

Report on International Maths Research Programme China 2014

By Specialist Leaders in Education (SLEs) in Mathematics in Shanghai and Ningbo, China 10-17 January 2014



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Introduction

It's a teacher's duty to teach but a student's duty to learn'.

Chinese student

The National College's International Maths Research Programme (Phase Two) for Specialist Leaders of Education (SLE) was provided to stimulate improvement in the quality of Maths teaching in England by investigating approaches used in those Chinese schools achieving top international rankings.

Designed in collaboration with the National College's Chinese partners, the Nottingham Ningbo International Leadership Centre and Shanghai Normal University, it built on research by National Leaders of Education (NLEs) and subject leaders in 2013 and the two reports published by the National College.

50 SLEs, from primary and secondary phases, were selected because of their potential, as highly successful system leaders, to influence wide networks of schools; their track record in curriculum innovation; and their commitment to adapt and apply their findings in their own and partner schools.

In preparation for the study tour participants considered themes and developed appropriate research tools with experts from Nottingham University. An intensive, eight-day residential research programme took place in January 2014 in the Shanghai and Ningbo regions. Participants visited four schools and two universities, receiving high-level briefings on the Shanghai education system and an analysis of the PISA 2013 survey by the Director of the Shanghai PISA Centre.

Participants explored the educational priorities and culture of schools visited. Through discussion with principals, teachers, teacher trainers, students and with some classroom observation, they learned about teaching methodologies as well as curriculum and assessment strategies, gaining insights into those aspects which have proved so successful in securing high attainment levels. The focus on teaching and learning enabled SLEs to explore more deeply some of the issues investigated by Phase One participants.

This report reflects the personal observations of participants from their diaries, observation records and interview notes, based on comments gained from the highest performing schools in Shanghai and Ningbo.

Recommendations are based on reflections prompted by what was observed. Much was striking and inspiring, although there was no exposure to middle or lower ability students or those in vocational schools. Access to schools, however, reflects a growing trust and new partnerships with the region from which system leaders benefited.

The research has identified transferable elements to bring about improvements in schools in England. Implementation ideas are now being considered in alliances. An Evaluation and Implementation Conference in March 2014 will discuss implementation plans, the dissemination of findings and strategies to develop this work.

A later report in December 2015, published by the National College, will describe the impact of Phase Two implementation over time of ideas trialled and successful practices introduced.

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Shanghai's secrets

'If we were to combine UK pedagogy with Shanghai structures, we would have an unbeatable Maths education system'.

SLE, South Dartmoor Community College

School organisation, structures and culture account for Shanghai's world-class results in PISA tests. In 2012 in Maths, Shanghai was ranked number one in the OECD with a score of 613; the UK was ranked 26th with a score of 494 which was also the mean. Where Shanghai leads the world, England is merely average.

Although England has the benefit of flexible, responsive teaching, changes could be made to improve teacher training and development in Maths, to increase the use of practise and improve number skills, to raise expectations of teachers and students, and to improve the quality of learning.

Teachers in England have a far greater repertoire of pedagogical skills than their counterparts in Shanghai whose preferred style is explanation, lecture and testing. Some lessons observed would have been given low grades by inspectors in England because of their need to see rapid progress. However, lessons were always prepared with immense care by specialist Maths graduates; they engaged the pupils and taught material at a significantly higher level than in equivalent classes in England.

Highly skilled teachers in England, working much harder than their pupils, use a wide variety of techniques in their classrooms to engage and motivate. Their methods encourage teamwork and the discovery of Mathematical concepts through exploration and investigation, creative approaches which are admired by the Chinese and are now being copied by them.

In Shanghai the pupils, demonstrating remarkably high levels of resilience, devote their young lives to gaining Mathematical knowledge and skills. Their efforts, the result of parental expectations, teacher focus and school structures, far exceed those of pupils in England. Structural rather than pedagogical changes are required if results in England are to improve.

Five distinct, deeply rooted practices define the Shanghai approach:

System 1: Practice and consolidation

Early training in number is the basis of all Maths learning with constant formal practice and repetition so that children demonstrate an assured fluency of use which supports accelerated progress. Mastery is achieved, not through reliance on repetitive drills, but through a rich variety in styles and approaches of practice questioning.

System 2: Specialist Maths teaching

In order to qualify, teachers are required to have a degree in their specialist subject. Graduate Maths specialists teach primary Maths, whereas in England, primary Maths teachers are unlikely to have Maths beyond GCSE level.

System 3: Efficient teaching

Low class contact ratios mean the Chinese teach a small number of collaboratively planned lessons each day with a smaller spread of teaching groups so that some lessons are repeated with the same age classes. Teachers work together rather than in isolation.

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System 4 Immediacy of feedback and interventions

Maths is taught in the morning: work is marked and returned by the end of the day. Prompt assessment supports rapid progress. Homework, handed in at the start of the day, is marked in time for the lesson later that day- a virtuous cycle of assessment supporting learning.

System 5: Preventing rather than closing the gap

Children are given additional help before they can fall behind, in the belief that everyone is capable of learning and that there are no intellectual boundaries to knowledge. Whereas in Shanghai, children work immeasurably harder than their teachers, in England the opposite is true.

'We are not better at Mathematics. We just have more knowledge. There are no Nobel winners from China.'

Engineering student, Nottingham University Ningbo campus

Professor Zhang, Director of the Shanghai PISA Centre, outlined the three traditional and the six modern concepts which underpin the region's success:

Traditional Concepts

1. Chinese high educational expectations are supported by stories and legends. The importance of learning has deep cultural roots, forming an unshakable belief system which shapes the national character.
2. There is a universal belief in diligence, persistence and hard work as instruments of change by which families and individuals, whatever their status or wealth, can shape their future.
3. An open and public examination system has safeguarded these two traditions from generation to generation for over 1300 years. Whether a farmer or a king, the individual must study hard and take the same examinations. Teachers must pass examinations to gain promotion. During the two semesters in the school year, pupils are examined and the results eagerly awaited by parents who suffer 'loss of face' if their children perform badly. Children are ranked from the age of five, as are their classes and the schools, creating a tier system.

Modern Concepts

1. There is an open door policy with the borrowing of the latest knowledge, experience and approaches, as scholars study abroad, producing educational diversification. Remarkably, there are more Chinese studying English than there are English speakers in the United States. For the Chinese, English is a tool to learn from the world.
2. There have been three rounds of curriculum and teaching reforms since 1986 with the latest emphasis on personalised learning and the development of creativity.
3. Teacher professional development continues to be a priority, with a variety of in-service training devices. For example, teachers have to spend 360 hours, partly in local district training centres, developing their professional practice during the first five years of their career. Subject specialists meet in research groups for two hours every week to share tacit knowledge with similar meetings for year groups. Masters degrees are a common form of CPD. Reading in libraries is also encouraged.

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4. 'Empowered management' has involved high performing schools supporting lower performing ones.
5. Local educational levies have led to the transfer of around 40% of funding from rich districts to poor ones.
6. High-performing schools have 30% of places designated for pupils from low-performing schools.

PISA test results have been used to inform the Ministry of areas for development, to overcome what they term their 'blindnesses'. The Chinese system is moving quickly towards the development of creativity and the use of interactive learning. There is now an acknowledgement, endorsed by the students themselves, that the emphasis on Maths, Science and reading has restricted the time for other subjects.

Shanghai's success is thus the result of learning from research, investment in teacher development, infrequent but measured policy changes, support for schools with difficulties and a focus on social mobility and equity. Key to success lies in the Chinese ability to develop highly skilled teachers and retain them in the classroom, supporting the learning in other schools.

In contrast, in England the highest performing teachers frequently move into management roles: we recognise a teacher's skills by removing them from the process of teaching.

Five Shanghai systems

System 1: Practice and consolidation

'It is impossible for a child to lag behind. We do not let them.'

'We are not better at mathematics. We practise more.'

Shanghai teachers

Formal practice and repetition are part of Chinese educational culture and used in Grades 1 to 3 (ages 5-7) to master the basics, widening the variation in question styles, strategies and applications from Grade 3. Mastery is achieved, not through reliance on repetitive drills, but through a rich variety in styles and approaches of practice questioning. This supports deep understanding. In England, many teachers do the opposite: applying a wide range of methods and strategies in the early years followed by a narrower, repetition-style of questioning, particularly for children where basic calculation techniques are not mastered by the age of 7.

At primary level there are four areas of study: number/algebra; geometry; probability and statistics; and applied mathematics. In grade one, children add and subtract from 1-20; in grade two, they multiply and divide 1-100; and by grade three they carry out all operations from 1 to 10,000.

The focus is on mental mathematics and core numeracy skills, whereas western approaches concentrate on enquiry. In Shanghai, the first two years of school focus on developing number sense and learning number facts so that children have this knowledge to build on when learning broader concepts later. Early training in number is the basis of learning. Teachers even make up limericks and ditties to act as aids to help memorise facts.

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The Chinese have limited, agreed methods of solving calculations and these are taught thoroughly and with absolute clarity. In England, especially in EYFS and KS1, there are several calculation methods taught which can be confusing for children, especially the less able. In China, there are no number lines, grids or expanded methods. Children learn one way at primary school then expand their thinking at secondary school about the numerous ways to do a calculation. This is the opposite to England, where primary schools teach an array of methods which are reduced at secondary school.

Everything becomes easier once the fundamental rules of number are assimilated. When multiplying, one formula is used. Children are asked to recite the formula and then devise their own, gaining understanding of the relationships and pattern building between numbers.

By the end of grade two, multiplication tables have been learned so efficiently that recall becomes natural and children demonstrate an assured fluency of use. Almost endless practice with early calculations makes the Maths taught later easier to complete.

The starting point for the teacher is to establish the understanding of facts which, as early as grade 3, leads to the application of more abstract concepts. They can begin to solve simple problems at this stage. While children are used to reciting formulae, they are now expected to find the formulae themselves. Children are, therefore, confident mathematicians. Given a problem, they attack it, using their personal toolkit of number facts and skills, embedded from an early age.

In China, there is a clarity around calculation strategies which is lacking in the English system. Simplification would provide clarity for all on progression which should take place only when mastery has been achieved, with strategies in place to ensure that no pupils fall behind.

The calculation strategy used is less important than the process and steps to get there. In England, children are taught a range of strategies for each operation, some mental, some written. There is an element of choice for children. Although it is important that children are able to look at numbers and make decisions about whether it is a calculation they can do mentally or with a written strategy, understanding of progression is crucial.

Clear links are made explicit to children when teaching written strategies. Children are given a step-by-step guide. The learning is relational, using visual representations before moving onto more abstract learning: 'If you know this, then you know this.'

Review lessons are used to consolidate learning. Children may do up to one hundred examples of the same problem. The practice, consolidate and re-visit model promotes deep learning because it focuses on depth rather than breadth of skills and knowledge.

In England, teachers move perhaps too quickly to new concepts in order to try and cover the curriculum. The pressure of moving on detracts from the need to embed these concepts fully. Calculation needs constant repetition so the children can then apply the skill to higher-end problems. Children are overloaded with methods and strategies before they have mastered some. The Chinese, in comparison, provide a clear method of calculation with options later to extend. This way the children always have a basic strategy to fall back on.

Real applications

Wherever possible, real applications are used. Lessons are always based on a real life problem and taught at a pace which encourages deep learning. Children are not moved on to new calculation or topic until full understanding has been gained.

Counting involves real items. Children first need to establish their thought patterns so that they can later grasp more difficult concepts. The numbers increase but the methods remain the same.

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Connections are made between the different strands of Maths with constant references to earlier work so that links are made. Practical apparatus are used as long as necessary.

Chinese teachers are clear about what they are teaching and what the children will learn, giving a real-life purpose as to why the work is important and allowing children to give their own ideas. In England, children are often unclear about why they are learning certain aspects of Maths and how the subject relates to real life. In English primary schools, teachers often provide children with a 'creative' application to use Maths such as compass points on a pirate ship or buying items for a monster tea party, but much is not sufficiently real or meaningful.

The Chinese approach ensures application by giving the children a problem and allowing time and practice to generate different ways of solving it. Children can look at any problem and select from a range of strategies. Teachers described giving the children a recognisable situation and asking what Maths would be needed to solve the problem outlined. They practice the same calculation but it is set in different ways and related strongly to their everyday life, their school or their city. This real life application means they can practise skills in different contexts outside school.

A concept is introduced and the context is slowly but precisely changed, broadened and extended. For example, addition is introduced visually with real objects, then with a range of other visuals combined with a written representation before connections are made by looking at its commutative and inverse relationships.

A lesson on compass directions, for example, revealed the deepening of understanding through a series of ever more complex but always familiar examples embedded strongly in real life contexts. There were elements of pupil talk on and around tables as well as opportunities for children to move around, comparing ideas from group to group.

Teachers regularly make connections between all areas of Maths. In the early stages they show children that + can be done in any order and also are constantly showing the connection between + and -. This is also evident in how the connections are made with different methods of representing a calculation.

Core textbooks, available to all schools, give teachers a baseline from which to work. Textbooks follow a logical structure and provide a clear progression of skills, covering number and algebra; geometry; problem solving; and application. Connections are central to textbooks, and to planning and teaching. Practice questions in English textbooks are less varied than those observed in lessons and books in Shanghai and Ningbo.

Teachers do not plan discrete application tasks. Instead a lesson or series of lessons revolves around an expanding concept rather than a linear one. This allows children's learning to develop at a far quicker pace as they have developed both a sound procedural and conceptual understanding.

Visuals form a key part of teaching. Central to the success of many of these is using 'five' to help support calculation. Children are encouraged and supported to make connections between number bonds to and from ten.

The published results of formal examinations in the middle and end of each year enable children to know their rank position in class. Moreover, parents are aware of this also, and the 'loss of face' or humiliation for them if their children fall behind is an additional pressure.

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System 2: Specialist Maths teaching

'She teaches Maths like a poem.'

said of Ningbo teacher, Mrs Su

'I am a master teacher in Mathematics, not in other subjects.'

Shanghai teacher

Specialist knowledge

Whilst teachers in England are judged largely on pupil attainment, recognition is given to Chinese teachers on the level of their reflective practice, the length of time they have been mentored, whether they have mentored others, and the research papers they have published. The development of teacher expertise is as linear as the development of mathematical skill. Teachers are an investment and are valued.

Although the English system concentrates on pedagogy and practice in training, the Chinese, in contrast, develop subject expertise to a high degree. In order to qualify, teachers are required to have a degree in their specialist subject. A national written test of subject knowledge is an additional requirement.

Pedagogy and practice feature in teacher development only when subject expertise is at an exemplary level. Coaching and mentoring provide these elements. There is very little focus on pedagogic knowledge during training with only around two months in schools and some micro-teaching which involves classroom simulation and peer teaching which is filmed and analysed. Graduate specialists teach primary Maths, whereas in England primary Maths teachers are unlikely to have a Maths qualification beyond GCSE.

Classroom Observation

How efficient is the English system of two formal observations a year with all the bureaucracy of preparation, interviews and target setting when compared with the on-going learning observations practised by the Chinese?

SLE, Driffield School & Sixth Form

During their first years in schools, teachers observe established teachers. In England there are requirements for senior staff to observe new teachers but not for them to observe, and learn from, experienced colleagues.

Teachers, particularly those new to the profession, also observe lessons in other schools, attending seminars and discussions. As a matter of course, a new teacher in Shanghai will have a mentor to observe lessons once a week.

Time is allocated during the day for teachers to perform CPD activities without detracting from the classroom contact. Frequent observations are a part of daily practice, carried out in non-judgemental ways. Lessons are rarely graded. In addition, teachers complete either 360 hours or 540 hours of CPD activities, with access to local district colleges, depending on their current status.

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Teachers can aspire to become 'famous' or master teachers, providing demonstration lessons which give the staff inspiration and offer guidance to younger colleagues. The progression through the profession for classroom teachers is clear and does not require them to move into leadership positions to advance up the pay scales.

A young teacher described the opportunity she had for fifty teachers to come into her lesson and give her comments on her teaching. In England such lesson observation is a source of stress. Teaching quality is based on observations over a period of time, test results and student questionnaires. In this 'learn together' culture, weak teachers are given a great deal of support, with daily observations by experienced or retired colleagues.

While graded lesson observations should be reduced in England, peer observations, carried out in open, supportive and non-judgemental ways should increase.

Teacher research

'Confucius is my best teacher.'

Shanghai teacher

A significant amount of a teacher's day is given over to research- an investigation of readily available information. Research involves talking to more experienced colleagues and reflecting on previously delivered lessons. Master teachers produce work of greater academic value with more structured and co-ordinated reflection on practice.

Teacher research groups might have the following themes:

- Study of the curriculum
- Differentiating the curriculum
- Discussion of class-based issues and group resolution
- Hot topics
- Discussion and debate around teaching methods
- Learning together from the corpus of academic knowledge

A teacher research paper was titled: 'Probability in life and life in probability'.

Teacher research has resulted in interesting innovations. One school had set up a database for all classes to identify misconceptions taken from tests to inform future teaching. The database evidence was collated to draw out common mistakes over several classes. These appeared on multi-step questions and were addressed in homework with classes.

System 3: Efficient teaching

"Each lesson reflects the power and effort of the team behind them."

Shanghai teacher

Time

Given the focus on efficiency, it is not surprising the group felt that the Chinese education system deployed its teachers more effectively than the English system. Chinese teachers in primary and

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secondary schools teach fewer, more focused lessons. The Chinese system values depth, whereas the emphasis in England is on breadth. Students are not set and the teachers do not have different expectations for different abilities.

Fifteen year-olds in Shanghai are taught Maths for around six hours a week in class with at least an hour each night- a minimum of eleven hours a week. Thus, they spend twice as much time on the subject as their counterparts in England.

The system in Shanghai focuses on the development in five subjects rather than eight or even ten subjects. Over a third of the curriculum in a junior secondary school (12-14) is devoted to Chinese and mathematics whilst at senior secondary level (15-18) over half of the teaching is concerned with science and Mathematics.

This narrower curriculum provides the increase in Maths time. In primary schools, the Chinese language and Mathematics are the required examination subjects for graduation, while the other subjects are treated as check-up subjects; progress is measured, but not considered essential for graduation. If Mathematics, Science and English are core subjects in England, we need to consider their status and time allocated.

Pupil-contact ratios are remarkably low. Teachers are responsible for no more than two or three lessons per day. The rest of their time is used to plan, mark and tutor children who have struggled in a lesson. A teacher might spend five or six hours planning a single lesson.

Teachers generally follow the same two classes for up to six years. This provides a solid foundation in students' understanding of concepts, ensuring the teacher is aware of individual needs and able to personalise the learning. The teacher is also more accountable for an individual's long-term progress. In England, teachers tend to work with pupils for one or two years at most, and accountability resides with the KS4 teacher.

A typical teacher's day involves:

- Eighty minutes teaching
- Checking and marking homework and classwork
- Tutoring students needing help
- Planning lessons in teams
- Carrying out research alone and in subject/year-based teacher groups
- Working with peers to improve teaching
- Observing colleagues and being observed.

Lessons are 35-40 minutes in length and surprise was expressed by the Chinese that they should ever be longer. This time with the teacher is highly efficient with specific and purposeful teaching the entire time. Teachers impart subject knowledge which the students practise at home.

Lesson structure

Classroom routines and systems are deeply embedded. Teacher talk is focused around the lesson content. Systems and routines reduce the need for talk relating to classroom management. A demonstration lesson revealed the intrinsic self-discipline of Chinese students. The students were trained to know exactly what they should be doing in the lesson. Talk partners were used and the students were animated, but at no point was behaviour an issue; the teacher trusted them to complete the task.

The grouping of the pupils was determined by their height and sight; bright students are placed to help less able pupils. The worksheets that were needed were already placed on desks. When it came to work on them the teacher issued simple instructions and the students instantly began to work.

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Concentration was absolute until the lesson ended when the students chatted, used phones, talked and joked. This highlighted the amount of learning time lost in lessons in England to behaviour management.

Lessons are traditional in nature with the teacher talking for the majority of the time, asking questions of individual students when required. Students will typically stand to answer questions, although in the older years there appeared to be a more open discussion with some calling out of answers. Ample time is given for consolidation and an expectation that students would continue this at home.

The main focus of lessons is the consolidation of knowledge rather than the delivery of content. As preparatory work is completed before the lesson, students arrive knowing the content already. Feedback from high performing students in England suggests that they prefer this because they come to the lesson knowing which parts they find difficult and have more time to go through practice questions and focus on high grade questions. There is already evidence that this increases student confidence. Whilst OFSTED might not regard this as demonstrating rapid progress, in fact greater progress will be made because more time is spent consolidating. This technique also, of course, requires high levels of student motivation and willingness to work independently.

The lesson structure consists of the teacher directing and reinforcing, followed by a short activity, with further teacher direction and reinforcement before another short activity. There is merit in the shorter Maths lesson, although, again, this structure would not meet OFSTED requirements.

During lessons, students are given consolidation work so the teacher is free to circulate and support those who need help. Students who master the skills of self-study can consolidate their learning and peer coach.

If students find an aspect of the work difficult, they are encouraged to try and find a solution first before asking a classmate. Only after this stage, will the teacher help, not by giving the solution but by showing them how to find the solution. During a lesson, children will never say they have finished or are stuck. Instead, they see the teacher afterwards to seek help. Similarly, teachers call students to their office to deliver additional support after a test.

Teachers teach students how to think. Asked what she did when stuck, one student explained that she would 'try another way'. When a teacher was asked about proportional reasoning she said that she taught a way of thinking and a way of solving problems. Students look at key words and then think about what they know and how they can apply their knowledge to the problem.

In England, we would benefit from using peer support more and asking the students to persevere with a problem for longer, developing the trait of resilience in which the Shanghai system scores so highly in PISA.

Teachers generally focused on the best and worst children providing the same work for all regardless of ability. Students reported that, if they became bored because work was too easy, they were not set harder tasks. Extra challenge was provided through homework or private tuition.

The content of lessons is far more advanced than in the UK. An observed year 10 class, for example, covered material which would stretch year 12 students in England. Answers were chanted. Some pupils did not follow what was being taught. They watched the examples but did not write anything down and were left to their own devices, responsible for their own learning.

There was no opportunity for and it was hard to tell if the teacher knew who understood. However, homework was collected in during this first lesson to be reviewed later that same day. Assessment was done in this way rather than during class activities. This lesson, typical of those seen, was entirely teacher-led and content-driven.

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In Shanghai, the teachers take the children through learning step by step. They complete some quick discrete tasks at various points along the way, arriving after explanations, and contexts for their learning. In England, teachers often try to elicit answers too quickly with insufficient rehearsal and contextualisation of the subject matter. Independent work and mini plenaries interrupt the flow.

However, good teaching is frequently simply high quality explanation through replication rather than development. If there is a misconception or problem, the teacher will demonstrate the correct method rather than unpicking the incorrect method.

Question techniques

Questions about pedagogy usually led to an explanation of 'the best way to explain' a concept. Flashcards and power point are common. Lessons are well considered in terms of the progression through a topic, and planning focuses on the way in which question content builds from simple to difficult. Like the Chinese, we should teach our students key ideas, key concepts and problem-solving so that they are able to tackle hard Maths.

Teachers explain a concept and then work on exercises. The test marks reveal student understanding. 'How?' or 'why?' questions are often restricted to deriving or proving or ignored because of time restrictions. The majority of questions ask: 'what?' Problem-solving and open questions such as: 'What is going on in the sequence 1, 2, 4, 8, 16?' are rare.

Questions build on prior learning and expand in difficulty much more quickly than in England. All the questions used in class were multifaceted. For example, a trigonometry question on finding the angles between two lines, using the tangent ratio, was linked to the topic of similar triangles, angle facts and ratio. Students had to find a number of parts to the problem before finally solving the relatively straightforward tangent part.

In addition, the workbook and homework sheets were made up of mostly multiple-choice questions and some more extended questions. Much time and thought had gone into their design. In both the workbook and homework sheet, two thirds of the questions were multiple-choice, designed as hinge questions. This reduced the marking burden but yet gave very quick feedback on any misconceptions students might have.

Typically in England, textbooks provide exercises for repetition with more worded questions at the end and do not make use of multiple-choice hinge questions. The rate at which topics are covered and the amount of practice students do, often mean the harder questions are not tackled.

In China, there was also evidence of pupils answering complex, written questions that had not been structured, displaying their ability to unpick a question and plan a strategy to work through it. This method develops resilience and sophisticated problem-solving skills.

In lessons observed, there was a focus on children explaining their thinking and demonstrating their learning to others. Mistakes were celebrated as an opportunity to learn and support each other. Teachers rarely praised children for correct answers, preferring instead to take many suggestions and ask the rest of the class to agree or disagree. In England, teachers often stop after correct answers and praise these rather than the work and effort that went into producing a solution. Much pedagogical research, that of Carol Dweck for example, would support the intrinsic motivation demonstrated by the Chinese students, as opposed to the extrinsic praise often provided in England.

There appeared to be little use of assessment for learning activities in the classroom which are a feature of current practice in England. These activities were not seen in observations nor mentioned in discussions with teachers. Instead, on-going assessment was carried out through tests and exercises which revealed to the teacher exactly what a child could or could not do. Ironically, such lessons would be graded 'requires improvement' under the current Ofsted criteria.

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Joint planning

Joint planning is the norm with the sharing of resources. Lesson plans are even shared online between schools. Groups of teachers for each grade plan together with a leader. They share resources, ideas and the order in which each chapter of the text book is to be completed.

A section of a chapter is prepared a week in advance, and the chapter a semester in advance. Teachers create questions and address misconceptions. This planning is done in the school. Student feedback is used to improve planning. A good plan has a structure specific to the teacher's own students. It will include:

- Objectives
- Materials
- Methods of teaching
- Questions to ask
- Questions to be answered
- Examples to be used
- Different methods to solve problems.

Co-planning was presented as a key reason for the success of the Shanghai system. The teams consist of a range of career stage teachers, including those new to teaching led by a master teacher. The focus is on subject knowledge, anticipating misconceptions and the sharing of experience.

Teachers said they would expect the following in a good lesson:

- Lively eyes
- Happy students
- Contributions from all
- A detailed plenary, involving discussion of learning
- Independent learning which is valued above group work.

In England, the curriculum requirements for GCSE Science are not always in line with those for GCSE Maths. There are different expectations for scatter graphs, with best fit lines in Maths and curved trends in Science. Alignment of formulae skills is required in Science so that they are taught first in Maths. Standard index form is a requirement for Foundation Tier Science students, but is only required at Higher Tier in Maths. As a consequence, Science teachers often deliver Maths content first in England.

In Shanghai, all Science teachers interviewed indicated that the children they teach have always met the Maths content needed for their Science lessons, Furthermore, the Science teachers said that they never have to recap on any Maths skills because the children have such a secure knowledge that they are able to apply them to Science confidently. Curriculum harmony, ensuring that specialist Maths teachers deliver Maths concepts, has helped Shanghai to the top of the PISA Test tables in both Maths and Science.

System 4: Immediacy of feedback and interventions

'Learning happens at home'.

Shanghai teachers and students

There is a rapid cycle of teaching, marking and feedback. Subjects are not regarded as equal and the high status of Maths is unchallenged. Maths and other core subjects are taught in the morning so that class and homework can be assessed immediately- a virtuous cycle assessment supporting learning.

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Teachers use their non-contact time to mark the work, adapt their lesson plans if necessary, and give specific personalised feedback in the afternoon. Prompt assessment supports rapid progress.

Feedback on the work is given by a tick or cross with follow-up additional work provided if errors are present. During the afternoon, teachers demonstrate correct solutions, providing one correct solution and one correct method. This instant feedback is a valuable form of assessment. One student, a self-proclaimed hater of Maths explained; 'Continual feedback builds up your confidence.'

An alternative method in England might be to give a greater proportion of a lesson to feedback, followed by time for students to engage in it directly through personalised actions. This would require a shortened starter; fast-paced activities; peer marking/self evaluation/pupil feedback through other AFL techniques; and time for the teacher to check performance/understanding when students are engaged in a further task, with remedial actions for students where appropriate.

Describing a typical day, teachers emphasised the importance of setting homework, checking it and collating questions on challenging topics; making pupils repeat work so that they can learn from their mistakes. Teachers also provide private tuition after-class, though it is the child's responsibility and not the teacher's to ensure attendance and completion of work.

Homework tasks, normally one hour in duration, are regarded by all as pivotal to students' success. They provide a form of overlearning: through extended practice of content, mastery is achieved. To allow differentiation by intervention and support, Chinese teachers might also set new learning as homework to introduce a skill. Students stated that their experience was to have varied amounts of homework depending on how well they did in any given lesson.

In some cases, children use video resources at home from the lessons they find difficult or have missed due to illness. These are uploaded onto school websites. Homework is an essential tool to re-inforce and extend children's understanding, an opportunity for teachers to differentiate the material and for parents to support from home. For the weekend children are given 'flipped' homework or preparation for the following week. During the school week, they practise at home what has been completed in the lesson.

During the primary years, homework assignments are often given by parents. As homework is regarded as essential to securing high grades, in senior school students frequently ask to do more homework.

The pressures, however, are enormous and for many mar enjoyment of the subject.

Childhood (in China) is incomplete - it is the time we need to play and be active, not to sit down and work; not to screw your butt to the table.'

Nottingham Ningbo student

'It burnt my brain!'

A Chinese student's description of the Maths level in High School

System 5: Preventing the gap

'When it is obvious that the goals cannot be reached, don't adjust the goals; adjust the action steps.'

Confucius

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Many English students regard education as an unnecessary burden. Our fascination with highly paid sports personalities, their wives and celebrities has encouraged them to look for the quick fix to become rich and famous rather than the realisation that for most, hard work and failure are the precursors to ultimate success.

In China, history and culture have created systems which promote equity in education. For example, all participate, without question, in regular, short bursts of physical exercise. The whole school assembles on the running track part way through the morning and jogs around, in class groups, two or three laps without complaint. Similarly, there are five-minute eye relaxation exercises each morning and afternoon when music is played and pressure points around the temples and sinuses are relieved.

Ancient tales tell of the mother who moved house three times to get her child into school or of the student who nailed his ponytail to the wall in order to stop himself falling asleep whilst studying. Confucius quotations, motivational idioms and legends of warriors support and reinforce the need to work hard and do the right thing.

Teachers in Shanghai also use these stories to build understanding of mathematical concepts, whether using monkeys and mangoes for addition, circle theorems or the mechanics of a car. At primary level, teachers in England use number lines for visual effect where the teachers in Shanghai employ stories.

Within-school variation in Shanghai is an issue as in England, but teachers work on a 'rising tide' principle. All pupils complete the same work. There is no differentiation of tasks in class. Children are given additional help before they can fall behind, in the belief that everyone is capable of learning and that there are no intellectual boundaries to knowledge. Teachers have the capacity to run after-school catch-up classes and provide group tuition. Demonstration lessons by excellent teachers and constant communication are key features.

All too often in England, gaps emerge, misconceptions become embedded and then the curriculum moves on without allowing time for these issues to be resolved, often to the detriment of lower-attaining children; so see children in Years 5 and 6 with little knowledge of how to add or subtract. In the Chinese system this is not as apparent; children's learning gaps are resolved early, often out of class or at home, but children are not allowed to fall significantly behind their peers.

Mobile phone apps used by Shanghai teachers included parental contact lists which were used daily. Parents expect daily communication from their schools and await text message alerts. They may even receive texted test results before their child arrives home.

Chinese parents understand the examination system, the end point, far better than their counterparts in England. One parent explained that his child practised Maths daily and, as far as he was aware, this was the same for all other families. This work consisted of using an exercise book of drills to increase understanding of calculation and work on reaction time. In addition to this, technology supported Mathematical learning at home with exercises on the Internet and school websites. It was seen as common for pupils to have access to this at home, but this has not replaced additional tuition, which was mentioned often and is seen as big business in Shanghai. The degree of both parental support and pressure is unimaginable.

System change would require regular contact through text or messaging with alerts for missing homework and information about day-to-day performance and progress. We need to explore successful ways in which schools have engaged parents in mathematics and begin to share good practice in this area.

Parents will need to join teachers in promoting the intense study of Maths if there is to be improvement. They will need to be actively informed, ensuring that games consoles are replaced by homework and independent study.

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Implementation in English schools

‘The education system, like everything in Shanghai, appears to be formed from explosive clashes of old and new. The creative future blends with the dictatorial past like the tents on run-down cottages next to science fiction-shaped skyscrapers.’

SLE King’s Oak Academy

The following ideas for adaptation and implementation are being considered by SLEs. Detailed implementation plans will be presented during an Evaluation and Implementation Conference at the National College on 21 March 2014.

System 1: Practice and consolidation

- Timetable Maths every day
- Request 4 hours per week Maths curriculum time per year group, from 3 or 3.5 hours currently in place, to allow for more consolidation and practice
- Introduce more testing within Maths to determine retention
- Core text books for primary Maths
- Use of practical resources in KS1, especially kinaesthetic resources and blank number lines
- DfE materials online with a focus on practice and made available to students, teachers and parents at no cost
- National collection of exceptional quality resources
Write a number of GCSE homework assignments which utilise multiple-choice hinge questions
- Increased demands placed on pupils: currently insufficient rigour
- Children need to learn number facts at an earlier age, practising and refining their skills in Mathematics, as they would if learning a musical instrument or being coached in sport
- Re-introduction of singing and chanting with counting up and down in all numbers to 10 from different starting points
- By the end of Year three, ensuring children taught a formal method for addition
- Maths beads: class sets for years 1 and 2
- Revision of Maths curriculum: simplify current Maths planning documents into one so that links and progression are clear
- Move towards a clearer number focus in lessons with time for repetition and consolidation
- Simplification of calculation policy, cutting out some methods
- Introduce one method for teaching calculation to ensure consistency, allowing for repetition and consolidation; abolish the use of number lines
- Trial a calculation method among a group of primary schools involving ‘the development of the story of the calculation’ (Shanghai) and the Singapore Bar as a visual representation. Approach made to University of Southampton to create a formal piece of action research
- Get pupils to spend time individually before working as a group. Adapt the ‘think, pair, share’ approach: pupils start a task independently to develop their understanding before looking at more challenging questions together.

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System 2: Specialist teaching

- Development of teachers with high levels of knowledge throughout KS2 using Mast and 'A' Level courses
- Lead Maths teachers producing research in the area to develop practice
- Encourage specialist Maths teaching in primary schools through timetable changes, and subject knowledge training for teachers even if not to degree level
- Collaborative lesson planning in SLE link school with 6 non-specialist teachers
- In a three-tier primary: one person teaching all three Maths classes and another all three literacy classes
- Peer observation: teachers matched up with appropriate colleagues in other year groups and given allocated times to observe each other
- Model lessons: Maths co-ordinator to plan and deliver model lessons using approaches identified during visit
- New planning format: teachers to abandon conventional lesson structure and employ the more connectionist approach observed in Shanghai
- Create study, planning and research groups to improve practice with the provision of additional time
- Model videos of Shanghai style lessons by primary SLEs
- Establishment of lesson study groups with opportunities to observe within the group, publishing lesson plans on the NCETM forum
- Develop a community of enquiry across three trust primaries with expectation of published pieces between the schools every 12 weeks. Monthly inter-school research meetings
- Introduce lesson study and peer observation as non-judgmental tools to replace the current time-consuming and inefficient performance management system; assess performance through external exam levels of progress made, student voice and appraisal targets
- Allocation of one CPD slot per term to focus on action research and classroom practice, using an agreed question and answer line of enquiry
- Celebration of teachers through competitions: for example the NQT *New Born Eagles* prize
- Adopt *Sunshine Award*: to a teacher on termly basis for positive contributions to departmental work

System 3: Teacher efficiency

- Re-evaluate the questions set both in homework and classwork to ensure a greater diagnostic framework, identifying understanding and misconceptions
- Switch lesson planning focus from classroom management to the structure of the questions to develop skills.
- Establish planning teams which meet every day to develop a consistency across lessons, cascading valuable teacher expertise and identifying potential areas of difficulty
- Adjust times to 35-40 minutes of directed teaching (as in Shanghai) and move away from the input/independent work combination used in the three- part Maths lesson in England
- Investigate restructuring the classes in year 7 to allow a reduced number of teachers and allow joint planning of lessons
- Provide a National Calculation Policy, at least in advisory form, identifying specific strategies and calculation methods recommended for each year group
- Work out ways to reduce overall contact ratio of staff and increase the number of Maths lessons per pupil
- Structure lessons by category, such as learning and mastery
- Progression map for key phases in form of posters
- Embed cultural and historical themes into the Maths curriculum to improve engagement

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- Work with local primary schools to jointly write Year 5- 7 schemes of work and agree Level 6 material, reducing the repetition in Year 7 of Year 6 work
- Consider alignment of schemes of work with link school which has 6 non-specialist teachers so that lesson planning ideas can be shared online
- Introduce the *three stripe model* of peer leadership and support in class
- Introduce the *little teacher model* of peer to peer teaching
- Introduce more timetabled collaborative planning within the department
- Develop specialist teachers in a primary school for children with special needs where there is overlap between the levels, enabling teachers to work across several classes and teach the same lesson several times. Including PPA teachers, there will be four afternoons of lessons in early years/KS1 and five afternoons of lessons in KS2. Teachers will produce one afternoon of lessons/resources that they will adapt for each group of children. This will enable them to develop a real understanding of one area of the curriculum and empower them as subject leaders across their key stage.

System 4: Immediate interventions

- 'Flipped-teaching': pre-teach key content for the week to vulnerable children during morning assembly
- Trial the use of 'flipped-teaching' to enable students to develop stronger study skills so that lesson time can be used for reflection, consolidation, mastery and extension. This will require textbook, worksheet and online resources
- Afternoon catch up: teachers to be given 30 minutes after lunch to work with children who need extra support from the morning lesson
- After school Maths sessions: children to stay behind for an extra hour of Maths one day a week. Children work on tasks to embed learning from the week
- Maths games with teacher available to support children identified as needing extra support
- Develop reactive and immediate intervention systems
- Set up opportunities to give immediate, daily feedback to individual children and small groups
- Use e-assessment systems for the practice of questions with rapid, timely feedback. Currently UK market leaders in e-assessment produce diagnostic activities: potential area for development
- ITT students to work with pairs of Maths teachers in the morning; work collected in and assessed jointly by the teacher and student after the lesson. The student then emails or gives oral feedback to each student and also to their parents
- Timetable teachers to be released to have group/individual discussions so that children's misconceptions and gaps in learning can be addressed immediately
- Adopt large class lecture-style after-school booster lesson, with catch up support
- Consider pre-teaching for disadvantaged students (in advance of lessons) rather than catch up (after lessons)
- Give feedback in the lesson, and set up appropriate remedial strategies at the time by providing: a shortened starter; activities with quick pace; peer marking/self evaluation/pupil feedback through other AFL techniques; time for the teacher to check individuals' performance/understanding (students may be occupied with further task), and organised remedial actions for students to undertake where appropriate

System 5: Preventing the gap

- Develop the role of independent learners: 'if someone wants a fish, first teach them to catch it' (oft-quoted Chinese proverb)

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- Create a closer working relationship with parents through more regular communication such as messenger or phone calls, providing a clear indication of progress and support needed
- Mobile phone app for students, teachers and parents
- Host a video on the school VLE, showing the teacher working through a new skill; students to view this and try it themselves: provides high level of differentiation; it promotes independence, allowing able students to apply self-study skills and carry out peer coaching
- High challenge work for all that is differentiated for lower ability pupils rather than being extended for the most able
- Explore ceilings on learning. Do we differentiate too far in our Maths lessons, putting a ceiling on learning? Are our expectations too low? Do we assume our lower ability children cannot do it, so never challenge them?
- Assist primary schools in uploading video clips to VLEs: for CPD to use calculation policy progression in consistent ways; and to help parents to understand and encourage the use of calculation policies
- Introduce a Chinese-style *termly teacher day* for parents and children to record their appreciation for work done by teachers
- Introduce the Chinese *thank you, teacher* at the end of lessons

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Participating Schools/Teaching School Alliances



The following National Support Schools and Teaching School Alliances participated in this research and their contribution is reflected in this Report:

All Faiths' Children's Community School, Strood, Kent
Bellfield Primary School, Hull
Cheadle Hulme High School, Stockport
Cherry Oak School, Selly Oak, Birmingham
Church Stretton School, Church Stretton, Shropshire
Comberton Village College, Comberton, Cambs.
Cramlington Learning Village, Cramlington, Northumberland
Driffield School & Sixth Form, Driffield, Yorks.
Folville Junior School, Braunstone, Leicester
Gatley Primary School, Cheadle, Cheshire
Grange Infant School, Gosport, Hamps.
Gravesend Grammar School, Kent
Hareside Primary School, Cramlington, Northumberland
Harrogate Grammar School, Harrogate
Highworth Grammar School, Ashford, Kent
Holte School, Lozells, Birmingham
King's Oak Academy, Bristol
London Fields Primary School, London
McAuley Catholic High School, Doncaster, South Yorks
Ninestiles School, Acocks Green, Birmingham
Northfleet School for Girls, Gravesend, Kent
Oakham Church of England Primary School, Oakham, Rutland
Oakthorpe Primary School, Oakthorpe, Leics.
Parkland Primary School, Wigston, Leics.
Parkside Primary School, Goole, Yorkshire
Pool Academy, Redruth, Cornwall

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Portsmouth Collaboration of Schools, Southsea, Portsmouth
Rosehill Methodist Community Primary, Tameside, Greater Manchester
Rosetta Primary School, London
Sneinton St. Stephen's Church of England Primary School, Sneinton, Nottingham
South Dartmoor Community College, Ashburton, Devon
Springhead Primary School, Anlaby, Hull
St. Clement Danes School, Chorleywood, Herts
St. John's Primary, Midsomer Norton, Somerset
Staining Church of England Primary School, Blackpool, Lancs.
The Academy at Shotton Hall, County Durham
The Arthur Terry Teaching School, Sutton Coldfield, Birmingham
The Hermitage Academy, Chester Le Street, County Durham
The Rochester Grammar School, Rochester, Kent
The St. Marylebone Church of England School, Westminster, London
The Woodroffe School, Lyme Regis, Dorset
Thornden School, Chandlers Ford, Hamps.
Tubbenden Primary School, Orpington, Kent
Weydon School, Farnham, Surrey
Wistaston Green Primary School, Crewe
Witham St. Hughs Academy, Lincoln, Lincs.
Withernsea Primary School, Withernsea, Yorks
Wood Green Academy, Wednesbury, West Midlands

Acknowledgements

Participants wish to express their gratitude to the following that supported this research:

Professor Zhang Minxuan	President, Shanghai Normal University
Prof Zhu Xiaohu	Director, Shanghai PISA Centre
Xu Wenji	Deputy Chief, Ningbo Education Bureau
Wang Weimin	Director of International Cooperation and Exchange, Ningbo Education Bureau
Lin Xiaoyun	Consultant, Ningbo Education Bureau
Dr Trevor Nunn	Director, International Centre for School Leadership (ICSL) Nottingham University at Ningbo
Kiki Ye	ICSL project team
Rebecca Jin	ICSL project team
Annie Xia	Interpretation and International Communications teaching ICSL fellow
Dr. Qing Gu	Associate Professor, Educational Leadership, University of Nottingham
Dr. Andy Townsend	Associate Professor, School of Education, University of Nottingham

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We are grateful to the principals and staff of the following schools:

Shanghai Experimental School

Foreign Language School attached to Shanghai Normal University

High School attached to Shanghai Normal University

Number One Primary School attached to Shanghai Normal University

Shanghai Normal University Demonstration Primary School

Ningbo Foreign Language School

Ningbo High School

Ningbo National Hi-tech Zone Foreign Language School

Ningbo Wanli International Senior High School

Ningbo National Hi-tech Zone Experimental School

The National College

The National College is the first college anywhere in the world uniquely dedicated to the professional development of school leaders.

- The College was established in the year 2000 and the International Business Unit in 2011.
- It was the first College anywhere in the world dedicated to school leadership.
- Our remit from the UK government is to develop and inspire great leaders of schools and early year's settings in England. We regularly advise policy-makers on issues affecting leadership, including succession planning and strategies for school improvement.
- The UK Government Cabinet Office described the National College as a "world-leading" example of excellence in leadership development and support.
- Since 2000, over 150,000 school leaders have benefited from our programmes and we train over 30,000 school leaders every year.
- In England schools involved in National College leadership development programmes achieve faster rates of improvement in exam results – and the more involved a school is, the greater the improvement.
- We work with some of the world's foremost experts on leadership development in schools to ensure that we continue to innovate and develop our services.
- We are currently working in a range of countries in Asia, the Middle East, India, Australia and Europe and have recently run successful training for principals from the Ningbo region of China in country.

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- New products for school leaders worldwide include: the International Programme for School Principals (IPSP); the International Programme for Aspiring School Principals (IPASP); the International Programme for Middle Leaders (IPML); and the International Strategic Leadership of ICT (I-SLICT).
- The NPQH is now offered to heads of British International Schools.
- There are currently over 100,000 National College members.

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