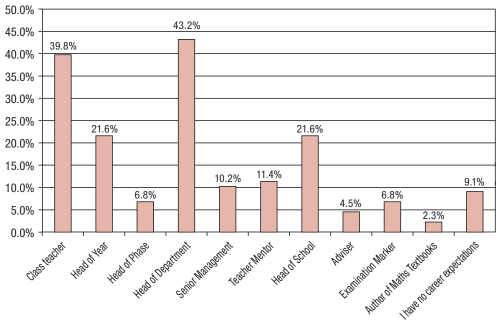
Chart 11: Length of time trainees expect to remain in teaching



“… about 40% have no thoughts of advancement beyond class teacher but just over 40% have aspirations to become a head of department…”

Finally we present the results for their future career aspirations, where about 40% have no thoughts of advancement beyond class teacher but just over 40% have aspirations to become a head of department, see Chart 12.

Chart 12: Trainees’ future career aspirations



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Section 6: Recommendations for initial teacher training

"A prerequisite 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."

We will be making recommendations, based on the international evidence, in seven overlapping interest areas; these are not country-specific but are what we consider to be good practice in these areas.

A: 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 have been central to a particular country's mathematical curriculum. Having said this, the questions were agreed by all participating co-ordinators.

Primary audit

The results show the success of Japan, China and Russia in both parts of the audit. These countries had particular success compared with the others in Part A of the audit, the component that was regarded as easier, with questions on basic skills and knowledge. The outcomes for other countries were closer for the questions in Part B (these are the questions shared between the primary and secondary audits).

England, Finland, Czech Republic and Hungary had similar performance profiles, although having a number of mathematics specialists in its sample might have influenced the English outcome. The concept of mathematics specialists does not exist in the other countries. Nevertheless, we should be pleased that our sample indicates that there is not much difference between England and the second tier of countries.

Secondary audit

There are very similar results here, except that the first tier of countries now includes Singapore alongside Japan, China and Russia but there is little difference between the second tier countries, Czech Republic, England and Hungary.

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

A prerequisite 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.

B: Length of training and level of award

The Bologna Declaration[6] for a three (Undergraduate) plus two (Master's level) year course is having an impact on all countries. 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).

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[6] http://www.magna-charta.org/pdf/BOLOGNA_DECLARATION.pdf

"Use University Practice Schools in the training model to integrate theory and practice."

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 PGCE (or integrated four-year course); PLUS***
>
> ***Part-time study on first school post (but with release time) at Master's level, with the intention of completing the degree within four to five years, and with enhanced pay for each module completed successfully.***

C: Balance between theory and practice

This was one area that alarmed us, as many of the English trainee teachers interviewed stated that they considered there to be a lack of relevance between the theoretical studies undertaken (and read about) 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).

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

- teacher trainees' first observations of expert teachers
- first teaching block (with trainee teachers working in groups of four or six)
- 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
- 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 for the training of doctors and nurses.

The Oxford model of internship,[7] does move in this direction with a much closer relationship between university tutor and school mentor but does not go as far as the UPS concept, where the university tutor has a definite role in the UPS and observations are made in groups of four or six trainees.

So our recommendation is:

> ***Use University Practice Schools in the training model to integrate theory and practice.***

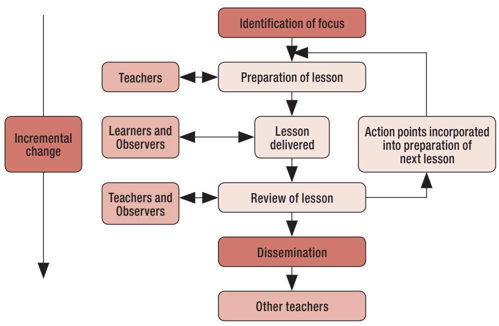
We will consider this again in the next section.

D: 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.

These 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. Each student takes their turn to give the lesson. This is the model underpinning the way in which University Practice Schools operate and is illustrated in Figure 9.

Figure 9: Model underpinning the way in which University Practice Schools operate



[7] Haggarty, L. (1995) *New Ideas for Teacher Education,* Cassell

“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.”

We are keen for more University Practice Schools, particularly for countries that have none, and for these UPSs to be used both for trainees' first observations of expert teachers and for trainees' first school practice. We were also convinced that trainees working in groups of four or six gain far more than in conventional placements as they have 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:

Use lesson study as the main concept for school-based work, where trainees cannot only teach and gain from peers 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 most inadequate trainee teachers realise their weaknesses and withdraw from the course rather than be failed.

At the other extreme, in England we have a criterion-based methodology but this degenerates to a tick box (about 45 boxes!) mentality and we have seen special lessons put on in order to achieve particular box or boxes to be ticked.

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.

E: 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 teacher training. 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 tutor teaches 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 a good 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.

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.

Section 7: Implications for England

"The first conclusion from these results for England is that (as with other recent international comparisons) we are not disgraced and are comparable to many other countries."

A: Mathematical ability of trainees

The first conclusion from these results for **England** is that (as with other recent international comparisons) we are not disgraced and are comparable to many other countries. It is true though that countries such as Japan, China, Singapore and Russia do outperform us in areas of mathematical skills and concept knowledge, so we should not be complacent.

Primary

Here perhaps the results rather exaggerate our true position, as a significant proportion of our sample were in fact mathematics specialists. It is a positive attribute that we do have trainee teachers entering the profession with a reasonably good grasp of mathematics. It is also true though that there is great variation in our sample compared to, for example, Japan, China and Russia.

Entrants from these countries have taken the equivalent of A Level mathematics in school before entering teacher training. We would very much like to see a higher mathematical entry hurdle to the profession in England. It is currently GCSE Grade C or equivalent and, from our audit results, it is clear that the Grade C entry trainees do in fact bring our scores down significantly.

In the short-term, we would propose raising the entry level to that of Grade B at GCSE; in the longer term, our recommendation would be to provide a dedicated AS Level award focused on mathematical concepts and applications, for intending primary teachers. A proposed syllabus is given in **Appendix 6**.

Secondary

We have similar comments here; we have a longish tail of mathematical ability but there are already a number of initiatives designed to alleviate this. We would support the **Mathematics Enhancement Courses (MEC)** that have become common practice in many institutions and would recommend their extension in a number of ways. It should be noted that in our interviews with tutors and mentors, there was a strong bias to those who were previously MEC students. They showed greater understanding both of the mathematics needed in teaching and the pedagogical skills required to become an effective teacher.

Our recommendation would be that ALL PGCE students first undertake a two- or three-month MEC course (some, as now, would require a longer course). The MEC course would focus on giving them both the expertise they need in school mathematics topics and also some of the pedagogical skills that underpin effective mathematics teaching.

B: Length of training and level of award

The international recommendations are not too far away from the practice that is developing here; we do though feel it is important that all mathematics teachers continue to be supported through the modules required for a Master's degree: this would necessitate a reduced timetable for at least three years.

C: Balance between theory and practice

Here our recommendations would require substantial changes; the establishment of University Practice Schools would be a significant change to current policy, not least as this would be across *all* subjects.

We are completely convinced that for the whole profession, this is the way forward. Not only would school practical work and university theoretical work be embedded in each other, but also, university tutors would be required to continue to teach (see below). It would raise the status of teaching to that of an all-graduate profession and achieve the desirable aim of linking theory and practice throughout training.

D: School-based work and assessment

The issue that most dominated our discussions with trainee teachers was the great variation in support given to them in partner schools. Almost all the interviewed

"Our university tutors are so isolated now that within a couple of years of appointment, not only have they lost many of their practical teaching skills but they have also lost touch with the real issues in schools…"

sample referred to this issue and to the fact that it was a real problem, even to the extent that it could damage their chances of becoming a teacher at all.

The concept of University Practice Schools, working with each provider, would at least ensure less variation, both in terms of the initial observations and the first school-based practice. It would also ensure that there would be peer support in the first practice; many of the trainees felt particularly isolated in their first teaching practice.

We would very much support the recommendation that the establishment of University Practice Schools in England would be the most important decision that could be made for taking the profession forward in the next decade and beyond.

E: Role of university tutors

Our university tutors are so isolated now that within a couple of years of appointment, not only have they lost many of their practical teaching skills but they have also lost touch with the real issues in schools and essentially become administrators in charge of quality control in their partner schools. This is unfortunate. However, the establishment of University Practice Schools would provide tutors with an appropriate role for their skills; most are clearly dedicated teachers and trainers but they need to be in school and not isolated in academia.

This is another reason for the establishment of a system of UPSs, attached to each provider. The UPSs would also provide a ready-made environment for research and development and they would also become the hubs for CPD support in the regions.

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Further research

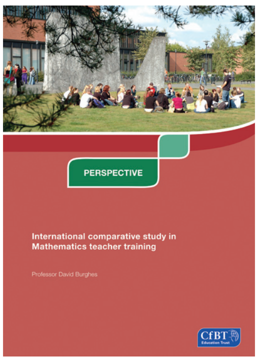
Through the Evidence for Education programme, CfBT Education Trust is proud to reinvest its surpluses in research and development both in the UK and overseas.

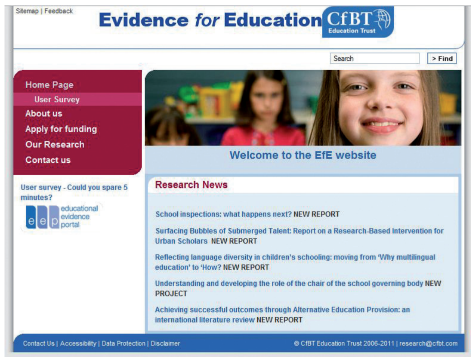
Our aim is to provide direct impact on beneficiaries, via educational practitioners and policy makers. We provide a range of publications from practice-based intervention studies to policy forming perspective papers, literature reviews and guidance materials.

In addition to this publication the following research may also be of interest:

- **International comparative study in mathematics teacher training (2008)**
  An introductory report which outlines the teacher training systems for each of the countries participating in the International comparative study in mathematics teacher training.The report describes the training regime for both primary and secondary teachers and highlights the strengths and weaknesses of each system.
- **Enhancing the training of teachers of mathematics: Full report (2011)**
  The final report of the International comparative study in mathematics teacher training. The report analyses data from the primary audit, the secondary audit and the attitude questionnaire from all the countries involved in the study. It also describes the training regime for both primary and secondary teachers and discusses each country's data in detail.
- **Enhancing the training of teachers of mathematics: Report synthesis (2011) – available in English and Arabic**
  A synthesis of the final report of the International comparative study in mathematics teacher training. The report summarises the data from the primary audit, the secondary audit and the attitude questionnaire from all the countries involved in the study.
- **Appendix documentation: audits and mark schemes, and responses on each question**
  Additional documentation available for free download from **www.cfbt.com/evidenceforeducation**

For further information or for copies of the above research please visit our website at **www.cfbt.com/evidenceforeducation** or contact our Research Team at **research@cfbt.com**





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