



Qualifications and
Curriculum Authority

A literature review of aspects of the Primary Curriculum produced by CUREE¹

Part 1

¹ The Centre for the Use of Research and Evidence in Education

Following our initial response to the call for evidence for the independent review of the primary curriculum, CUREE was asked by QCA to use its knowledge of the evidence base to bring together supplementary information which would inform the review in more detail.

Specifically QCA requested further evidence as it relates to primary education with regard to:

1. An accessible definition of 'scaffolding'.
2. Empirical evidence related to Vygotsky's learning theory.
3. Developing thinking skills.
4. How intense skills development and knowledge acquisition sits alongside Bruner's model of the spiral curriculum: using iterative and gradually cumulative approaches to encountering and making ever deeper sense of big ideas.
5. Approaches to student learning styles.
6. Taking new practice to scale.
7. Breakthroughs in mathematics teaching and learning.
8. The value of ICT in teaching and learning.
9. The maturity of the evidence base (where there is robust evidence for particular approaches, and where the gaps are).
10. Finding the optimum balance between a focus on knowledge, skills and understanding.
11. Soft, social, and personal learning skills.

This paper deals with items 1-6. A second paper, dealing with items 7-11 is available in a separate briefing.

We have taken a layered approach to identifying evidence sources in order to be as comprehensive as possible within the timescale:

- trawling our existing database of studies
- scanning summaries of research that have been appraised for robustness for CPD products such as Research of the Month and TRIPS digests
- conducting specific keyword searches using education-specific databases such as ERIC and BEI.

Where we have drawn on evidence already summarised in Research of the Month and TRIPS digests, the sources will have already been rigorously appraised in terms of the robustness of the research approach taken and the reliability and validity of the findings, including for an English audience. In the case of Research of the Month summaries, the completed appraisal framework for each study can be accessed on the summary webpage.

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1 Scaffolding

Many teachers now refer to their use of 'scaffolding' to support their pupils' learning. But what is scaffolding? The following definition is based on descriptions of teacher support in five studies – three on literacy teaching in primary school (Wharton-McDonald *et al*, 1998; Taylor *et al*, 2000; Pressley *et al*, 2001) and two on assessment in primary and secondary (Black & William, 1998; Black *et al*, 2003). The studies were included because they describe in some detail scaffolding linked to effective teaching, from which the above definition was extrapolated. Each study was fully appraised for Research of the Month summaries.

Definition of scaffolding

You can make it easier for pupils to reach their learning goals by splitting up big development goals or tasks into several, progressive stepping stones and providing support such as prompting questions or writing frames. This process is called scaffolding and can be used for a variety of complex tasks, such as writing a story, or designing an experiment. But an important aspect of scaffolding is that it is removed once pupils can make progress without such support. For example, you give pupils fewer prompting questions as they gain experience of a task. You can also foster your pupils' independence by explicitly teaching them how they can split big tasks up into smaller tasks for themselves.

(GTC Research of the Month Summary *Behaviour for learning: Engaging with research*. Accessible at: http://www.gtce.org.uk/shared/contentlibs/85419/1372774/191738/bfl_anthology.pdf)

Teachers referred to 'scaffolding', for example, in relation to splitting up a task into smaller ones; asking learners prompting questions; providing children with writing frames or other protocols, etc. The work of Lev Vygotsky is helpful in gaining a better understanding of what scaffolding is and the theory underpinning it.

Unlike other educationalists of his day, Vygotsky was convinced that what children can achieve, assisted by an adult, tells us more about their capacity to learn in the future than tests they tackle in isolation.

(GTC Research of the Month summary *Social interaction as a means of constructing learning: the impact of Lev Vygotsky's ideas on teaching and learning*. Accessible at: http://www.gtce.org.uk/research/romtopics/rom_teachingandlearning/vygotsky_dec03/study)

To describe this potential for further learning that he believed each child had, Vygotsky introduced the idea of the 'zone of proximal development (ZPD)'. He described the ZPD as the difference between the level of actual development as measured by tests, particularly IQ tests which were becoming common in Vygotsky's day, and the level of potential development that a learner could reach in collaboration with an adult; in other words, a zone of shared thinking in which a child, assisted by an adult or more knowledgeable peer, can successfully realise a new stage of development.

While Vygotsky himself did not propose the notion of scaffolding, it is consistent with his ideas of learning through social interaction that aims to support development. As Vygotsky's observations about what a child can achieve when supported became more widely known, other practitioners began to develop ways of supporting children's learning in their ZPDs. The term scaffolding was first coined by Wood, Bruner and Ross (1976), who were probably influenced by Vygotsky's work, when they were

investigating how adults support children's learning. In the context of the ZPD, scaffolding is the structured learning environment the teacher creates to help the pupil develop and use the tools, skills and abilities they require to complete their learning.

The teacher needs to choose the type and content of the scaffolding carefully. There are dangers in making the scaffolding too cautious and limited to extend the pupils' thinking. But there are also dangers in using it to offer too big a step and thus take the pupil into completely unknown territory:

Scaffolding must begin from what is near to the student's experience and build to what is further from their experience. Likewise, at the beginning of a new task, the scaffolding should be concrete, external, and visible. Vygotskian theory suggests that learning proceeds from the concrete to the abstract. This is why math skills are learned from manipulatives, and fractions from pies and graphs. Eventually these concrete and external models can be internalised and used for abstract thought.

(MyRead: Strategies for teaching reading in the middle years. Accessible at: <http://www.myread.org/scaffolding.htm>)

The following case study illustrates what scaffolding looks like in practice:

A low achieving group of 12 year olds were doing a 'mystery' about the disappearance of a tribe of Amazonian Indians. They had before them slips of paper which included information about:

- gold prospectors
- water pollution
- infectious diseases
- hunting practices, and
- poverty among the non-Indian population etc.

Although the data on the cards offered quite a bit of introductory support, the group of four boys hadn't made much progress in solving the problem of why the tribe had disappeared. The teacher visited them and pulled out a data item about the tribe's water supply. She then asked them to find any other data items about water and left them to work alone. The teacher had diagnosed the group's weakness in being able to classify/group data and had pointed them towards what they needed to do next.

(Case study 2 of the GTC Research of the Month summary Enquiry-based learning, cognitive acceleration and the spiral curriculum. Accessible at: www.gtce.org.uk/research/romtopics/rom_teachingandlearning/bruner_may06/casestudies)

2 Evidence base in support of Vygotsky's theories of learning

Vygotsky's theories of learning are often used to justify approaches to teaching and learning without any direct reference to empirical evidence that supports the theory. QCA wanted to know if there is any research evidence that supports these theories.

The Research of the Month (RoM) summary on Vygotsky provides an overview of his theories and goes some way to link contemporary evidence with them. It teases out and clusters Vygotsky's ideas in the following way:

- language in children's learning - Vygotsky believed strongly in the importance of the social and cultural features of children's learning. He regarded speech as a tool that developed in a social context and which became the vehicle for thought
- children's play - from his analysis of pre-school children's play Vygotsky concluded that not only does play fulfil children's emotional and physical needs, it provides a major stimulus to their cognitive development
- the part played by schools and teachers - Vygotsky viewed school instruction as a key factor in children's development, which was crucial to the development of specific forms of thinking
- the significance of the zone of proximal development for teaching and learning - the concept with which Vygotsky is most closely and famously associated is that of the 'zone of potential (or proximal) development' - the ZPD. As described above, the ZPD is the difference between the level of actual development as measured by tests, particularly IQ tests which were becoming common in Vygotsky's day, and the level of potential development that a learner could reach in collaboration with an adult
- learning with others – Vygotsky's work strongly emphasised social learning, so much so that the idea of learning outside a social context was alien to him. (Much recent research into collaborative learning through structured group work offers a strong empirical basis for this premise)
- the unity of higher order skills – Vygotsky also explored the problematic topic of the transferability of thinking processes from one context to another and concluded that higher order skills – such as classification and logical thought – were transferable. (This is a contested notion partly because we do not know enough about the structures and processes that support transfer).

The RoM connects Vygotsky's ideas with high quality contemporary empirical evidence via the outcomes of research into the Cognitive Acceleration through Science Education (CASE) project. The CASE project team collected performance data about pupils who had been taught by their methods, which explicitly aimed to improve children's thinking in science. This approach combined the significant Vygotskian

elements of pupils working together to solve problems and teachers' 'scaffolding' of children's learning.

In 'The long-term effects of Cognitive Acceleration on pupils' school achievement, November 1996' (Michael Shayer, Centre for the Advancement of Thinking) the CASE team presented evidence showing overall increases in the numbers of children achieving grade C or better in the science GCSE examination equivalent to increases in the national average from 43 to 57% in 1995 and from 44 to 63% in 1996. The evidence from the CASE project is based on the performance data of some 4,500 pupils from 17 intervention schools and a similar number of control schools, in the example just given.

Research into cognitive acceleration programmes in primary schools (Adey *et al*, 2002) has produced similar results, albeit with a smaller sample size (300 pupils in 10 intervention schools, and 170 children in 5 control schools). The 5 and 6 year-olds in intervention classes made significantly greater gains in tests compared with children in the control classes. Analysis by gender, however, showed that experimental boys' greater gains over controls were not significant.

(King's College London – Cognitive Acceleration pages:

<http://www.kcl.ac.uk/schools/sspp/education/research/projects/cognitive.html>)

Further evidence of the importance of the teacher's role in developing children's thinking in the early years has been provided by the EPPE team. This large scale, multi disciplinary empirical study found sustained, shared thinking happens when an adult works with a child or two children to solve a problem, clarify a concept, evaluate an activity, or extend a narrative etc. This meant contributing to the thinking in a way that develops the children's understanding, as in this example:

A BOY was watching various items floating on water:

"Look at the fir cone. There's bubbles of air coming out."

TEACHER modelling curiosity and the desire to go further: *"It's spinning round".*

BOY: *"That's 'cos it's got air in it."*

TEACHER, picking up fir cone and showing the children how the scales go round the fir cone in a spiral, then turning the fir cone round with a winding action: *"When the air comes out in bubbles it makes the fir cone spin around."*

GIRL, using a plastic tube to blow into the water: *"Look, bubbles."*

TEACHER: *"What are you putting into the water to make bubbles?...What's coming out of the tube?"*

GIRL: *"Air".*

(GTC Research of the Month summary *Researching effective pedagogy in the early years*. Accessible at:

http://www.gtce.org.uk/research/romtopics/rom_curriculum/early_years_jan03/)

In terms of the importance of play for children's cognitive development, evidence exists from a Slovak study with 3-6 year old children which supports Vygotsky's conclusions from his own observations that play not only fulfils children's emotional and physical needs, it provides a major stimulus to their cognitive development (Gmitrová, & Gmitrov, G, 2003). The study compared the relative effects of teacher-directed play with child-directed play, finding a significant increase in thinking behaviour among the group where play was directed by the children. The researchers concluded that 'children think more, learn more, remember more, spend more time on task, and are more productive' when learning through child directed play.

(Summary available at: http://www.standards.dfes.gov.uk/research/themes/early_years/FriApr21051132004/)

Learning with others is another key facet of Vygotsky's approach. Recent years have seen the development of a strong evidence base for improvements in learning when pupils work in groups with clear guidance and facilitation from the teacher. The research covers all phases and ages, from early years to post 16.

The TLRP SPRing project (eg. Kutnick, Ota & Berdondini, 2008) noted that when teachers helped their young pupils' (age 5-7) to work effectively in small groups, through enabling them to develop close working relationships with each other, the children improved their reading attainment in Y1 and 2 and their mathematics attainment in Y2. They were also more likely to stay on task and were more able to communicate effectively with their peers. Extensive research by Mercer, Wegerif and colleagues (e.g. Wegerif, R., Littleton, K., Dawes, L., Mercer, N., & Rowe, D., 2004) showed that primary aged children who had been taught the 'Thinking Together' approach (whereby pupils were taught how to reason with each other through the use of ground rules) used more exploratory talk more often after the programme of lessons than they had before it. (Exploratory talk is the type of talk considered to be effective for thinking and learning).

Furthermore, the pupils showed improved individual and group scores on tests of non-verbal reasoning. Overall, the scores of the target groups increased more than the scores of the control groups. In two schools where the researchers' observations revealed that the 'Thinking Together' programme had been most carefully and comprehensively carried out, group scores increased by over 10%. The gains made by individual target class children were also significantly greater than those made by children in control classes. Teachers of the target classes reported on the positive impact the approach had on inclusion. For example one teacher said: 'Most of the social groups have really knitted well and they have a sense of togetherness, and a sense of helping each other'.

A map of systematic research reviews undertaken for QCA followed by a detailed examination of the key studies in the reviews found similar improvements (Bell *et al*, 2007); in particular in mathematics and science learning, when teachers provided clear guidance for groups to follow, tasks to undertake and activities that help students develop the skills they need to work collaboratively. By contrast, in groups where learning is not collaborative there may be no specific requirement that students work together; they often work individually, albeit side by side, on tasks for their own ends. These studies showed how the teacher can make group work collaborative by structuring activities that generate effective patterns of discussion.

Vygotsky believed that in the earlier stages of thinking, i.e. at concrete levels, pupils grasp specific skills but do not generalise them. Vygotsky believed that because such activities depend entirely on the specific material with which they operate, they cannot be generalised.

This has even been shown to be the case when the applications are quite closely related. For example, Nunes described how street children in Brazil who were used to selling fruit on the streets were presented with three types of problem:

- some were typical of the buying/selling transactions they were used to
- some were similar problems but involved different types of goods

- some were without the problem solving context e.g. $85 + 63$ in the abstract.

Success rates declined markedly from 98% to 74% to only 37% across the three sets of questions. Discussing this issue Freeman (2000) commented that the children had not understood any fundamental law of mathematics but were only mastering some techniques that made use of numbers. There was no reflection or insight involved so the children were unable to transfer their techniques to different contexts.

3 Thinking skills

Work on promoting and accelerating thinking skills attracts a good deal of attention from practitioners and is linked to good evidence about achievement benefits. QCA wanted an overview of evidence about thinking skills and also to consider how far they are core skills for deepening access to the curriculum.

Thinking skills programmes aim to promote better thinking among pupils so that they can adopt, and retain for further use, strategies for problem solving and analysis (higher order thinking skills). Thinking skills programmes include:

- evaluative thinking which is based on critical thinking but which involves the application of criteria to judge the value of information or ideas
- exploratory thinking, which is strongly related to creativity and is evident in problem and puzzle solving
- hypothesising, which is a process involving the generation of ideas (creative) and the evaluation of outcomes (critical).

The purpose is less concerned with maximising curriculum coverage than with improving pupils' ability to find patterns in the processes of thinking and reasoning that make it easier for them to accommodate new learning content.

All thinking skills strategies contain the elements:

- challenge, where children meet problems which challenge what they know already
- social construction, where children work together to solve problems
- meta-cognition, where children are guided by teachers to become conscious of, and to articulate, their own reasoning.

Two other features of this model are:

- concrete preparation – a preliminary activity in which children are made familiar with the various components of the task
- bridging – a process in which children transfer their thinking strategies into other contexts, e.g. between different subjects.

A feature of the programmes is that teachers train pupils to use the strategies and/or coach pupils to acquire them, for example, by asking probing questions. The key point is that teachers aim to move their pupils from concrete everyday thinking to more abstract or higher order thinking through a structured approach. Higher order thinking includes, for example, looking for patterns and expressing them, evaluating outcomes, asking critical questions, and proposing strategies to solve problems.

In some cases thinking skills programmes consist of discrete lessons interspersed among a subject curriculum, e.g. Cognitive Acceleration through Science Education (CASE). In other programmes they are 'infused' through the normal curriculum

provision (Submission based on comments by Philip Adey and Robert Fisher to the national Thinking Skills group on defining higher order thinking skills)

The Cognitive Acceleration in Mathematics Education (CAME) is a sister project to CASE. Like CASE it aims to enhance students' thinking ability rather than focusing solely on their knowledge of mathematics procedures. Students taught using CAME in the first two years of secondary school, later gained, on average, 0.8 of a GCSE grade compared with other students following the normal curriculum only. CAME has been used successfully at primary level too. For example, around 40% of pupils from classes that had been well below the national average before the programme of lessons in Year 1 were at the 2B level by the end of Year 2.

(Shayer and Adhami, 2007)

Different types of Thinking Skills programmes stress the above elements to different extents. One case study showed how teachers used debriefing to foster metacognition by getting pupils to talk about their solutions to geography tasks and to explain how they carried out the tasks. Features of the debriefing activity were:

- the high number of open questions asked by the teacher; and
- the frequent references made by the teacher to learning skills (pupils commented: "We learnt how to group things together and see what might affect other things" and "like one thing starts another").

(GTC Research of the Month summary of CASE (Cognitive Acceleration through Science Education) *Improving learning through cognitive intervention*. Accessible at:

http://www.gtce.org.uk/research/romtopics/rom_teachingandlearning/case_jun01/)

The ACTS (Activating Children's Thinking Skills) is an infusion programme with a major focus on meta-cognition. It includes analysing wholes and parts and similarities and differences, making predictions and justifying conclusions, reasoning about cause and effect and generating ideas and possibilities. ACTS children rated themselves highly on items such as:

'I spend some time thinking about how to do my work before I begin it' (planning);

'I ask myself questions when I do my work to make sure I understand' (self-monitoring);

'When I make mistakes I try to figure out why' (evaluating); and

'When we have difficult work to do in class, I try to figure out the hard parts on my own' (independence).

(See: Carol McGuinness, www.sustainablethinkingclassrooms.ac.uk)

'Philosophy for Children' focuses on children working together in a structured way to tackle problems. In one 'Philosophy for Children' approach teachers encouraged 10 to 12 year olds to follow a number of rules, including being willing to communicate their views about the topic, supporting their views with reasons, providing alternative viewpoints and reaching a shared conclusion. The children improved on number tasks, on verbal and on non-verbal reasoning tasks. Pupils of all abilities benefited from the intervention – middle level performers benefited most.

(Topping and Trickey, 2007. Summary available at:

<http://www.standards.dfes.gov.uk/research/themes/thinkingskills/philosophy/?version=1>)

Other thinking skills approaches model reasoning strategies for children. In one study teachers taught the 8-9 year olds of all ability levels how to recognise and place different numeracy problem types into categories or schema. Researchers found that pupils of all achievement levels improved their mathematical problem-solving more than a comparison group which had not received the training. Schemas helped pupils see connections between familiar and new problems.

(Fuchs et al, 2004. Summary available at:

<http://www.standards.dfes.gov.uk/research/themes/Mathematics/pupilsclassify/>)

Thinking skills programmes can also be used to benefit the younger age groups. Teachers in London primary schools trained year 1 pupils in thinking skills strategies. In one classification activity, teachers introduced children to the challenge of sorting model dinosaur figures into groups. Pupils initially sorted them by single variables such as colour or type. The teacher then asked the children to put all the T. Rex dinosaurs in one hoop and all the blue ones in another. Conflict arose over the blue T. Rex, which the children resolved by constructing the idea of overlapping the hoops. Pupils who took part in the programme showed significant gains in learning.

(Adey, P. 2002. Summary available at: <http://www.standards.dfes.gov.uk/research/themes/thinkingskills/6553/>)

Summary of current views on thinking skills

Common to all thinking skills programmes is the aim to develop patterns of thinking pupils can use in tackling problems or analysing new material. They can be used in a single class, at whole-school level or even across a number of schools. The key idea is that by raising pupils' thinking abilities teachers equip them effectively for understanding new curriculum material. Time spent on developing the thinking skills of pupils, proponents of thinking skills believe, is regained when pupils use their skills to tackle and understand unfamiliar material more effectively than would otherwise have been the case.

There are a number of centres of excellence in thinking skills in the UK, including:

- CASE and CAME (Michael Shayer and Philip Adey and team) based at King's College, London
<http://www.kcl.ac.uk/schools/sspp/education/research/projects/cognitive.html>
- ACTS (Carol McGuinness) www.sustainablethinkingclassrooms.ac.uk
- Thinking Through Geography (David Leat) <http://www.geoworld.co.uk/>
- Teaching Thinking (Robert Fisher) <http://www.teachingthinking.net/>
- Philosophy for Children <http://www.sapere.net/>
- Research Centre for Learning and Teaching, University of Newcastle
<http://www.ncl.ac.uk/cflat/projects/>

4 Bruner

QCA was concerned that Bruner's work may carry an implication that young pupils learn through an iterative stream of experiences whereas new evidence (e.g. phonics and literacy in general) makes it clear that the finer grained pictures of learning patterns for some core skills involve, for a period, some sustained immersion. In the main, Bruner's work was focused on the development of knowledge and understanding rather than skills development. Although he advocated structured enquiry as a key development process and was clear that enquiry skills themselves needed to be taught, he was clear that not all learning could take place through enquiry and discovery. Therefore, new evidence about intense immersion in the development of particular skills can be seen as complementary rather than in opposition to Bruner's notion of a spiral curriculum.

The question then is what forms of skills development might be needed to underpin learning through more iterative and cumulative approaches to encountering and making ever deeper sense of the key ideas and knowledge and understanding?

Reading and writing skills

The evidence about the need for an intense focus on phonics in developing core literacy skills was emphasised in the Rose Report which found that well-designed phonics programmes that are taught discretely and systematically for short periods of time by well-trained teachers and teaching assistants provided effective foundations for literacy development. We have not summarised this evidence here because we know that it is already available to the Independent Review of the Primary Curriculum team led by Sir Jim Rose.

Group work skills

We know from a particularly strong research base (Bell et al, 2007) that collaborative learning and structured challenge in group work are effective learning strategies and there is evidence that it is important to teach a foundation of talk and collaboration skills to enable pupils to access such opportunities. A follow up review of individual studies provides a richly illustrated picture of this

Recently the SPRING Project (Baines and Blatchford, 2007) demonstrated the powerful learning improvements which effective group work can bring about. The aim of the project was to provide teachers with strategies for enhancing pupil group work. The research involved 560 pupils aged 8 to 10 who were taught by the SPRinG trained teachers. 1027 pupils acted as a control group and were taught by teachers using their usual approach. The researchers measured students' developing science skills on two levels over the year, using 'macro' and 'micro' tests. They found that the involvement in the group work programme had a positive effect in terms of pupils' measured progress in science. Group work can also be used by teachers in other disciplines to develop reasoning and problem solving skills and enhance learning and achievement.

The following are just two of many examples of different ways of helping pupils develop

these group learning skills:

ICT: TRAC (Talk, Reasoning and Computers).

This study involved 60 children aged 9-10 years and their teachers. The programme developed children's reasoning and collaboration skills by developing their awareness of language use and promoting 'ground rules' for talking together for learning. The teachers undertook appropriate CPD and took the children through a series of lessons to show how the rules work. The rules are based on evidence about building exploratory talk, in which partners engage critically but constructively with each other's ideas. Statements and suggestions are offered for joint consideration. These may be challenged and counter-challenged but challenges are justified and alternative hypotheses are offered. Using experimental and control groups and pre and post tests, researchers found that children's use of language and problem solving scores increased.

(Mercer et al 1999)

Another study explored how the development of thinking skills through group talk could be used across the curriculum. The experimental group of 33 mixed ability children aged 9-10 worked in groups of three as well as in a whole class setting. In two lessons they made use of especially designed educational software. They were trained in effective listening, giving information and co-operating in a group. They were also given ground rules for talk. The study found that coaching for exploratory talk leads to improved group problem-solving, can improve test scores in reasoning and that computers can be used to support exploratory talk amongst groups of children and to direct this towards curriculum ends.

(Wegerif, 1996)

Clearly there is strong evidence about the importance for learning of the acquisition of core skills in the areas described above. This is not the same as the development of knowledge and understanding through the curriculum and we would suggest that the evidence points to the need for both.

Other possible foundation skills

There are no other widely recognised and researched strategies for immersing young learners in the development of the skills they need to access the curriculum. But there are two interesting practice based developments that share several features with the evidence about phonics and group work, albeit on a smaller scale.

Number Skills

In the area of mathematics the research behind Numicon maths has highlighted the importance of developing spatial awareness of number relationships. Numicon is a multi-sensory maths teaching programme which arose from original research (based on the work of Catherine Stern) and years of classroom research and application, first by Romey Tacon, then an early years teacher and head of an infant school, and Tony Wing of Brighton University. Their work has since been funded by the Esmee Fairbairn Foundation and taken to scale. The approach uses visual images in a series of practical teaching activities currently comprising three stages – Foundation, Stage 1 and Stage 2. The teaching activities use structured shapes showing the patterns in number relationships. The patterns are visualised through plastic shapes that

correspond to the numbers 1 to 10. The pattern of the holes for each number follows the same basic system of arranging holes 'in pairs'. So when the images and patterns are arranged in order, pupils begin to notice important connections between numbers - for instance that each number is one more than the last and one fewer than the next, odd and even numbers and place value. This approach to teaching core number skills has been researched and evaluated at school, cluster, regional and national levels and has been linked to positive achievement gains across the pupil profile but particularly for struggling learners. The development of spatial awareness of number relations seems to be particularly helpful in increasing the efficiency of strategies selected by pupils for manipulating numbers. It also seems to be important for those pupils, like Down syndrome pupils, who struggle with short term memory (Wing and Tacon, 2007)

Practitioners' cumulative research over 10 years raises the interesting possibility that there may be a core development process for writing in relation to laying down proper procedures for children to follow. Dissatisfied with their children's performance in writing at key stage 2, teachers at a school in Kent studied what their counterparts in French primary schools were doing in their classrooms. Following this experience "we began by identifying the basic patterns children needed to learn for letter formation and formulating a progressive teaching programme to ensure that these were taught systematically." The focus shifted from "writing in print to developing gross motor experiences and pattern work to aid improved formation and ultimately a cursive script from the outset". The results were impressive. Pupils at the school have consistently shown increased numbers achieving Level 3 compared to the LA and National figures. The schools' research and tracking of the evidence has been widely adapted by many other schools in the area. The research draws on and links with evidence from studies of teaching patients to write following a stroke that had destroyed the relevant area of the brain. Here too evidence points to the importance of careful progression from gross to fine motor skills in laying down a strong foundation for the development of writing.

The writing strategy began with the work of Fiona Thomas *Une question de writing* a research project commissioned by the then Teacher Training Agency as part of the Teacher Research Grant scheme 1996/7. It has continued with the work of Gill King and colleagues. See also the National Teacher Research Panel (NTRP) summary *Children writing: shaping words, shaping thoughts* NTRP Conference 2008.

The spiral curriculum

Bruner believed that for children to acquire knowledge and understanding they needed to learn to make connections between different experiences in learning rather than rely solely on mastering facts. To achieve this, he proposed that children learn through enquiry, with the teacher providing guidance to accelerate children's thinking. Bruner gave an example of a geography lesson to illustrate the enquiry approach. During the lesson, the students were introduced to the geography of an area. The teacher asked them to locate the major cities on a map that contained physical features and natural resources, but no place names. He described the impact of this task on children aged 11-12 years. During discussion about the problem, the children produced a variety of theories about what cities required, such as:

- a water transportation theory that placed Chicago at the junction of three lakes;

- a mineral resources theory that placed it near the Mesabi range; and
- a food supply theory that put the city on the rich soil of Iowa.

Bruner commented on how the level of interest and conceptual sophistication shown by the children involved was far above that of children in the control classes. He was particularly struck by the children's attitude to learning. For the first time, they saw the location of a city as a problem, and a problem they could discover the answer to through thinking about it.

Like Vygotsky, Bruner believed that effective teaching involved starting from what children know already and providing them with guidance that moves their thinking forward.

In *Towards a theory of Instruction* Bruner outlined more explicitly how children's thinking could be developed:

- enactive – learning by doing;
- iconic – learning by means of images and pictures; and
- symbolic – learning by means of words or numbers.

(Bruner, 1966)

Bruner recommended that the early teaching of any subject should emphasise grasping the principal ideas intuitively. He believed that the curriculum should then revisit these fundamental ideas repeatedly, building cumulatively upon them and making links and connections between them until the pupil has grasped full understanding. He called this cycle the spiral curriculum. Bruner was not suggesting that all learning should be by discovery and enquiry. He was aware that the discovery method would be too time-consuming for presenting everything that pupils would need to cover in a particular subject. For example, he saw little point in asking children to "discover" the names of US Presidents, or dates in history.

Bruner warned that it is important to present a child with ideas that are not too far from the child's natural way of thinking. He suggested that putting basic ideas into formalised terms too early puts them out of reach of the young child unless the child has tried them out first and come to understand them intuitively. So, he suggested for example, whilst ten year olds can play mathematical games using rules modelled on highly advanced mathematics, and can arrive at the rules themselves inductively, they will flounder if they are expected to use a formal mathematical equation because they will apply the device without understanding it.

(GTC Research of the Month Summary Enquiry-based learning, cognitive acceleration and the spiral curriculum: Jerome Bruner's constructivist view of teaching and learning. Accessible at: http://www.gtce.org.uk/research/romtopics/rom_teachingandlearning/bruner_may06/)

The same point is made in a number of other studies. For example, in a study of year 5 pupils' approach to division the author concluded that the use of formal methods may inhibit children's understanding of mathematical problems unless it is underpinned by sound strategies for mental mathematics. She found that the use of formal algorithms created more errors for many of the pupils. Efficient but less formal methods of problem-solving produced more successful results.

(Anghilieri, 2001)

Similarly, a numeracy teacher used games to enable children to continually revisit and build on key mathematical ideas in enjoyable, familiar contexts. After consulting with the children's parents she set up a mathematics games library which the children could borrow. She selected games that would help with addition, subtraction, multiplication and division and categorised them according to the suggested age range, level, and national strategy strand (e.g. calculating, counting and understanding number, understanding shape and measuring etc). She also identified learning objectives and kept them with each game. Early feedback from parents and students suggests that the venture is making an impact on students' learning.

(Stoppa, 2008)

5 Learning styles

QCA was interested to find out if there is any reliable evidence about the efficacy of tailoring teaching to the perceived 'learning style' of the individual child or young person.

A review of 800 studies of post-16 learning styles by Coffield and co-researchers found that:

'...there is some overlap among the concepts used, but no direct or easy comparability between approaches; there is no agreed, 'core' technical vocabulary. The outcome – the constant generation of new approaches, each with its own language – is both bewildering and off-putting to practitioners and to other academics who do not specialise in this field.'

This review also identified the problem of labelling students as particular types of learner, even self-labelling: '...students begin to label themselves; for example, at a conference attended by one of the reviewers an able student reflected: "I learned that I was a low auditory, kinaesthetic learner. So there's no point in me reading a book or listening to anyone for more than a few minutes".' Overall, the review found that many learning styles models and instruments are weak and unreliable, and using them has a negligible impact on teaching and learning.

Learning styles may be a useful way of raising students' self-awareness of ways of learning and showing how they can move beyond their comfort zone. But it is important to be wary of over-emphasising attitudes and skills at the expense of subject knowledge. It is also important to ensure we do not overlook other interventions which research shows can have a powerful effect on student learning, such as thinking skills. (Coffield, 2004 <http://www.lsneducation.org.uk/user/order.aspx?code=041540&src=XOWEB>)

For a summary of this review see:

How do we know how we learn and what difference does it make? National Educational Research Forum (NERF) Bulletin No. 2 which can be downloaded from <http://www.mymgl.com/downloads/journal/NERF%20Bulletin%20Issue%202.pdf>

Following a review of learning styles Philip Adey of King's College commented:

'...there are no such things as learning styles – at least not as stable entities which are any use to teachers.'

(Adey et al, 1999 http://www.ase.org.uk/htm/members_area/journals/ssr/ssr_dec_05/letters.pdf)

Neuroscience research sounds a cautionary note about learning styles too. One review of research found no scientific evidence of a correlation between the degree of creativity and the activity of the right hemisphere. Nor was there any scientific evidence to support the view that analysis and logic depend on the left hemisphere. Both hemispheres were found to be involved in reading processes. Further the review suggests: '...the need for holistic approaches which recognise the close

interdependence of physical and intellectual well-being, and the close interplay of the emotional and cognitive, the analytical and the creative arts.'

(OECD, 2007

www.dfes.gov.uk/research/programmeofresearch/projectinformation.cfm?projectId=15336&type=5&resultspage=1)

The RoM summarises and synthesises three studies by Rupert Wegerif and co-workers (Wegerif et al, 2004)

6 Going to scale

What do we know about taking new practice to scale (this could be small scale, i.e. across departments or schools; or larger scale – local authorities, regionally and nationally)?

The transfer and scaling up project undertaken by CUREE on behalf of the Innovation Unit was a comprehensive attempt to bring together what was known about transferring good practice and taking it to scale and drew on a wide range of research within the field of education and beyond. Work by the American educationist Cynthia Coburn (2003) provided a framework for analyzing the evidence base. Coburn's review of studies on taking practice to scale led her to conclude:

'...scaling up not only requires spread to additional sites, but also consequential change in classrooms, endurance over time, and a shift such that knowledge and authority for the reform is transferred from external organization to teachers, schools, and districts. Thus, I propose a conceptualization of scale comprised of four interrelated dimensions: depth, sustainability, spread, and shift in reform ownership.'

(Coburn, 2003)

In marshalling the evidence on transfer and going to scale CUREE added to the four areas of depth, sustainability, spread, and ownership, a fifth dimension, that of goal and purpose. The five areas were defined in these terms:

- Goal and purpose - how much change is involved, of what kind?
- Depth - beyond surface structures or procedures [such as a lesson plan] to alter teachers' beliefs, norms of social interaction and pedagogical principles
- Sustainability - teachers acquiring deep understanding and therefore being better equipped to respond to new challenges and the availability of support mechanisms including professional communities of colleagues in schools
- Spread - not only the numbers taking up the initiative but also its impact on policy and professional development at whole school, local and regional levels
- Ownership - when the initiative is no longer controlled by an external agency and becomes part of the internal operation of districts, schools and teachers

The evidence highlighted the importance of deep change: 'Transfer of learning in the form of practice involves both a change in practitioners' knowledge and normal practice and an understanding of the underpinning rationale.' Key findings emphasised the importance of:

- structuring communications about practices to be transferred to model the practices wherever possible – structured around pedagogic rather than marketing principles and distilling and illustrating are features of the practice to be transferred
- recognising the need for local adaptation for context from the start at the same time as holding out for faithful adherence to the practice to be

transferred in its early iterations. Successful adaptation depends on having tried an approach out as prescribed in the first instance to enable practitioners to grasp its essence

- diagnostic protocols and tools. Practices supported by an explicit diagnosis of the starting points of pupils, schools and practitioners are more successfully transferred from those which do not support and emphasise on individual diagnostic stages
- offering practitioners clarity about the underpinning rationale for practices being transferred
- a focus or goal that is linked to evidence about pupil success
- segmentation or differentiation. Transfer of practice is dependent on tailoring tools, communications and resources to particular needs and contexts
- collaboration and shared problem solving

(Cordingley and Bell, 2007)

In addition to the specific study of taking practice to scale, there are a number of reviews about the impact of continuing professional development on teachers and their pupils that highlight important elements of supporting the development of practice in contexts other than those in which the practice originated. This material emphasises, in particular, the importance of modeling new practices and professional learning, of collaborative learning and of engaging with the underpinning rationale and theory of practices that are to be transferred.

Professional development processes that support deep professional learning and help teachers achieve ownership were identified in three reviews of CPD that were linked to benefits for students and teachers. In particular the reviews highlighted the importance of:

- contributions from specialists combined with in-school peer support and collaboration
- observation of new approaches working in context
- building on teachers' starting points
- structured dialogue rooted in evidence from experiments with new approaches in the classroom

A fourth review by the same group identified a number of core specialist practices which supported the transfer of deep professional learning including:

- specialists building the CPD processes on what teachers knew and could do already
- extensive specialist contact with teachers (both scheduled and 'on call' sessions)
- specialist guidance and encouragement of teachers working collaboratively and supporting each other's learning
- introduction by specialists of the theoretical and practical knowledge base
- ongoing specialist support including modeling, workshops, observation and feedback, coaching, and planned and informal meetings for discussion

The key finding about the role of specialists was that they both introduced new knowledge and/or skills *and* they employed a repertoire of support mechanisms to help embed learning and bring about changes in teachers' practice.

(Cordingley *et al* 2008)

Collaboration as a means for achieving the transfer of deep learning is also emphasised in a report by Michael Fielding and co-workers (Fielding, 2005). Based on interview data with some 120 practitioners involved in transferring good practice, the authors refer to '*Joint practice development*' which 'validates the existing practice of teachers who are trying to learn new ways of working and acknowledges the effort of those who are trying to support them. It also underscores the necessity of mutual engagement which lies at the heart of the complex task of opening up and sharing practices with others.'

From an analysis of 11 studies reporting student outcomes an Australian review identified the key role of leadership in supporting professional learning in schools. In the review the author found that leadership in promoting effective change had the biggest impact on students' learning. Specifically she noted that leadership of learning was most effective when:

'The leader participates with his or her staff as the leader, learner or both. The contexts for such learning are both formal (staff meetings and professional development) and informal (discussions about specific teaching problems).'

(Professor Viviane M. J. Robinson (2007) School Leadership and Student Outcomes: *Identifying What Works and Why* Australian Council for Educational Leaders (ACEL) Monograph Series Number 41 October 2007)

A review of the leadership of CPD in networks has emphasised the importance of networks in securing access to specialists for CPD.

(Cordingley and Temperley, 2006)

A New Zealand review of best practice stressed the importance of goal and purpose. The author suggested that 'experts' need more than knowledge of the content of changes in teaching practice that might make a difference to students; they also need to know how to make the content meaningful to teachers and manageable.

'Expecting teachers to act as technicians and to implement a set of 'behaviours' belies the complexity of teaching, the embeddedness of individual acts of teaching, and the need to be responsive to the learning needs of students.'

The author suggested that effective support for CPD participants involved support in processing new understandings and their implications for teaching, which could include 'challenging problematic beliefs and testing the efficacy of competing ideas'.

(Timperley *et al*, 2007)

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