RESEARCH PAPER

International comparative study in mathematics teacher training

Enhancing the training of teachers of mathematics

Professor David Burghes

CfBT Education Trust

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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.org.uk**

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We are also grateful to our colleagues Margaret Roddick and Rob Smith for their contributions at the start of the project and to our research officer, Russell Geach, who has both set up the interactive website for the project and completed the data analysis.

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

David Burghes, Project Director.

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About this report

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: Report synthesis (2011) – available in English and Arabic
- 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

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 **Section 3** presents further details of each of the participating countries and their particular issues in mathematics teacher training. Recommendations for good practice in ITT are given in **Section 4**.

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?
- 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 $1\mathrm{n}(2x)$ $1\mathrm{n}(2x)$ 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.

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.

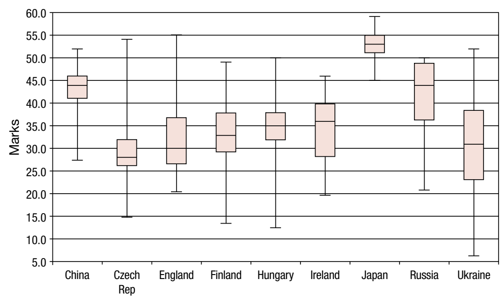
We also provide a comparison between primary and secondary trainees as there were core questions undertaken by both samples; some of the country reports have highlighted this.

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:

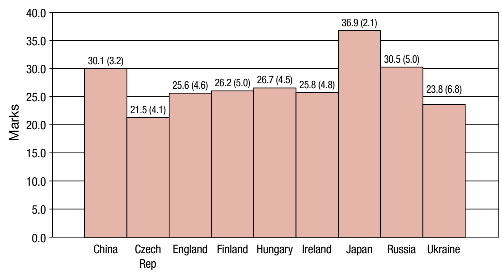
- Japan significantly outperforms all other countries
- China and Russia perform above the average for the participating countries
- the performances of England, Hungary, Finland and Ireland are all similar
- England and Ukraine have a relatively high spread compared to China, Ireland and Russia, showing the wide variation in performance between the participating trainee teachers in the samples.

Figure 1: Country Primary Results



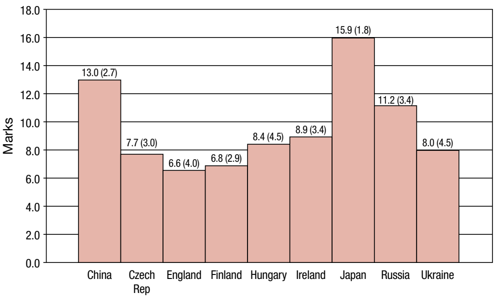
The box and whisker plots (Figure 1 above) are for the full primary audit; performance on the component parts A (Figure 2 below) and B (Figure 3 on page 12) are given in the form of bar charts, based on the mean score and with standard deviations given in brackets. What is clear from the bar charts is 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



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

Figure 3: Primary Audit Part B



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'.*

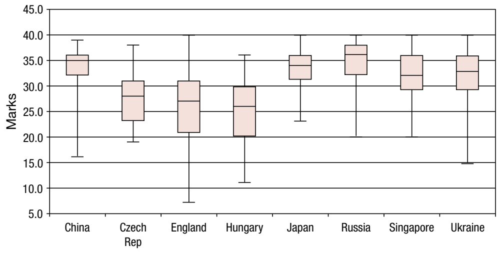
2.2 Secondary audit data[2]

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:

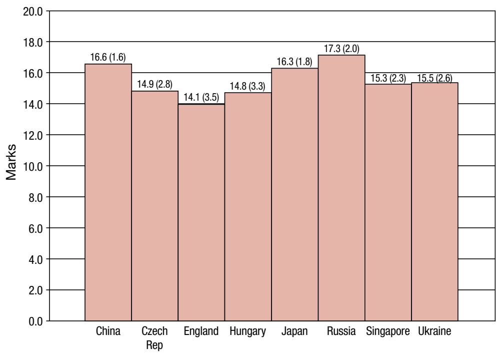
- China, Japan, Russia, and Ukraine outperform the other countries
- There is little difference between the medians and quartiles of Czech Republic, England and Hungary
- England has the highest range of all the participating countries, showing that there is great variation in the sample; perhaps as expected, Japan has the smallest range.

Figure 4: Country Secondary Results



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.

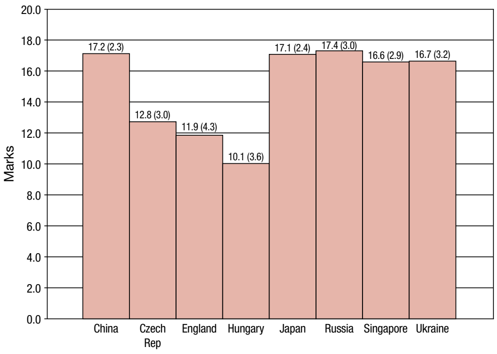
Figure 5: Secondary Audit Means (Part A)



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

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

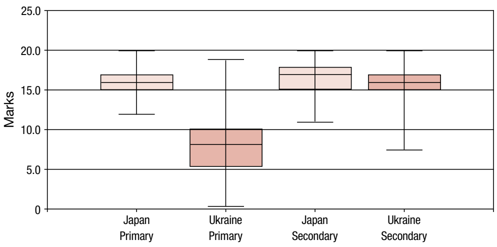
Figure 6: Secondary Audit Means (Part B)



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*

[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. Country reports

After the final meeting of the project co-ordinators, we asked each of them to provide a report on their project implementation, key results and findings and implications for practice in their country. We did give them freedom of expression but asked them to report under the headings:

1. Overview of mathematics teacher training
2. Sample
3. Audit data
4. Attitudes data
5. Continuing professional development
6. Issues

We have edited some of these reports to ensure the report is balanced but we have not edited the comments and personal thoughts.

Social and educational reforms over the past 20 years have had a huge impact on teacher training in China.

3.1 China

(**Professor Yanming Wang**, University of Science and Technology of Suzhou, China)

Overview of mathematics teacher training

Social and educational reforms over the past 20 years have had a huge impact on teacher training in China. Two actions are currently being implemented in teacher training: firstly, to ensure that teachers are suitably qualified and committed to undertake the training of talented personnel for science and technology (considered essential for the country's modernisation), the government decided (1998) to improve teacher training in general; secondly, to provide sufficient teachers for the increasing number of schools resulting from the move (since 1986) to nine-year compulsory education, the government called for the establishment of a highly qualified contingent of primary and secondary school teachers. Investment in teacher training is recognised as being essential to the country's modernisation. Table 2 below summarises some of the main features of ITT courses in China.

Sample

We had a sample size of about 80 teacher trainees in primary and 100 teacher trainees in secondary, taken from two teacher training institutions which belong to two universities. In secondary, we chose the participants from a university of the developed region of China. The university is a comprehensive university and is located in the coastal part of China; the economic environment is quite good there. In primary, we chose the participants from a university of the developing region of China; the most important task of the university is training teachers – primary and secondary. There is a great shortage of primary teachers in China, especially in the rural areas. The participants were in their fourth year (final year) of studying at university and would graduate after one year. I first visited the classes; the teacher trainees had done both the subject knowledge audit and the questionnaires in the appointed time. After these visits I interviewed the trainee teachers. China is a large country and our sample size is very small so the results might not be applicable to the whole country.

Table 2: Summary of some of the main features of ITT courses in China

Entry route	Primary	Junior secondary	Senior secondary
Length of course and qualification	3 or 4-year course leading to Bachelor's Diploma[1] and Certificate of Teacher Training	4-year Bachelor's Diploma/Bachelor's Degree and Certificate of Teacher Training ([2]Bachelor's degree required for senior secondary teaching)	
Entry qualification	Entrance exam for 16+ junior secondary school graduates (including Chinese, Mathematics, English and Physics)	National entrance exam for senior secondary school graduates	
Course components	Compulsory subject and methodology/ pedagogy courses Optional courses (to support local development needs) School-based work Extra-curricular activities	Pedagogy Psychology Educational Technology Mathematics and Applied Mathematics Computer Science Teaching Practice Dissertation	

[1] There are some four-year courses where the trainees are awarded a Bachelor's Degree when they graduate.
[2] Some Master's Degree graduates have recently become senior secondary school teachers in the developed and coastal areas in China.

"From the primary audit, we found that the trainees could do the simple algebra questions very well but were weakest in geometry and statistics."

Audit data

See Table 3 below. From the primary audit, we found that the trainees could do the simple algebra questions very well but were weakest in geometry and statistics.

From the common questions for primary and secondary we found that both groups of trainees had done Q1, Q2, Q3 and Q5 at a similar level; for other questions, the secondary trainees did better than the primary trainees. This indicated that the mathematics level of the secondary trainees was higher than that of the primary trainees.

From the more advanced questions of secondary, we found that the trainees had done well in algebra and simple calculus questions, whereas they found the series and complicated calculus questions more difficult.

Attitudes data

From the list provided of which attributes they regarded as being the key qualities of an effective mathematics teacher, the modal response was to be 'encouraging' with 'explains clearly' and 'excellent subject knowledge' also strongly supported.

We asked which area of mathematics they felt least confident about teaching and 'geometry' was the modal response (as demonstrated by the weaker performance on geometry questions in the audit, particularly for the primary trainees). 'Probability' and 'mensuration' were also mentioned.

Their main concerns about teaching mathematics for the secondary sample were varied but with 'teaching strategies' the most popular choice, whereas for our primary trainees, their modal choice was 'subject knowledge'.

The modal responses to the question 'what is the length of time that you expect to remain in teaching?' was 'working lifetime' with just over 50 per cent of the secondary sample giving this answer and two thirds of the primary sample. It should be noted that over ten per cent of the trainees would not want to teach in the secondary sector.

We interviewed a part of the sample, both primary and secondary trainees. There was some agreement on the responses to our questions and subsequent discussions. Most of the trainee teachers thought their university teacher trainers were very helpful. The primary teacher trainers gave them more support during their training. Trainees enjoyed their time at the university. They found most of the education and mathematics teaching method courses were useful during their teaching practice though they would like more experiences in teaching practice. They mentioned the variability in support from one school to another and from one practice to another. Most of the school teachers, especially the experienced teachers, were willing to give them some support during their practice teaching time; support levels varied in the different schools with some being more supportive than others.

Continuing Professional Development

In China, our government and educational experts have stressed recently more and more the importance of CPD, based on the experiences of other countries. CPD has been provided by the higher education institutes, mainly the universities. There are differences in CPD provision in different parts of the country. Most CPD takes the form of short time training, taking about one month per year. In the developed regions, the state schools pay

Table 3: Audit data – China

	Part A		Part B		Total	
	Mean	**Per cent**	**Mean**	**Per cent**	**Mean**	**Per cent**
Primary	30.1 (out of 40)	75	13.0 (out of 20)	65	43.1 (out of 60)	72
Secondary	16.6 (out of 20)	83	17.2 (out of 20)	86	33.8 (out of 40)	85

"Teachers can choose whether or not to participate in training, but if they want to gain promotion to a higher position, they have to do the training."

the fees, but in rural areas, the schools pay two thirds of the fees and the teachers have to pay the other third. Training usually takes place in school break times, mostly during the summer holidays. Teachers can choose whether or not to participate in training, but if they want to gain promotion to a higher position, they have to do the training. In the developed regions, teachers may undertake three years part time study to gain the Master's degree in education.

Lesson study is in place in most schools as the method of school-based professional development, and the teachers are encouraged to be involved. Usually each teacher has one or two open lessons per term. This is less time than previously as some teachers feel nervous due to the pressure.

Issues

Our main concern is about the teachers of mathematics. We have followed a number of our trainees into their first year of teaching. We call these teachers NQTs (Newly Qualified Teachers). From the research, we note the following points:

The percentage of trainees who actually go into teaching directly after training is about 70 per cent, depending on the teacher training university. The better the training level of the university, the higher the percentage of trainees that go directly into teaching. Most teach in state primary and secondary schools, with some schools being in the countryside. A few are teaching in private schools. Most of the trainees would prefer to teach in city schools, particularly state schools.

We only have the school-based graduate teacher route, and we think this route is, in general, effective. The government has recently introduced some new and positive strategies to support teacher training. For example, trainees get free tuition in some higher universities, with the government then arranging their position in primary and secondary schools. Universities work hard to try to enhance the trainers' teaching quality and professional knowledge. These are very effective in our teacher training route depending on the university.

Most experienced school teachers would like to give some support to Newly Qualified Teachers. These teachers help the NQTs to prepare their teaching plans, and give them some instruction during their teaching, usually in the group discussion after classes. We think that this is useful and effective. From the interviews, we found that most NQTs were supported by teachers in the following ways:

- experienced teachers observed the trainee's lesson and analysed together
- the trainee observed a colleague's lesson and analysed together
- the trainee was given advice in response to his/her question/queries to colleagues
- colleagues sometimes volunteered help without being asked
- the trainee was involved in group discussions with colleagues.

The drop out rate of NQTs during their first year of teaching has recently been about 10 per cent. One reason for this is that they found teaching to be hard work and sometimes felt they were not sufficiently supported. Another reason is that some of them try to find a position with a higher salary (for example, that of manager in a big hotel).

> The explanation is the fact that Czech primary students are not usually interested in mathematics at all.

3.2 Czech Republic

(**Dr Miroslav Belík** and **Professor Tomáš Zdráhal,** J. E. Purkyne University, Ústí nad Laben, Czech Republic)

Overview of mathematics teacher training

Universities in the Czech Republic develop their own study programmes for their study majors, accredited by the Accreditation Committee, which reviews a detailed description of each course and programme. The Committee, established by the State Department of Education, comprises distinguished experts in the given study field and evaluates whether the university has adequate faculty members, facilities and equipment for the proposed study programme. Additionally, it reviews whether the programme coincides with legal regulations and can be financially supported from the State budget. During accreditation, the Committee may audit the programme to verify that given conditions are being met, and it has the right to cancel the accreditation if the contract is breeched. An accredited degree programme provides a higher education that terminates in a state examination and the awarding of a degree (Bc., Mgr. and Ph.D.). In accordance with the Higher Education Act, Master's programmes that do not follow a Bachelor's programme may be accredited and offered, though only on an exceptional basis – this is the case with primary mathematics teacher training.

The study mode may take the form of on-site, combined or distance studies. The on-site mode is mostly based on class attendance, while the distance mode comprises independent learning complemented by consultations with teachers. The combined mode shares features of the two other modes; classes are usually concentrated in blocks.

Students who would like to become teachers and graduated in majors other than the teacher training programmes have to complete their education by taking classes such as pedagogy, psychology, didactics of subjects etc. during three or four semesters.

Teacher Training for Secondary Schools consists of two consecutive sections, namely Bachelor's degree program (duration three years – students study mathematics) followed by Master's degree program (duration two years – students study mostly didactics of mathematics). Teacher Training for Primary Schools is only one section of the so-called Long-cycle Master's degree program (duration five years – as for mathematics, students study only didactics of mathematics at the elementary level, there are many other subjects such as Czech language and literature, physical training, music teaching, etc). Table 4 on page 20 summarises some of the main features of ITT courses in the Czech Republic.

Sample

We sampled more than 400 trainees (students) in primary and around 200 in secondary from three Faculties of Education in the Czech Republic. These numbers involved only the knowledge audit made in autumn 2007; about half in each category undertook the questionnaires in March 2009. All students took both knowledge audit and the questionnaires online. All tasks and questions were translated from English to Czech. We followed more than 100 students (in total, from both categories) on their school-based training and had the opportunity to interview them and their school mentors.

Audit data

See Table 5 on page 20. Primary seems to score the lowest in comparison with other countries (the median and the upper quartile namely). On the other hand, the upper end of whisker is high enough. The explanation is the fact that Czech primary students are not usually interested in mathematics at all. Moreover, many of them are graduates of secondary pedagogical schools, where mathematics is only a minor subject. Their degree program at Universities (Long-cycle Master's degree program) includes a wide range of other subjects, such as pedagogy, psychology and many of the abilities and skills needed to be a primary teacher. On the other hand, some of these students achieved results that bear comparison with secondary students. We realise that some primary students change their attitude towards mathematics during either their university studies or their teaching practice.

To return to Czech secondary students, they are trained for teaching a combination of

Table 4: Summary of some of the main features of ITT courses in Czech Republic		
	Primary	**Secondary**
Entry route, length of course and qualifications	5-year Master's degree[1]	3-year Bachelor's degree + 2-year Master's degree (from 2007–08)[3]
Entry qualifications	High school diploma and leaving exam Psychological testing (some Universities) Oral interview evaluates general knowledge	
	University entrance exam (mathematics, Czech, abilities audition for music, fine arts and sports)[2]	University entrance exam (mathematics plus second subject)[4]
Course components	All primary subjects Specialist subject Didactics Pedagogy Psychology IT Foreign language Social studies	Mathematics Second specialist subject Didactics Pedagogy Psychology IT Two foreign languages
Time in school	12 weeks over 3 blocks	

[1] 5-year course from 2007–08: previously a 4-year course
[2] Czech and mathematics may be waived for outstanding high school graduates in these subjects
[3] Previously 5-year Master's
[4] Mathematics test may be waived for outstanding high school mathematics graduates

Table 5: Audit data – Czech Republic						
	Part A		**Part B**		**Total**	
	Mean	**Per cent**	**Mean**	**Per cent**	**Mean**	**Per cent**
Primary	21.5 (out of 40)	54	7.7 (out of 20)	38	29.2 (out of 60)	49
Secondary	14.9 (out of 20)	74	12.8 (out of 20)	64	27.7 (out of 40)	69

two subjects (mathematics and physics, for example) and have graduated mostly from grammar schools where mathematics is the main subject. Therefore their results in the test are comparable with other countries.

Attitude data

The attributes taken from the English original have been used (translated to Czech) and, because some of them are not very usual in the Czech Republic, our trainees were instructed on their meanings before undertaking the online questionnaire.

The topics of statistics and probability are the main ones in which both secondary and primary trainees lack confidence. We have discussed this with our trainees and we have found some of the reasons:

- Most students find statistical theory to be too abstract and technical in nature

"The topics of statistics and probability are the main ones in which both secondary and primary trainees lack confidence."

- There are many new concepts and strange sounding terms to be learned
- Students fail to see any connection between statistical knowledge and their majors
- Some may regard a course in introductory statistics as a bothersome degree requirement and thus approach the subject with a negative attitude.

Trainees were asked to give their main concerns about teaching mathematics that they hoped would be covered in their training course. The responses were varied across the samples; the secondary group was particularly concerned about 'discipline', 'supporting less able pupils', 'class management' and 'pedagogy' whereas the primary group was most concerned about 'supporting less able pupils' and 'pedagogy' but also with 'challenging able pupils'.

There were several differences between the secondary and primary groups regarding the length of time they expected to remain in teaching. More than 15 per cent of secondary trainees intend to teach for only the first year after graduation (during this time they will seek better paid work – this has become apparent during our above mentioned discussions with some students); on the other hand, only one per cent of primary students think in this way. About 20 per cent of secondary students have already decided, before graduation, that they will never teach; on the other hand, hardly any primary students do not intend to teach. The main reason for this difference is the fact these two degree programs (and therefore also students) vary widely in the Czech Republic.

Continuing Professional Development

For Continuing Professional Development (CPD) in the Czech Republic, the following range of opportunities is available for Czech teachers: seminar meetings, lectures, courses, workshops and other activities connected to further education of pedagogical staff. These activities are free for teachers, because every school has a budget dedicated to CPD costs.

CPD work is obligatory but every teacher can choose his method of CPD. Schools provide their own school-based CPD within activities such as creating teaching programs, monitoring of teaching, evaluation, etc. There is also external CPD provided by

- the National Institute for Further Education and its regional workplaces
- the Centres for Further Education, organised by teacher training oriented universities
- the education departments of regional authorities.

Some courses are award bearing, namely university courses that are subject to special accreditation.

Issues

From research carried out through long formal and informal written and verbal discussions over more than two years, we have determined that the social and economic prestige of the teaching profession in the Czech Republic compares with other countries participating in this project at the lowest level. We surmise that this is the main reason why the most talented high school graduates do not apply for study at Faculties of Education in the Czech Republic.

> Most initial teacher training in England is undertaken by universities in partnership with local schools…

3.3 England

(**Professor David Burghes** and **Russell Geach**, CIMT, Faculty of Education, University of Plymouth)

Overview of mathematics teacher training

Most initial teacher training in England is undertaken by universities in partnership with local schools but there are other routes into teaching approved by the Training and Development Agency for Schools (TDA), such as school-centred Initial Teacher Training Courses (SCITTs), the Graduate Teacher Programme (GTP) and Teach First. School-centred ITT courses (SCITTs) are normally run by a group of schools in a particular area, with the involvement of a university for accreditation and, in some cases, direct involvement (e.g. trainee teachers spending one day a week at the university).

On the Graduate Teacher Programme (GTP), graduates are employed at a lower level of pay than qualified teachers to teach and essentially learn 'on the job'. These trainees usually have one day each week allocated for training at a local college or university. This is becoming a more popular route into teaching but it has a high dropout rate. It does, though, provide the means for mature students with dependents to undertake a semi-funded career change.

Teach First is an initiative to persuade graduates with a good degree in mathematics or a mathematics related subject to spend at least two years teaching mathematics in challenging secondary schools in London and Manchester. After an intensive 6-week training period they start teaching at the beginning of the school year in September. The idea is to get high quality graduates to act as role models to encourage pupils to consider going to university. Table 6 below summarises some of the main features of ITT courses in England.

Sample

Our aim was to have a sample size of about 200 in each of primary and secondary, taken

Table 6: Summary of some of the main features of ITT courses in England

	Primary (5–11)		Secondary (11–16/18)
Entry route	**BEd**	**PGCE**	**PGCE**
Length of course and qualification	3 or 4 year degree course leading to Qualified Teacher Status (QTS)	1 year Post Graduate Certificate in Education (PGCE) leading to QTS	
Entry qualification	2 relevant A Level passes GCSE grade C+ in mathematics, English and science	Relevant degree GCSE grade C+ in mathematics, English and science	Mathematics (or mathematically-based) degree GCSE grade C+ in mathematics, English and science
Course components	Professional studies Subject study School-based work		
Time in school	At least 24 (3 year) or 32 weeks (4 year) spread out in blocks over the course	At least 18 weeks (2 or more schools)	24 weeks in two or more schools

All trainee teachers – primary and secondary – are required to pass the TDA's national computerised tests in numeracy, literacy and ICT before obtaining QTS. (They can retake these tests as many times as necessary.)

"In primary, we were not quite so successful, and it was very difficult to get non-specialist trainee teachers to volunteer to take mathematics audits; even those who did volunteer, often left without completing the audits."

from a number of teacher training institutions. In secondary, we did almost achieve this and the sample was from volunteers in seven higher education teacher training institutions (now all universities). In most cases it was the complete cohort of PGCE secondary mathematics students but our university ethics protocols insist that all participants have to be willing volunteers and can indeed withdraw at any time, even as they are taking the audits. In the main though our secondary cohort was a fair representation and they undertook both the subject knowledge audit and the questionnaires. They all took these online. We were also able to follow a number of the students, observing them during their school- based training and having the opportunity to interview them and their main school mentors.

In primary, we were not quite so successful, and it was very difficult to get non-specialist trainee teachers to volunteer to take mathematics audits; even those who did volunteer, often left without completing the audits. So we know that we do have a sample that is biased towards the mathematics specialists (usually about 10 per cent of complete cohorts) with about 30 per cent coming in this category. This does mean that we cannot be confident that our sample does in fact represent the overall intake to teacher training in primary and this must be acknowledged in the subsequent discussions and comparisons.

Audit data

See Table 7 below. We will not comment on individual questions on the audit, except for the one question for which the primary cohort had a higher mean (80%) than the secondary cohort (64%); namely question 12(b):

Question 12(b)

Mark the following statements 'a square is a rectangle' as:

A. always true ☐

B. sometimes true ☐

C. never true ☐

It is of some concern that our secondary trainees appear not to fully understand the definition of a rectangle.

The comparison with other countries is best illustrated through the box and whisker plots in Section 2. At first sight, the data for England is not too dissimilar to many of the other countries and indeed has an extended whisker, showing that some of the cohorts were very competent in mathematics. This does of course confirm that we did have a significantly high proportion of mathematics specialists in our sample and that this skewed the data. Nevertheless we were pleased not to be disgraced in this audit and it indicates that our primary teachers should be able to make their lessons more mathematical than at present.

For the secondary plots, although the performance is relatively low compared to the other participating countries, the most alarming result is the very high variation in the audit data as shown by the extended whiskers in both directions.

Attitude data

When asked to identify the attributes of effective mathematics teachers, 'explains clearly' was the modal response, with the categories 'well prepared', 'excellent subject knowledge' and 'enthusiastic' all featuring highly from both the primary and secondary groups. There was only

Table 7: Audit data – England

	Part A		Part B		Total	
	Mean	**Per cent**	**Mean**	**Per cent**	**Mean**	**Per cent**
Primary	25.6 (out of 40)	64	6.6 (out of 20)	33	32.2 (out of 60)	54
Secondary	14.1 (out of 20)	70	11.9 (out of 20)	59	26 (out of 40)	65

‘Geometry’ and ‘statistics’ came top of the topics that trainees did not feel confident about. This was surprising for us…

one significant difference in the responses between our primary and secondary trainees and that was the ranking of ‘enthusiastic’. For the primary cohort, it was the highest ranked attribute whereas for secondary it was the fourth and only just above a number of other attributes. It would be tempting to suggest that maybe our secondary trainees (and subsequently teachers) need to show their enthusiasm more openly for mathematics.

‘Geometry’ and ‘statistics’ came top of the topics that trainees did not feel confident about. This was surprising for us; we had expected ‘algebra’ to feature prominently, especially for the primary cohort, but this was not the case.

We also asked the trainees to give their main concerns about teaching mathematics that they hoped would be covered in their training course. The secondary trainees had most concerns about ‘classroom management’ whilst ‘teaching strategies’ was also of some concern. The reverse situation is true for our primary sample with ‘teaching strategies’ coming top of their concerns and a number of the concerns coming a close second, with ‘classroom management’, ‘supporting less able pupils’, ‘linking theory and research to practice’ and ‘challenging able pupils’ all featuring highly.

We were even more surprised by the responses to the question about the length of time expected to remain in teaching; there was almost complete agreement across the two samples but what surprised us most was that more than half in each sample expected to be teaching for life. The reality for secondary teachers is that the median length of time in the profession is about three to four years so the reality does not match the aspirations of our trainee teachers. Therefore all concerned with improving mathematics teaching need to consider what happens to these trainees over their first few years in the profession that leads to such a poor retention rate in English schools.

All the trainee teachers were in praise of their university teacher trainers, indicating that the sessions with their subject trainer were helpful, enjoyable, motivating and, at times, inspiring. Clearly the mathematics education tutors were seen in a positive light and well respected, particularly those that still took demonstration classes in schools, observed by the group of trainees.

The trainees were all very critical though of the generic education sessions that all seemed to have to sit through in large groups; even after a term in school, their comments were still critical and they could see little or no relevance of their ‘theory’ sessions to actual teaching in schools.

There was also concern about the variability in support from one school to another and from one practice to another. Whether it was the first or second, practice seemed not relevant but many students said that one school was supportive, with mentors freely giving of their time to help and support, whilst their other school was the reverse with little or no support; they were treated as the lowest priority of all and often left to fend for themselves.

Some of the students worked in pairs on their first placement and this seemed to be well received by the trainees, appreciating the fact that there was always someone to discuss their problems and issues with. This was true except for one pair that just did not get on together.

Continuing Professional Development

Despite all concerned (schools, unions, teachers, government) stressing the importance of CPD, what actually happens has great variation from school to school. In theory, schools are funded to provide CPD or facilitate opportunities for CPD but in practice, the funding is not ring fenced and hence the great variation in provision.

From our observations, we would be keen to see a more detailed arrangement in which CPD was both a right and an entitlement. This could be linked with University Practice Schools (see below) in the location and by using lesson study methods, as happens in countries such as Japan, for professionals to share and enhance their (mathematics) teaching skills.

The outlook for CPD in England is not optimistic with likely heavy cuts in some parts of the Education budget due to the dire economic state of the country. Whilst front line services are likely to be protected, items such as CPD funding are likely to be squeezed. This will promote school-based CPD (in the form, *Above all though, to avoid the variation in help and support given to trainees and NQTs, we would support the establishment of University Practice Schools (UPSs) to work closely with their local teacher training providers.*

for example, of lesson study) as opposed to external courses, which schools will not be able to afford in the future.

Issues

Our main issue is the retention rate of teachers of mathematics. We have followed a number of our trainees into their first year of teaching. We call these teachers NQTs (Newly Qualified Teachers). It has been interesting to both record their reactions to becoming a real teacher as well as to have information about the support given to them.

From our own data, it appears that more than 15 per cent of the initial trainees either did not take up a teaching post or did not last more than a year in teaching. The reasons are varied but we have summarised the data into two main concerns; namely:

- Lack of support given to NQTs in their crucial first year of teaching; there seemed to be such a variation in support and help given for CPD and this seemed to be a key factor in the decision of some of the teachers to abandon the profession at an early stage.
- School ethos, where there seemed to be a lack of respect for teachers accepted throughout the school and where teachers were blamed rather than supported in dealing with difficult pupils.
- Paperwork required for everyday teaching; many new entrants were overwhelmed by the demands for paperwork that was time consuming and felt to be of little real relevance for improving teaching and learning; the paperwork demands appeared to leave so little time for reflection on teaching and learning, and, for example, observing and discussing lessons with expert teachers etc.

Retention rate is not the only issue but it is seen, particularly in the secondary sector, as one problem that needs to be solved if we are ever to have a stable workforce that has the potential to enhance the teaching and learning of mathematics.

The other main issue is that of the mathematical attainment of our teachers. At secondary, we would be in strong support of the MECs (Mathematics Enhancement Courses) that now precede the one year PGCE course. It is clear from our data that those who have taken an MEC course have a stronger understanding of mathematics and, more importantly, of school mathematics.

In the primary sector, we would be keen to ensure that all entrants come into the profession with a higher mathematical qualification than a Grade C in GCSE examinations, which is the current practice. We would be keen to see either a higher grade requirement, for example, Grade B in GCSE mathematics or preferably a dedicated AS-Level in 'Mathematical Concepts' for entry into teacher training.

Above all though, to avoid the variation in help and support given to trainees and NQTs, we would support the establishment of University Practice Schools (UPSs) to work closely with their local teacher training providers. The University Practice Schools would not only provide the first teaching observations for the trainees, they would also provide the school for the first teaching practice in which trainees would be in groups of four or six and hence teach less than in our current practice but observe and reflect far more. The UPSs could also provide teacher practice and demonstration lessons for the teacher trainers to ensure they are fully aware of current issues etc., to provide CPD for the region and to act as the catalyst for change, innovation, research and development. These schools would be akin to University Practice Hospitals in which student doctors and nurses first observe, work alongside and learn from expert practitioners. These schools would though need to be fully funded to take on this extended training role.

> In Finland, secondary school teacher training has only ever been provided in universities.

3.4 Finland

(**Professor George Malaty**, University of Eastern Finland, Finland)

Overview of mathematics teacher training

In Finland, secondary school teacher training has only ever been provided in universities. Primary school teacher training started in the 19th century at special institutes called seminars, but this changed in the 20th century to be provided also only by universities. Education as a science has a special place in teacher training, starting in the 19th century with the establishment of the first university professorship for Education. In parallel to the interest in the Science of Education, practical training has had a remarkable place in teacher training. This can be seen from the tradition of providing teaching practice in University Practice Schools, where each teacher training department has its own Practice School. The first Teaching Practice School was established in the 19th century. Table 8 below summarises some of the main features of ITT courses in Finland.

Sample

The faculties, or departments, of education of seven universities, provide primary teacher education in Finland. These universities provide teacher education for mathematics teachers. The main part of study for mathematics teacher education takes place at the faculty or departments of science, where mathematics has to be a major or a minor. In addition, mathematics teacher education includes a minor in education, which includes mathematics education.

The Finnish sample of the ISCMTT only includes primary trainees and only students from the University of Joensuu. Despite this

Table 8: Summary of some of the main features of ITT courses in Finland

	Primary (7–11)	Secondary (11–16/18)
Entry route	Bachelor's degree plus M.Ed.	Bachelor's degree plus MSc (in which mathematics is major or minor)
Length of course*	4 or 5 years, of which 3 are on the Bachelor's cycle	6+ years Mathematics majors – Senior Secondary Mathematics minors – Junior Secondary
Entry qualification	Secondary school graduation (matriculation), 'performance points', study achievement points and Faculty of Education Final Selective Tests.	Secondary school matriculation – good graduates in mathematics are exempt from further tests but others take a university-set examination in 'Long Mathematics'.
Course components Bachelor's degree	Education 12 school subjects and their didactics Language, communication and ICT Minor specialisation study	Mathematics major Chemistry/physics/computer science minor Education minor Language and communication
Course components M.Ed	Education Thesis Language and communication Minor study	Mathematics major (with thesis) Chemistry/physics/computer science minor Education minor Language and communication

*Courses in Finland are organised around courses and points rather than time.

"The reason is related to the homogenous type of education at Finnish schools, where the geographic effect on students' achievement is less than in other countries."

limitation, this sample should be accepted as a relevant and even a representative one. The reason is related to the homogenous type of education at Finnish schools, where the geographic effect on students' achievement is less than in other countries. In addition, for Finnish universities, university students are not only from the surrounding area, but represent all the provinces of the country. In our sample of 130 students, 80 per cent are primary teacher education students and 20 per cent are special education teacher students.

Since the English knowledge of our students is good, the available online version of the audit was used. For each question a translation of the mathematical terms into Finnish was given in a separate paper file to avoid the problem of unfamiliarity with English mathematical terms.

The audit was completed in a computer class of the University of Joensuu. The class was reserved to sample students' use, where the author was available for only technical assistance. The high number of computer reservations was made to meet with the differences of students' study schedules. This has had a positive effect in getting all the population involved.

Audit data

See Table 9 below. Bearing in mind the fact that mathematics is not one of the strengths of primary school teacher students in Finland, these results would be accepted by us as satisfactory. Nevertheless, here it is interesting to investigate some of the cases where the percentage of students, who were able to answer correctly, was less than 20 per cent.

Question A8
What is the lowest common multiple of the numbers 40 and 140?

Only two students out of 130 (1.5 per cent of students) were able to answer this question correctly. This is understandable, as in Finland the lowest common multiple of numbers was removed from school curriculum at the beginning of the 1970s, as part of the implementation of the Nordic Countries School Curriculum Reform of the 'New Math'. The two students who were able to write the number 280 as the lowest common multiple of 40 and 140, might have used the language meaning of the phrase 'lowest common multiple'.

Question A1b
Find the rational numbers among the six numbers:
$\sqrt{2}, 0.1, \frac{8}{9}, \pi,$ 9 and 4

The results of the audits of section B reflect facts about primary education teacher students in Finland. They are some of the best achievers in secondary school matriculation examinations, but this is not related to an interest in mathematics. Only 25 per cent of students had taken 'advanced level' matriculation examination in mathematics; section B items are relevant only to these students. Here also we notice that students who studied mathematics at the 'advanced level' and had a genuine interest in mathematics, in general, do not apply either for primary teacher education study or for mathematics teacher education study. The applicants for primary teacher education are mainly interested in physical education and art, especially music.

The results of section B are much worse than those of section A. But these results can be evident of a type of consistency in Finnish education. This can be related to school students' results in comparative studies like

Table 9: Audit data – Finland

	Part A		Part B		Total	
	Mean	Per cent	Mean	Per cent	Mean	Per cent
Primary	26.2 (out of 40)	65	6.8 (out of 20)	34	33 (out of 60)	55
Secondary	–	–	–	–	–	–

"Compared to the other countries in the study, Finland's results for primary education teacher student audits are of average level on the median and quartiles marks."

those of IEA and PISA, and as well in the competitions of Mathematical Olympiads.

Primary education teacher students can do well in relatively straightforward questions, like the case of section A, but the result is different when answering questions with relatively more emphasis on an understanding of mathematical concepts and relations, as say, the understanding of structured mathematics, as in the case of section B questions. This partly relates to the fact that among these students 55 per cent had passed only the 'lower level' matriculation examination in mathematics, 20 per cent had not taken any mathematics matriculation examinations, and only 25 per cent had passed mathematics 'advanced level' matriculation examination.

Compared to the other countries in the study, Finland's results for primary education teacher student audits are of average level on the median and quartiles marks. But the dispersion shown in the box and whisker plots in Section 2 is of a significant meaning to Finland. Here we can see, for the first time in international comparative studies, that the dispersion of the Finnish students' sample is of average level. The numerical data shows that Finland has the fifth highest standard deviation among the ten countries participating in the study. This order is significantly high for Finland.

Continuing Professional Development

In Finland the idea of lifelong learning is rooted in Finnish society. Lifelong Learning is appreciated and available not only for teachers, but for everybody. For teacher education, we have different types of CPD. Local education authorities organise CPD days for their schoolteachers. There are also other types of longer CPD. Some details of such CPD are presented below.

Each university has its 'Centre for Continuing Education' and every province has 'Summer University'. Both organisations offer in-service education courses in mathematics education. At the time of the LUMA-project, the 'National Board of Education' had offered wide support to both organisations. The courses provided at that time offered the participants additional university credits.

At that time, these courses gained great popularity among teachers. In addition the National Board of Education provides in-service education in mathematics education in different places, including at its special centre situated in Heinola.

We must not forget the national and local in-service education provided by teachers' associations. These associations are, 'Mathematics and Natural Sciences Teachers Association', 'Primary School Teachers Association', 'Special Teachers Association' and 'Teachers of Beginners Association'. The final one is for those working in teaching first and second graders. The 'Mathematics and Natural Sciences Teachers Association' has branches in each province. These branches are called 'Mathematics and Natural Sciences Teachers Clubs'; these clubs also provide in-service education.

Issues

The teaching practice provided for primary teacher students 20 years ago was much better than it is today in terms of both the quantity and quality of teaching practice. Both have been declining gradually, with the quality now being about half that of the 1980s. For secondary school, there is no involvement from university specialists in the teaching practice of mathematics teachers. This is a drastic change, which has had a negative effect on the development of the mathematical curriculum and teaching approaches of secondary school teachers in the country. It has also had a serious negative effect on the study of mathematics and related areas in higher education.

Despite the popularity and the relatively special status of primary teacher education in Finland, we do have some problems of special difficulty:

- Acceptance of students with no matriculation examination in mathematics is not a positive side of our system. Twenty per cent of today's primary school teachers were awarded places to study at university with no matriculation examination in mathematics.
- The majority of primary school teachers have minor studies in the group of art and physical education, but less than five per cent have a minor in mathematics or natural

This is a success that cannot be ignored, especially when we notice that the number teaching mathematics at our schools is one of the lowest worldwide.

sciences. There is a need to organise the selection of minor studies to be related to just school subjects, for example, some primary school teachers' students have chosen 'adult education' to be one of their two minors.

- The obligatory part of mathematics education study for primary teacher students forms about two per cent of the whole program of study, and this part is all that most primary teacher students get.

Finally, we must not forget the numerous positive aspects of our school system and, in particular, the strengths of the teaching profession that are behind our success in PISA. This is a success that cannot be ignored, especially when we notice that the number teaching mathematics at our schools is one of the lowest worldwide. But the problems we have in our education, including teacher education, must not be ignored. Regarding PISA, we need to remember that PISA items are not measuring mathematics achievement, but mathematics literacy. Our results in Mathematical Olympiads are modest, as is the case with our results in the section B audits. Understanding of mathematical concepts and relations to solve real mathematical problems requires more mathematics education at schools and increased education in mathematics and mathematics education in teacher education.

“Hungary also has a different structure to its schools in different regions, with both primary and secondary schools but also general schools and separate kindergarten schools where education is not compulsory until the age of five.”

3.5 Hungary

(**Professor Tibor Szalontai**, College of Nyíregyháza, Hungary)

Overview of mathematics teacher training

Hungary has a strong reputation for education and a tradition of expertise in mathematics and mathematics teaching. In the past, teaching was regarded as a very prestigious career, with a strong demand for places. In the Communist era, teachers were not only valued but also paid well in comparison with many other jobs and professions. This has partly changed during the last 20 years, with teachers still valued but no longer remunerated as well as before. This is particularly pertinent to mathematics since mathematics graduates now have many other well paid options available, particularly in the booming IT industry. Hungary also has a different structure to its schools in different regions, with both primary and secondary schools but also general schools and separate kindergarten schools where education is not compulsory until the age of five. The main characteristics of the different sectors and their ITT courses are summarised in Table 10 on page 31.

Sample

After some pilot trials, we joined the international project in 2007. The tested sample contained a kindergarten student teacher group (H01, n = 38), a primary student teacher group (Years 1 to 4, H02, n = 48), a junior secondary (Years 5 to 8, H03, n = 32) and a senior secondary (Years 9 to 12, H04, n = 53) mathematics student teacher group; each group's students were in their final year. The kindergarten and H04 secondary groups were from the University of Debrecen. The primary and H03 secondary groups were from the University College of Nyíregyháza. Both cities are situated in the north-east part of Hungary and the average ability of these students is lower than the country average, since the universities in Budapest (the capital) attract most of the higher ability students.

All four types of course were traditional complex courses. The first three were 4-year long Bachelor's courses and the last one was a 5-year long Master's course. In Hungary, the kindergarten and primary training courses remain the same, but the two types of secondary course have been phased out since 2005 and a new, 3 + 2.5 year long course system has been initiated (the BSc from 2005 and the Teacher Master MSc from 2008).

H03 students did the test online, and the other three groups did the translated paper test.

Audit data

See Table 11 on page 31. The mean result of the kindergarten trainee group was quite poor, 38 per cent (23 marks from the possible 60) in the primary audit test. It is not involved in the international comparison, since other participant countries did not study kindergarten teacher training. It is interesting that their ‘intermediate’ maturation performance (at age of 18) was 57 per cent in mathematics and 80 per cent in Hungarian.

Our result ranked fourth, after the outstanding Japan, China and Russia results, and it slightly exceeded the other samples. We achieved 67 per cent (ranked fourth) in part A, and 42 per cent (ranked fifth) in part B. It has to be emphasised that the most attractive universities in Budapest (in economy, engineering and science) get the best students with ‘advanced level’ and I venture to say that these international audit results show the strengths and weaknesses of ability of the students who wish to be mathematics teachers, rather than indicating the quality of mathematics tutoring in the course.

Attitudes data

The questionnaire revealed that mathematics was enjoyed most by only eight per cent of kindergarten trainees, by 12 per cent of primary trainees and by 76 per cent of the secondary trainees. Fifty-eight per cent of kindergarten, 52 per cent of primary and 75 per cent of secondary trainees were confident that they will make good mathematics teachers. Most trainees expected to stay in the teaching profession for the rest of their working lives (45 per cent, 16 per cent and 32 per cent respectively); although a small percentage said that they would not teach at all (24 per cent, 14 per cent and 10 per cent respectively).

Table 10: Summary of the main characteristics of the different sectors and their ITT courses in Hungary	
Sector	**Training**
Kindergarten teacher training course Four-year (240-credit) complex BEd course for educating children aged 3–6 years	Children who are five years old must attend a kindergarten where they are prepared for primary school. This preparatory time is normally one year (although almost half of the children stay in the kindergarten for an extra year if parents or the kindergarten recommend it). Teachers are now trained for this sector with a four-year degree course.
Primary teacher training course Four-year (240-credit) complex BEd course for teaching pupils in Years 1–6	Primary teachers usually teach classes only in Years 1–4, the current lower section of general school, but in larger schools teachers sometimes take classes in Years 5–6 in their specialist subject. The Government plans that primary teachers will teach all classes up to Year 6 in the future. The course consists of: • social studies and informatics • psychology and pedagogy • seven academic subjects and their teaching methodologies for years 1–4 • school-based practice • diploma work • compulsory specialisation in a subject area for Years 5–6 (e.g. in mathematics), with advanced academic content, special teaching methodology and additional teaching practice.
General school mathematics plus another subject teacher training course Four-year (240-credit) complex Bachelor's degree course for teaching pupils in Years 5–10 of general schools	These subject teachers usually teach only in Years 5–8, the current upper section of general school. (At the moment, a very limited number of general schools extend to Year 10.) The course consists of: • scientific courses in two subjects • pedagogical and psychological courses • the two subject methodologies • facultative and intellectual aspects diploma work • school-based work.
Secondary school mathematics plus another subject teacher training course Five-year (300-credit) complex MSc degree course for teaching pupils in Years 5–12 and also for teaching mathematics in higher education if the applicant has already attended a PhD course in mathematics	The majority of these subject teachers teach only in Years 9–12 (in four-year gymnasiums and technical and vocational secondaries) but an increasing number of gymnasiums run six-year and eight-year classes. The structure of this course is similar to that of the previous course but it requires more knowledge of course subjects at advanced level in mathematics (and in the other subject). Teaching practice is in the final, fifth year and consists of both University Practice School (UPS) practice and a longer practice in an ordinary school.

Table 11: Audit data – Hungary

	Part A		Part B		Total	
	Mean	**Per cent**	**Mean**	**Per cent**	**Mean**	**Per cent**
Primary	26.7 (out of 40)	67	8.4 (out of 20)	42	35.1 (out of 60)	58
Secondary	14.8 (out of 20)	74	10.1 (out of 20)	50	24.9 (out of 40)	62

During that time, student teachers have tended to be of lower average ability, as the more able preferred to opt for more attractive professions.

Key attributes of an effective mathematics teacher, chosen most frequently, were being 'well-prepared', although for kindergarten trainees being 'patient' was also cited whilst 'subject knowledge' was also cited by secondary trainees.

Continuing Professional Development

Until the 1980s, when we had supervisor teachers who regularly observed schools, every teacher attended CPD days twice a year, along with lesson observation and review. Annual and occasional conferences and workshops provided additional events for (mathematics) teachers. From the middle of the 1980s to 2009, every teacher had to collect 120 credits in CPD courses within every seven years, up to the age of 50. The various courses of competing providers had to be accredited and registered. The most worthy courses were provided by universities and the county (capital) education centres. If a teacher attended a further subject or a higher degree teacher training course, this replaced the CPD for seven years.

A new 'Special examination in pedagogy' course system has just been initiated. Each new course at our college has 120 credits within two years and 360 contact lessons, which many of us think is too much, although it gives a higher qualification for a higher salary class.

Issues

The new secondary teacher training course is a two-and-a-half year long, two-subject MSc course for those who have the BSc diploma in those two disciplines. An applicant with a primary or kindergarten teacher diploma may enter only the 'Pedagogy teacher' M.Ed course which is, again, two-and-a-half years long. There is an exceptional one or one-and-a-half year long MSc teacher training course for those teachers who have the former Y5–8 teacher (BSc) diploma (one year for one subject and one-and-a-half years for two subjects). It is not yet clear what impact this will have.

It was to be expected that dispensing with the school inspector system in the 1980s would cause a general decline in the school standard at every stage. It was clear that raising the number of gymnazium and technical secondary pupils to 70 per cent from 50 per cent (thereby reducing vocational schooling to 30 per cent from 50 per cent) within about 40 years, would lead to a natural average decline in the maturation secondary schools. It was clear that duplicating the number of students in higher education, within about a decade, would give rise to a natural depressing of the average ability of university students. During that time, student teachers have tended to be of lower average ability, as the more able preferred to opt for more attractive professions. Despite the limited salary and reputation of teachers, a surplus number of teachers were trained in the 1970s and 1980s. Because of this and the fall in pupil numbers, the number of teaching posts fell in 1990, resulting in a reduced number of teacher trainee applicants, mainly in science and mathematics. Since the 1970s, the number of mathematics and science lessons in the first eight years of school has been reduced three times. There has also been a general decline which has affected mathematical literacy. It is clear that fewer able teachers and a reduced number of mathematics lessons are unlikely to achieve higher results than before, and it seems a diabolic circuit.

Beside the concerns above, this project confirmed the evidence that good teaching abilities are not in close correlation with success in higher mathematics, but that there are other key factors of good mathematics teachers. The methodology and the practice school-based work are key factors. We recommend increasing results in the mathematics BSc course, by raising the entry requirement (advanced level mathematics maturation and/or entry examination). A complex, five-year mathematics – other subject teacher training course should be reintroduced. Some pedagogic subjects could be replaced by extra seminars on both junior and senior secondary school mathematics. University Practice Schools should be saved and developed further as model schools and for dedicated CPD courses.

3.6 Ireland

(**Noreen O'Loughlin**, Primary teacher)

Overview of mathematics teacher training

"Teaching is still considered an attractive, high-status profession in Ireland and attracts extremely high-calibre applicants, particularly at primary level."

Teaching is still considered an attractive, high-status profession in Ireland and attracts extremely high-calibre applicants, particularly at primary level. A Teaching Council came into being in the spring of 2006, one of its remits being to establish standards, policies and procedures for the education and training of teachers. Each provider is responsible for the development of its own programme syllabus and content for the education of its prospective teachers, though each qualified teacher is expected to meet the requirements of the Teaching Council. Table 12 below summarises some of the main features of ITT courses in Ireland.

Sample

The study was carried out in one of Ireland's two largest primary teacher education institutions. It was hoped to draw a sizeable sample from the final year cohort of approximately 400 students. However, as the ethics protocols dictate that students are in no way obliged to participate in this or any other research, the willing sample proved to be disappointingly small at just 6.75 per cent of the overall cohort (27). Each student participated by choice. The sample can be considered representative of the general group of final year B.Ed students. The majority of the sample undertook and completed the primary audit, parts A and B, as well as the personal and attitude questionnaires.

Audit data

See Table 13 on page 34. Almost the entire set of test items in part A form part of the Irish primary mathematics curriculum with the exception of items 11, 12, 14a, 14b, 15a, 15b. In part B, 9 of the possible 20 marks are derived from items relating to the primary mathematics curriculum, for which students will almost immediately have responsibility in their capacity as a primary teacher.

Taking both parts together, only in two items was there a full 100% correct response. They were items 4b (writing a number as a

Table 12: Summary of some of the main features of ITT courses in Ireland

	Primary		Secondary
Entry route	B.Ed	Graduate Diploma in Education (specialising as either primary or secondary)	
Length of course and qualifications	3 year degree course leading to a B.Ed	11 year (secondary) or 18 month (primary) Graduate Diploma in Education	
Entry qualifications	450 out of 600 points on School Leaving Certificate 3 'honours' grades (to include Irish) and 3 'pass' grades (to include English and mathematics)		Initial degree to include at least 30 per cent mathematics
		As for B.Ed plus initial degree and interview passes in English and Irish	
Course components	Education modules (subject pedagogies) Teaching Practice placements		Foundation studies Professional studies The study of teaching Teaching practice placements (teaching at least 100 hours)
	Academic subject		

Table 13: Audit data – Ireland						
	Part A		Part B		Total	
	Mean	Per cent	Mean	Per cent	Mean	Per cent
Primary	25.8 (out of 40)	64	8.9 (out of 20)	44	34.7 (out of 60)	58
Secondary	-	-	-	-	-	-

"Seventy per cent of the respondents attributed their decision to become a primary teacher to either a parent, usually their mother, or to a primary or secondary teacher."

fraction, decimal and percentage) and 20a (the probability of obtaining a head when tossing a fair coin) in part A. The most difficult item appears to have been item 15b on part A where the average correct response was 3.7 per cent. This item required knowledge of similar shapes. The average correct response rate across the sample for part A was 64 per cent which is quite a respectable result. The average correct response rate across the sample for part B was 44 per cent; not as healthy.

Comparing the audit responses to the other countries was interesting. Looking at the overall means shows Ireland performing in the mid-range. The box and whisker plots in Section 2 indicate that the bulk of the responses lay close to the mean, with the best and weakest performers far spread from the mean. In part A, Ireland lay in a mid-section with a number of other countries. This is not out of line with other international comparisons. It is concerning however, that the vast majority of the questions in this section relate to the primary programme. The Irish sample provided a marginally better response to part B. Considering the questions in this section were more challenging, this is slightly more heartening.

Attitudes data

All the participants had come into the B.Ed through the national examinations system. This is the traditional route for those leaving post-primary school at about 18 years of age. There are routes for postgraduate and mature students also. Only 17.6 per cent of the respondents were male. This is a reflection of the proportion of males in the system en route to becoming primary teachers. All students on the programme must meet the course's minimum requirements which include English and Irish at higher level and must have mathematics at grade D on either higher or lower level. That said, very few students entering the programme have such a low level. Almost two-thirds of the students said they had undertaken at least one leadership role before undertaking this programme. Just over half of the students had acted as a teaching assistant or teacher shadow before joining the B.Ed course and just under 50 per cent of them had engaged in voluntary activities. Seventy per cent of the respondents attributed their decision to become a primary teacher to either a parent, usually their mother, or to a primary or secondary teacher. From the answers, it is possible that the parent may also have been the influential teacher but that's not entirely clear.

Findings from the attitude questionnaire were very interesting. Enjoyment of mathematics was split into a 50:50 divide: 66.6 per cent of the respondents said that it was not a subject in which they excelled; 70.6 per cent of students admitted that mathematics was the subject in which they worked hardest; while 81.25 per cent thought that it was not the most important subject. Only 29.5 per cent of the students regarded mathematics as a creative subject. None of the students considered the correct answer to a mathematical problem more important that the method. The majority of the sample (82.4 per cent) was confident that they would be 'good mathematics teachers'.

A closer examination of their selection of the key qualities required to be an effective mathematics teacher shows that the highest ranking was given to 'explains clearly' with 'patient', 'well-prepared' and 'excellent subject knowledge' next in terms of initial ranking. Looking at the overall mentions given to the attributes, the four already mentioned continue to retain the highest number of mentions, again with 'explains clearly' getting almost double the number of mentions as the next highest 'excellent subject knowledge'. Third overall is shared by 'sets challenges' and 'enthusiastic' followed by 'patient', 'encouraging', 'approachable', 'high expectations' and 'hard working'. In relation to which aspects of mathematics are important to pass on to pupils, while students mentioned some curricular areas, almost half made reference to life-skills and real-life applications of mathematics. They felt less confident about teaching fractions, decimals and percentages than geometry and probability. They were concerned about 'challenging able pupils', 'supporting less able pupils' significantly more than any other areas, with 'planning', 'management of resources', 'class management', 'using IT', 'teaching strategies', 'pedagogy' and 'mathematical knowledge' all getting some mentions. One student said they had no concerns.

88.2 per cent of the respondents stated that they intend to stay in the teaching profession for the duration of their working life. The remainder, in equal share, indicated that they would remain for either 8–10 years or 10+ years. To the questions on their possible impact on their future pupils and the mathematics teaching profession, the sentiment was one of encouraging enjoyment in the first and promotion of the value of mathematics as a subject and of active learning as a methodology in the latter.

Continuous Professional Development

CPD in any subject in Ireland is in the main voluntary. National priorities, as decided by the government, receive significant funding and support. Currently, three of the few national programmes getting this support are in mathematics. Two of these are at primary level and one is at post-primary level. The post-primary professional development programme will be compulsorily implemented in all post-primary schools over the next few years. The two primary programmes are only available to designated disadvantaged schools. There are several national DES services providing support in mathematics and numeracy as part of their role. Individual teachers undertake courses in mathematics in their own time and usually at their own expense. In recent times, national targeted funding has been awarded to a 'National Centre for Expertise in Mathematics and Science Teaching and Learning' based in the University of Limerick. Its remit spans research and continuing professional development in areas from early childhood mathematics to service and degree level mathematics and beyond. CPD in mathematics in the primary context in Ireland sought by teachers includes the areas of the curriculum (particularly the early years) and the more senior classes, gifted pupils, weaker pupils, involving parents, whole-school planning and co-ordination of mathematics, problem-solving, and IT issues. The notion of a mathematics specialist in each school needs exploring to bring an expert in every school to a level where the CPD can be geared and focused to the particular needs of the school. The current economic climate in Ireland is bringing pressure to bear on mathematics teaching and learning. It is time to develop an evidence-based, flexible, sustainable, effective approach to training and continuing professional development for mathematics teachers.

Issues

Industrial and economic factors have given rise to increased attention to our mathematics attainment levels and there is considerable tension between broad educational and mathematical needs of pupils in schools and the values and requirements of the 'system'. Issues around teacher content and pedagogical content knowledge and the reduction in time for teaching and learning of mathematics on the primary school timetable are regularly cited as concerns surrounding the teaching and learning of mathematics, as is insufficient time for mathematics education courses at undergraduate B.Ed level. Transition from primary mathematics to post-primary is an area needing attention, particularly now that the post-primary curriculum is coming more in line with the philosophy and principles of the primary situation. There is now a common first year (post-primary) mathematics programme to help align the two sectors. This will need considerable support.

The basic mathematics entry requirements for entry to teacher education primary programmes need review. Where entry level grades are low, monitoring and supports need to be put in place. Perhaps an exit qualification in at least primary level mathematics needs consideration. Furthermore, specific mentoring of newly qualified primary teachers in their first year of qualification is necessary, both by their own outlining of their concerns above and in terms of the considerable investment it would be in a system where the majority of teachers intend to stay for their working life in the profession.

In Japan, the initial (pre-service) teacher training for a general teacher certificate is undertaken by universities and other institutions of higher education…

3.7 Japan

(**Professor Masataka Koyama**, Hiroshima University, Japan)

Overview of mathematics teacher training

In Japan, the initial (pre-service) teacher training for a general teacher certificate is undertaken by universities and other institutions of higher education, which have the course approved by the Ministry of Education, Science, Sports, Culture and Technology (*Monbukagakusho*) in partnership with university-attached schools, or local schools if universities/institutions have no attached school. Teaching practice is mainly undertaken by university-attached schools or local schools. Table 14 below summarises some of the main features of ITT courses in Japan.

Sample

Our aim was to have a sample size of about 100 in primary and about 200 in secondary taken from three teacher-training universities in different regions in Japan. In secondary, we did achieve this and the sample of 209 students (trainee teachers) was from volunteers in three teacher-training universities. All participants were taking a mathematics education course in order to get a regular teacher certificate for secondary school mathematics teacher.

In primary, we were not quite so successful and the sample of 75 students (trainee teachers) was from volunteers in two teacher-training universities. All participants were taking a mathematics education course in order to get a regular teacher certificate for primary school teacher.

Table 14: Summary of some of the main features of ITT courses in Japan

	Primary (6–12)		Lower secondary (13–15)		Upper secondary (16–18)
Entry route, length of course and qualifications	4-year Bachelor's degree and first class certificate	2-year second class certificate	4-year Bachelor's degree and first class certificate	2-year second class certificate	4-year Bachelor's degree and first class certificate at faculty of education/science
Entry qualifications	The nation-wide 'Common Test' in five school subject areas (Japanese Language, Foreign (mainly English) Language, Mathematics, Science and Social Studies) Individual university entrance examination (for example Japanese Language, Mathematics, Essay, Interview, etc. dependent on universities/colleges) Report submitted by upper secondary schools (i.e. applicant's evaluation of all school subjects and his/her record of activities in upper secondary school)				
	Students must have taken four of the six mathematics subjects taught at upper secondary		Students must have taken all six mathematics subjects taught at upper secondary		
Course components	Subject study Professional study School-based work				
Time in school	Varies but e.g. 6 weeks at Hiroshima University		Minimum 5 weeks		Minimum 3 weeks

Students are required to work for seven days as carers in special education schools and/or social welfare facilities to be awarded general teacher certificates at primary and lower secondary schools.

A 2-year PG route is available leading to a Master's degree and advanced certificate.

There is also a part-time route and correspondence courses in education for those students who have graduated from a junior college or a university without a teaching certificate.

We translated English primary and secondary mathematics audits into Japanese language. In the beginning of the 2007 academic year, before their teaching practice, all participants undertook the subject knowledge audit, not online but in paper-and-pencil format. Our primary and secondary trainees were given 60 minutes for their mathematics audit. Our primary and secondary sample of trainee teachers are not a fair representation of trainee teachers in Japan and this must be acknowledged in the subsequent discussions and comparisons.

"There are some surprises here for us in that we did not anticipate that our primary trainees would have a higher mean on some questions than our secondary trainees."

Audit data

See Table 15 below. The primary cohort showed a high performance on 40 relatively straightforward questions. The mean of 36 questions was more than 80 per cent. However, question A16 (b) on transformation had the lowest mean of 57.3 per cent. Moreover, three questions, A20 (c) on probability, A1 (b) on rational number, and A15 (b) on similar shape, had a lower mean of 70.7 per cent, 73.3 per cent, and 74.7 per cent respectively. This suggests that our primary trainee teachers are relatively weak in identifying a transformation of shapes, understanding concepts of rational and irrational numbers, and judging a probability of some unfamiliar events.

On the 20 common questions on mathematical concepts and understanding, there was not much difference between our primary and secondary trainees. There are some surprises here for us in that we did not anticipate that our primary trainees would have a higher mean on some questions than our secondary trainees.

Our primary and secondary trainees had the lowest mean on question 11 (primary 1.3 per cent, secondary 13.4 per cent). Even though this question was an unfamiliar one and would be difficult for our trainees to understand, it is obvious they are weak at logical thinking. The mean of question 12 (a) was also very low (primary 2.4 per cent, secondary 29.7 per cent); this suggests that our trainees did not have enough experience to tessellate a plane with different kinds of quadrilateral in their primary and secondary school mathematics.

The secondary cohort showed a high performance on the 20 more advanced mathematical questions. The mean of 14 questions was more than 80 per cent. However, question B9 on solving a trigonometric equation had the lowest mean of 59.3 per cent. Four questions, B7 (b) on an infinite geometric series, B14 (c) on a graph and a differential, B15 on a differential of logarithmic function and B8 on an arithmetic series, had a lower mean; 68.9 per cent, 72.7 per cent, 72.7 per cent, and 73.7 per cent respectively. For our secondary trainees most of these topics were taught in the advanced mathematical subject 'Mathematics III' at upper secondary school. It shows that some of our secondary trainees do not fully understand concepts of limit and calculus.

The comparison with other countries shows that our primary and secondary trainees are very different from the participants in other countries. The mean performance is relatively high, and the variation in the audit data is relatively low. This can be interpreted as a result of unique university entrance examination in our country. Our primary and secondary trainees were 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.

The primary and secondary mathematics audits in this international comparative study require a basic mathematical ability. Therefore,

Table 15: Audit data – Japan

	Part A		Part B		Total	
	Mean	Per cent	Mean	Per cent	Mean	Per cent
Primary	36.9 (out of 40)	92	15.9 (out of 20)	79	52.9 (out of 60)	88
Secondary	16.3 (out of 20)	81	17.1 (out of 20)	85	33.5 (out of 40)	84

During the teaching practice, they not only teach mathematics but also observe their peers' lessons, followed by lesson study to reflect on and share teaching ideas and skills among the group members.

among our primary and secondary trainees, there was not much difference in their mathematical performance on the audits.

Continuing Professional Development

In Japan, because the Law of Special Regulations Concerning Educational Public Service Personnel requires teachers to pursue consistent in-service training, various systematic programs are conducted at national and local (prefectural and municipal) levels, at schools and at other levels. For example, local boards of education are required by law to be responsible for planning and encouraging daily in-service training in local public schools. Local education centers that have lodging facilities, educational equipment and apparatus and professional staff, play an important role in in-service training. Local boards of education also dispatch teachers to universities, research institutes, private firms and other institutions for long-term training in order to improve their professional competence and their social character. Moreover, local boards conduct periodic in-service training at different stages of a teacher's career, for example, after five years, ten years and 20 years of service.

Teachers also have a right to take the training programs offered by local boards of education and to attend various lectures and workshops held by municipalities and educational organisations. Usually the local education authority pays money to enable teachers to undertake official CPD work. The CPD work is usually four/five-days program per year.

In addition, many schools do 'lesson study' as important school-based CPD work for teachers to understand their students deeply, and share and enhance their (mathematics) teaching philosophy and skills. Especially in some primary schools all teachers are requested to do a lesson each year, and sometimes university (mathematics) educators are invited to lesson study to enhance its quality.

Issues

Our main issue is that of the mathematical attainment of our trainee teachers. As a result of mathematics audits, our primary and secondary trainees showed a high performance on mathematics questions used in this comparative study. On the 20 common questions on mathematical concepts and understanding, there was not much difference between our primary and secondary trainees. However, we have summarised the data into three main concerns as follows:

- Our primary trainees seemed to be relatively weak in identifying a transformation of shapes, understanding concepts of rational and irrational numbers, and judging a probability of some unfamiliar events.
- Our primary and secondary trainees seemed to be weak in logical thinking and be lacking in experience to tessellate a plane with different kinds of quadrilateral in their primary and secondary school mathematics.
- Our secondary trainees seemed to not fully understand concepts of limit and calculus taught in the advanced mathematical subject at upper secondary school.

The mathematical attainment of our trainees is not the only issue; we should pay more attention to their weakness in thinking logically and understanding basic mathematical concepts, and their lack of concrete mathematical experiences in mathematics teacher training at university level.

The other main issue is that of continuing professional development. In Japan our trainee teachers usually do their teaching practice at University Attached Schools (University Practice Schools) in groups of four or six trainees with one or two mentors. During the teaching practice, they not only teach mathematics but also observe their peers' lessons, followed by lesson study to reflect on and share teaching ideas and skills among the group members. However, the teaching practice at school is for about one month, so our trainees do not have enough experience in both teaching mathematics and managing classrooms with difficult pupils. In that sense, the CPD work such as lesson study has the potential, especially for first year teachers, to become a real mathematics teacher, then continuously develop their profession and enhance the teaching and learning of mathematics supported and respected by school colleagues, pupils, and their parents. We need more detailed research on the effectiveness of lesson study for continuous professional development in mathematics teacher training.

"Russia is a large country and our aims were to have a sample of newly qualified teachers (trainees/NQTs) taken from different regions and Pedagogical Universities with different educational programs."

3.8 Russia

(**Professor Eugeny Smirnov**, Yaroslavl State Pedagogical University)

Overview of mathematics teacher training

Since 1917 the training of teachers has been done mainly at teacher training universities and institutes, which provide special courses combining the study of mathematics and education with pedagogical and technological training and teaching practice. Currently there are about 100 high schools for teacher training and about 200 different kinds of pedagogical colleges providing educational and professional programmes for the training of teachers. The Ministry of Education and Sciences co-ordinates, finances and supervises the activities of teacher training universities and colleges in Russia (state institutes as well as non-state, i.e. commercial ones). Table 16 below summarises some of the main features of ITT courses in Russia.

Sample

Russia is a large country and our aims were to have a sample of newly qualified teachers (trainees/NQTs) taken from different regions and Pedagogical Universities with different educational programs. These are Yaroslavl State Pedagogical University (YSPU), near Moscow, Vologda State Pedagogical University (VSPU), in the north of Russia and Perm State Pedagogical University (PSPU), in the Ural Mountains. We had 173 future teachers, 63 primary and 110 secondary.

Audit data

See Table 17 on page 40. In Russia the mathematical training for primary and secondary teachers is very different. The national standard for primary mathematics does not include high level mathematics whereas for secondary, training includes high levels of abstraction (functions of several variations, differential equations, functional analysis, theory of complex functions). Also, the level of scientific thinking of primary students is much lower than that for secondary. These two factors account for the differences in the courses for primary and secondary trainees.

In comparison with other countries, the data for the Russia secondary audit is good, but for

Table 16: Summary of some of the main features of ITT courses in Russia

<table>
<tr><th colspan="2">Type of Institute</th><th>1 year</th><th>2 year</th><th>3 year</th><th>4 year</th><th>5 year</th><th>6 year</th><th>Qualification of teacher</th></tr>
<tr><td rowspan="3">Classical University</td><td>Since 1958</td><td colspan="5">Linear Teacher Training</td><td>→</td><td>Mathematician
Teacher of high or secondary school</td></tr>
<tr><td rowspan="2">Since 1992</td><td colspan="4" rowspan="2">Bachelor of Science</td><td colspan="2">Master of Science</td><td rowspan="2">Mathematician
Teacher of high or secondary school</td></tr>
<tr><td>Vocation</td><td>→</td></tr>
<tr><td rowspan="3">Pedagogical University (Institute)</td><td>Since 1917</td><td colspan="5">Linear Teacher Training</td><td>→</td><td>Teacher of primary or secondary school</td></tr>
<tr><td rowspan="2">Since 1995</td><td colspan="4" rowspan="2">Bachelor of Education</td><td colspan="2">Master of Education</td><td rowspan="2">Teacher of primary or secondary school</td></tr>
<tr><td>Vocation</td><td>→</td></tr>
<tr><td colspan="2" rowspan="2">Pedagogical College (Secondary Vocational Training)</td><td colspan="2">→</td><td colspan="2">↑</td><td colspan="2"></td><td rowspan="2">Teacher of primary school</td></tr>
<tr><td colspan="4">Linear Primary Teacher Training</td><td colspan="2">→</td></tr>
</table>

Table 17: Audit data – Russia						
	Part A		Part B		Total	
	Mean	Per cent	Mean	Per cent	Mean	Per cent
Primary	30.5 (out of 40)	76	11.2 (out of 20)	56	41.7 (out of 60)	69
Secondary	17.3 (out of 20)	86	17.4 (out of 20)	87	34.7 (out of 40)	87

"In comparison with other countries, the data for the Russia secondary audit is good, but for the primary audit it is not so good…"

the primary audit it is not so good (one of the first three positions). In particular, question responses of students for secondary part B show high levels of mathematical training and professional skill.

For primary trainees there is concern that special attention should be paid to algorithms and calculating procedures, modelling of real processes, operations with integers, and nonstandard situations in teaching mathematics.

Attitudes data

From the list provided of the attributes thought to be the key qualities of an effective mathematics teacher, the modal response was 'excellent subject knowledge' with 'explains clearly' and 'well prepared' also strongly supported. We asked which area of mathematics they felt least confident about teaching and perhaps surprisingly 'geometry' was the modal response closely followed by 'probability', 'algebra' and 'statistics'. The main concerns about teaching mathematics for the secondary sample were varied, with 'linking theory and research to practice' and 'using ICT' highest but with 'forming relationships with pupils' the most popular choice, whereas, for our primary trainees, their modal choice was 'subject knowledge', with 'supporting less able pupils' and 'mathematical knowledge' also popular choices. For the primary sample, the choices were very different with 'class management' the modal response by far and 'teaching strategies' next in popularity.

Regarding the length of time expected to remain in teaching there were some surprising results. 'Two to three years' was the modal response, followed someway behind with 'will not teach'. This illustrates a big problem with the prestige of the teaching profession; for example, salaries are low, schools are under-resourced with lack of investment etc.

We asked each co-ordinator from the regions (Vologda, Yaroslavl, Perm) to interview three trainee teachers, secondary or primary. These trainees were being supervised by school mentors and school administrations. All trainees gave a very positive evaluation of school mentors' input into their adaptation and professional growth. One problem that was identified was the adaptation process for NQTs. The NQTs often observe open lessons given by experienced teachers, but they are uncertain as to how to put into practice themselves what they have observed. If the NQT is able to observe his fellow NQTs teaching mathematics to a high standard he will gain confidence in his own abilities. So it is very important for NQTs to observe some lessons given by other successful trainees.

Continuing Professional Development

Teacher training in Russia historically has different opportunities for providing continuous professional development (CPD). The Ministry of Education and Local (Regional) Administration pay for CPD work. According to National Law a teacher should undertake CPD in different ways: in-service once every five years; participating in the School Professional Society; applying for research grants; competitions (local or national); attending didactical seminars at university or local education centres; participating in conferences (national or international) and publication of articles; participating in research projects (national or international), and so on.

CPD work takes approximately 20 days per year. Every school in Russia has a School Professional Society (SPS), for didactical and

In 2003 Russia signed the Bologna Declaration and until 2010 we were part of the European educational area.

research activity for all serving teachers at the school. The Council of an SPS consists of teachers of high qualification, school administrators, heads of problem groups and methodical groups.

Issues

The good results obtained by primary trainees (82.5 per cent in education area) are explained by good practice in kindergartens or primary schools during their training period at university. However secondary trainees have a higher level of scientific thinking and managing skills.

In 2003 Russia signed the Bologna Declaration and until 2010 we were part of the European educational area. In short, we must move toward a multilevel system of education (Bachelor's and Master's degrees) that includes teacher training. This presents problems for Russia. Most teachers for primary and secondary schools are trained in Pedagogical Universities and Institutes (more than 80 per cent). The new approach will lead to late motivation on the teaching profession (after Bachelor's degree) and a shorter period of vocational education (one year). Some problems of such an approach can be compensated for by a longer period for trainees under the supervision of qualified mentors. However, historical analysis states hypotheses regarding the weak creativity of such NQTs. It will be very interesting to compare these positions with Russian and European teachers because it seems that European teachers are prepared using such an approach. As yet our Ministry of Education does not have a detailed program for the modernisation of teacher training, but the Pedagogical Universities will try to maintain the most positive traditions of Russian teacher training.

The audits show that there are positive and negative points in our educational system of teacher training. There are positive positions:

- Our strong conviction which is supported by Russian responses, that NQTs should have as their first priority 'to manage mathematical knowledge' in the teaching process. This was confirmed by the best results of Russia Secondary Mathematics Audits.
- School administration tries to provide for trainees' conditions forming the individual style of teaching and wide opportunities for career growth. A sustainable percentage of teachers study for PhD and undertake scientific research.
- It is a tradition in the Russian educational system to appoint school mentors for every trainee's TD, which helps to define the area of an NQT's methodical activity and diagnostic of initial teaching experience: skills, evaluation, problems and so on. Moreover some TD teachers became qualified teachers (nominated on first or second category) during their first year of teaching. All trainees value the role of school mentors in their adaptation and professional growth.
- Professional standard of pedagogical activity of teacher (PPS), which was created in Russia on 2007 under the supervision of the famous psychologist V. Shadrikov, is the basic landmark for trainees in defining methods of professional development. Indeed PPS is positive in developing good practice of teachers, and valid and psychological laws of pupil development. So it can define the main positions which will be addressed to trainees on their training courses.

There are some problems concerned with teacher training in Russia which become apparent through analysis of trainees' responses:

- The status, salary and morale of the teaching profession in Russia is low; many trainees leave the profession after only one or two years' teaching.
- Analysis of the primary students' skills (tutor's interview, exams, applications and correlation) suggests that real numbers should be learned more deeply with different kind of representations and using practical skills; our students have very limited ability to solve problems in nonstandard situations.
- It seems that the quality of mathematical skills and competence of future primary teachers will be improved if special attention is paid to algorithms and calculating procedures in teaching mathematics. So it is very important for NQTs to observe some lessons of other successful trainees.

3.9 Singapore

(**Dr Toh Tin Lam**, **Dr Koay Phong Lee** and **Professor Berinderjeet Kaur**, National Institute of Education, Singapore)

Overview of mathematics teacher training

In Singapore, the Ministry of Education (MOE) recruits suitable candidates for teaching positions in primary and secondary schools and junior colleges. All successful candidates not trained in teaching pedagogy are trained by the National Institute of Education (NIE), the country's sole teacher education institution. Their fees are paid by the MOE and they receive a full monthly salary. Upon successful completion of their training, they are deployed to teach in schools and have to serve a three-year teaching bond. Table 18 below and Table 19 on page 43 summarise some of the main features of ITT courses in Singapore.

Sample

Our aim was to have a sample size of about 300 student teachers in total from the Singapore National Institute of Education (NIE), the sole teacher training institute in Singapore. Altogether 308 student teachers participated in this study. Our cohort was a fair representation and they undertook both the subject knowledge audit and the questionnaires. They all completed these audits during specially arranged common

Table 18: Summary of some of the main features of ITT courses in Singapore

Primary			
Entry route	**Diploma in Education**	**Bachelor's Degree (Arts/Science)**	**Postgraduate Diploma in Education**
Length	**2-year**	**4-year**	**1-year**
Entry qualifications	For A Level holders: • 2+ A Level and 2 AO Level passes to include English[1] • 5+ O Level passes including English as a first language • At least O Level mathematics For polytechnic Diploma holders: • Polytechnic diploma • 5+ O Level passes including English as a first language and mathematics • Possibly entrance tests	For A Level holders: • 2+ A Level and 2 AO Level passes to include English • 5+ O Levels at grade C6+ including English as a first language • Grade D7+ in A Level 2nd language or in O Level 1st language • O or AO Level in mathematics For polytechnic diploma holders: • Any diploma with good results	An acceptable degree O Level passes in English, mathematics and a science.
Course components	Education studies, curriculum studies, subject knowledge, practicum, language Enhancement & discourse skills, group endeavors in service learning – a year-long student initiated group project		
		Academic subject	
Time in school	15 weeks	22 weeks	10 weeks

[1]O, AO and A Levels refer to the Singapore-Cambridge GCE.

Mathematics specialists must have a grade B at A Level mathematics/further mathematics (or pass the Mathematics Qualification Test).

All trainee teachers, who will be teaching curriculum subjects in the English language, need to pass the English Entrance Proficiency Test for admission into NIE.

"In Singapore, the Ministry of Education (MOE) recruits suitable candidates for teaching positions in primary and secondary schools and junior colleges."

The median performance of the Singapore student teachers was ranked fourth, topped by Russia, China and Japan.

Table 19: Summary of some of the main features of ITT courses in Singapore		
Secondary		
Entry route	**Bachelor's Degree (Arts/Science)**	**Postgraduate Diploma in Education[1]**
Length	**4-year**	**1-year**
Entry qualifications	As for primary	An acceptable degree Depending on level of mathematics to be taught, there are different requirements regarding mathematics qualifications
Course components	Education studies, curriculum studies, subject knowledge, practicum, language enhancement & discourse skills, group endeavours in service learning – a year-long student initiated group project	
	Academic subjects (2)	
Time in school	22 weeks	10 weeks

[1]The PGDE qualifies trainees to teach mathematics and another subject at secondary school

All trainee teachers, who will be teaching curriculum subjects in the English language, need to pass the English Entrance Proficiency Test for admission into NIE

timeslots in the form of paper-and-pencil tests. The student teachers were briefed clearly on the objectives of these audits.

Audit data

See Table 20 below. The median performance of the Singapore student teachers was ranked fourth, topped by Russia, China and Japan. From the results of the secondary school mathematics pre-course and post-course audits, it is clear that the student teachers entered NIE with reasonably good knowledge on topics related to the school mathematics curriculum. Most pre-service teachers across the different programmes were able to perform standard mathematical procedures and solve the problems that are within the secondary school mathematics curriculum with a rather high level of accuracy.

The individual questions with the lowest number of correct responses were questions 11 and 12(a) from part A of the audit:

Question 11

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?

Question 12(a)

Mark the following statements 'a square is a rectangle' as:

A. always true ☐

B. sometimes true ☐

C. never true ☐

Table 20: Audit data – Singapore						
	Part A		Part B		Total	
	Mean	Per cent	Mean	Per cent	Mean	Per cent
Primary	-	-	-	-	-	-
Secondary	15.3 (out of 20)	76	16.6 (out of 20)	83	32 (out of 40)	80

CfBT Education Trust

It is of some concern that the student teachers appear not to have understood the concept of tessellation, which occurs mainly in the Singapore primary school mathematics curriculum.

It is understandable that the student teachers were not able to answer question 11, since this is a counting problem solvable by using Pigeonhole Principle, which is not in the Singapore O Level and A Level mathematics curriculum. Our student teachers are not particularly proficient with discrete mathematics in general and counting in particular.

It is of some concern that the student teachers appear not to have understood the concept of tessellation, which occurs mainly in the Singapore primary school mathematics curriculum. This suggests that the student teachers' knowledge of mathematics tends to be bound by the school mathematics curriculum – all those questions with the lowest scores are those whose content is not included in the Singapore secondary school mathematics curriculum.

Attitudes data

The attitude questionnaire was also administered to the entire cohort of the student teachers. From the findings of the questionnaire, generally the experiences of the subjects were positive. They enjoyed mathematics at school, excelled in it and felt proud of what they did in mathematics lessons. They also helped their friends and sought help from others to do mathematics. Only about half of them claimed that they worked hard for it and thought it was the most important subject at school. Generally the attitudes of the prospective secondary school mathematics teachers towards the subject of mathematics were varied. Almost all of them regarded mathematics as an exciting, creative and beautiful subject always or at least sometimes. The majority of them (80 per cent) felt that the process was more important than the product when solving a mathematical problem. About four-fifths of them felt that mathematics is best learned as modules (algebra, geometry, etc.) rather than as an integrated course. However, only a fifth of them felt that it was not important to learn multiplication tables and formulae by heart, implying that conceptual understanding was important compared to instrumental understanding (i.e. knowing the rules and applying them). Almost half felt that the use of technology was important for the teaching and learning of mathematics. Almost three fifths of them were confident that they will make a good mathematics teacher.

With regard to the most important aspect to pass on to their students, more than half of them felt that it was important for their students to engage in problem solving, experiencing the different approaches to solve problems and a sense of achievement during the process of solving problems, and developing a systematic approach to it. More than a quarter of them felt that it was important for their pupils to understand the mathematical concepts and have a strong foundation in them. About a fifth of the students felt that making explicit the relevance of learning mathematics was important.

With regards to what they would choose to do differently from the way they were taught mathematics when they were students, about two-fifths of them would like to engage their pupils in exploration and investigations to learn mathematics. Also, two-fifths of them would like to use manipulative and hands-on activities to teach mathematics. More than three-tenths of them felt that they would like more interaction with their students and more than a quarter would like to use information and technology tools to engage their pupils in learning mathematics.

Issues

From this study, we observe that generally the student teachers performed well in school mathematics. From the attitude survey, we also observe that the student teachers' experiences of doing mathematics in school were positive; generally, they enjoyed mathematics, excelled in it and felt proud of their achievement.

Their attitudes towards the subject were both positive and not so positive. On the one hand, they regarded mathematics as an exciting, creative and beautiful subject and felt that the process was more important than the product when solving a mathematical problem. On the other hand, they showed preference for learning mathematics as distinct modules, such as algebra, geometry, etc. and learning multiplication tables and formulae by heart, implying that instrumental understanding (i.e. knowing the rules and applying them) took preference over conceptual understanding.

It is crucial that the student teachers be equipped with significantly more mathematics than that stipulated by the school curriculum, in anticipation of the rapidly changing educational landscapes in general and the mathematics curriculum in particular; especially when there is a worldwide trend of the mathematics curriculum moving towards modelling and applications. We propose that teachers should be equipped with more mathematical knowledge of 'modern mathematics' through in-service professional development courses, in anticipation of the changing trends in the mathematics curriculum, thereby preparing them to be competent classroom teachers of the future.

The preparatory course for training a secondary mathematics teacher lasts up to five years (Specialist or Master's degree – five years, Bachelor's degree – four years).

3.10 Ukraine

(**Professor Sergey Rackov** and **Dr Tatyana Vakulanko**, State Pedagogical University, Kharkov, Ukraine)

Overview of mathematics teacher training

The preparatory course for training a secondary mathematics teacher lasts up to five years (Specialist or Master's degree – five years, Bachelor's degree – four years). The diploma is complicated and includes a specialism with an additional specialist subject, for example mathematics with informatics; mathematics with physics; mathematics with English. Primary teacher training is provided in specialised higher educational institutions or pedagogical universities. It includes six educational areas: mathematics, language and literature, science, art, prevocational education and modelling, and physical training. Primary teachers' training is conducted in pedagogical colleges, institutes and universities, with a college being the lowest level of training. The duration of study is two years after graduating from a high school or four years after eight years of school education. Table 21 below summarises some of the main features of primary ITT courses in Ukraine.

Sample

Our aim was to have a sample size of about 200 in each of primary and secondary, and taken from a number of teacher training institutions. We did not quite achieve the goal. In secondary the audit was performed in four universities. The total number of participants was 113. Within the primary cohort we worked with three universities and 83 students took part in the audit. The audit was overseen by experienced teachers; all the tests were taken in class, so we were able to observe the procedure.

Audit data

See Table 22 on page 47.

Only a few students answered questions A1b and A15b:

Question A1b
Find the rational numbers among the six numbers:
$\sqrt{2}$, 0.1, $\frac{8}{9}$, π, 9 and 4

There was only one question for which primary school trainees had higher results than secondary school trainees and that was 13b. In general it is obvious that secondary school trainees had higher results on similar questions. When looking at section B for the secondary cohort we may notice that most of the questions were not very difficult for students. We should also notice that there were a number of students who completed all the questions.

Attitudes data

The responses to the questionnaires were quite interesting, especially when comparing the responses of the primary and secondary cohorts. For example, we asked both primary and secondary participants what they felt were the most important attributes for a teacher of mathematics. The difference in the responses between our primary and secondary trainees

Table 21: Summary of some of the main features of ITT courses in Ukraine

Type of educational institution	Qualifications	Specialty
Pedagogical specialised secondary institution	Pedagogical University	Primary school teacher
Pedagogical College	Junior Specialist, Bachelor	Primary school teacher
Pedagogical Institute	Bachelor	Primary school teacher
Pedagogical University	Specialist, Master	Primary school teacher, teacher of psychological and pedagogical subjects

The responses to the question 'length of time trainees expect to remain in teaching' were disappointing for our educational system.

Table 22: Audit data – Ukraine

	Part A		Part B		Total	
	Mean	**Per cent**	**Mean**	**Per cent**	**Mean**	**Per cent**
Primary	23.8 (out of 40)	59	8.0 (out of 20)	40	31.4 (out of 60)	52
Secondary	15.5 (out of 20)	77	16.7 (out of 20)	83	32.2 (out of 40)	80

was significant, for example in the ranking of 'excellent subject knowledge'. For the secondary cohort this was one of the top attributes named, but for the primary it was not as important. Both the primary and secondary cohort supposed that 'excellent subject knowledge' was very important as well as 'well-prepared', 'explains clearly', 'encouraging' and 'supporting'. Such qualities as 'sympathetic', 'enthusiastic', 'kind' and 'punctual' were not of great importance in the trainees' opinion.

Another question with interesting results was 'topics which trainees did not feel confident about'. As we expected, 'probability' and 'fractions, decimals and percentages' were some of the main concerns of the trainees. It was surprising though that 'problem solving' as well as 'application' were the topics in which trainees felt confident but the results of the test did not confirm this. Additionally 'geometry' and 'mensuration' were the fields of concern to the primary cohort. We should also say that in general, primary trainees felt less confident in the subject field. This is confirmed by the results of the audit.

We also asked the trainees to give their main concerns about teaching mathematics that they hoped would be covered in their training course. The secondary trainees clearly had most concerns about 'pedagogy' and 'relationships with pupils'; they were also interested in 'identifying good practice'. Unfortunately, there were some students who did not have any concerns; we understand that is mainly because those students did not want to work as teachers. In most of the categories the primary cohort differs little from the secondary one, but they are especially concerned about 'supporting less able children'. It is rather surprising that such topics as 'management of resources', 'using ICT', 'assessment' and 'linking theory and research practice' are not of great concern for our trainees, which is the consequence of the real situation with resources in Ukrainian schools.

The responses to the question 'length of time trainees expect to remain in teaching' were disappointing for our educational system. Over 15 per cent of secondary trainees will not teach. And more than three per cent are intending to teach for only one year. The situation in the primary cohort differs. More students want to work in schools for life and none want to teach for just a year. Fewer than ten per cent are not going to teach.

We interviewed some students from the secondary and primary cohorts. The generalisation of the answers gave us some results. Most of the students would like to have more special courses. They want to have more time studying mathematics. Many trainees complained about the number of general courses. They admit that these courses help to broaden their minds, but they would prefer to study more special subjects. Most of the students appreciated the attitude of their teachers. They stressed the fact that the teachers supported them and gave them a greater understanding of the subject. The students though emphasised that they need more understanding of the possible applications of theoretical material. Quite a few students want to become principals in schools or at least work in school administration.

Issues

Unfortunately, the processes in mathematical education in Ukraine starting with its independency were not very productive. The number of mathematical lessons per week has decreased. Some schools even provide

"The development of methods based on a social constructivism approach is becoming more popular in Ukraine (more than 50 per cent of classes use this approach)."

fewer than three lessons of mathematics for students per week. Furthermore, the process of reforming assessment (there are no negative marks in Ukraine) has fully influenced the desire of students to learn and mathematical courses both in primary and secondary schools are becoming less and less fundamental, concentrating on reproductive methods of solving standard problems.

Ukrainian teachers of mathematics are not socially respected which is seen from their salaries. The average starting salary for a teacher in Ukraine is about 900 hryvnias (about $120) per month (half the average salary in the country). Their teaching practice in the university is not successful; mainly because the number of hours for practice is not significant and because the number of students at one school is very large. In particular, faculties for primary school trainees are not very popular among the school-leavers, which is why the initial knowledge of mathematics in school is very low. This consequently influences the results of learning. Few professional teachers want to provide workshops for the students.

Trainees are mainly interested in observation of demonstration materials, some real lessons, new methods of teaching and they are not provided with that during their training programs.

It is very disappointing that the level of mathematical education since 1990 has significantly decreased. A high level is maintained only in specialised mathematical schools which gives the impression that all is well in the country. Our data showed that many trainees, especially in secondary schools, do not plan to teach, and their low motivation reflects on the quality of education in the whole, which explains the results of our audit.

Nevertheless there are some attempts to change the situation in mathematical education. The development of methods based on a social constructivism approach is becoming more popular in Ukraine (more than 50 per cent of classes use this approach). Specialised mathematical IT laboratories with special educational software are being given to schools and an obligatory national entrance test to Universities on General Educational Competence (GEC) is being developed.

There is one issue that is highly important for Ukraine. In the times of the Soviet Union the educational system was very scholastic; it was based mainly on theoretical investigations and abstract categories. Independence has brought a new understanding of mathematical teaching. Trainers wanted to make it more practical, but unfortunately they had only partly achieved their goal. New approaches helped to make mathematics less abstract but did not make it more practical. It is a great hope of the whole educational system that the situation will change and that mathematics will become a practical science with a significant theoretical base.

4. 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.

4.1 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.

4.2 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.

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

4.3 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.

4.4 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.

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4.5 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.

4.6 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.

5. 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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