Research for Teachers

Jerome Bruner's constructivist model and the spiral curriculum for teaching and learning

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In response to the popularity of our TLA research summary about Lev Vygotsky, we decided to feature the work and contemporary relevance of another influential educational thinker - Jerome Bruner (1915-).

Bruner has made an enormous contribution to our understanding of the education process. As a professor of psychology at Harvard, he was particularly interested in the cognitive development of children and what appropriate forms of education might be. His 'landmark' text, *The Process of Education* (1960) revealed his particular view of constructivism - the theory that learners actively construct their own knowledge based upon the things they know now and have known in the past.

Bruner's view of teaching and learning was influenced by research studies conducted by other American psychologists, which were beginning to show a shift in emphasis - from exploring the transfer of specific skills to exploring the value gained from training such 'faculties' as analysis, judgement and memory. Their studies were showing that general 'transfer' could be achieved by appropriate learning, even to the extent that learning properly led to 'learning how to learn'.

Bruner argued that in order to enable the transfer of thinking processes from one context to another, children needed to learn the fundamental principles of subjects rather than just master facts. He advocated learning through enquiry, with the teacher providing guidance to accelerate children's thinking, and recommended that the early teaching of any subject should emphasise grasping basic ideas intuitively. After that, he believed, the curriculum should revisit these basic ideas, repeatedly building upon them until the pupil understands them fully (the spiral curriculum).

Bruner commented in his preface to the revised edition in 1977, that his view of teaching and learning was out of step with the dominant view in education at the time his book was first published. But it struck a chord with many and had a direct impact on policy formation in the United States. Today, constructivism is widely

considered an important model of effective teaching practice, and Bruner's ideas underlie many contemporary approaches and practices, such as thinking skills and assessment for learning.

Bruner organised his ideas in The Process of Education into four key themes:

- the role of structure in learning and how it may be made central in teaching
- readiness for learning
- intuitive and analytical thinking
- motives for learning.

In this summary we explore the ideas for teaching and learning that Bruner put forward nearly half a century ago and draw out the messages for today's teachers and leaders. The case studies we have chosen show the applicability of Bruner's ideas in current school settings. We think practitioners will find exploring the theory underpinning effective classroom practices makes a useful basis for professional development by providing a focus for reflection and action.

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Overview

Why is the issue important?

In 1959, Jerome Bruner brought together the world's leading educationalists to think through what a meaningful curriculum could/should look like. The ideas about the curriculum that emerged related to checking teaching and learning experiences through which students could not only learn new things but construct meaningful understanding. These constructivist ideas, which Bruner put forward in *The Process of Education* (1960), underlie many contemporary approaches and practices, such as thinking skills and assessment for learning and have the potential to support curriculum development and innovation in practical and inspiring ways.

What are the key messages?

Bruner argued that for 'transfer' to happen, children needed to learn to make connections between different experiences in learning rather than just master facts. To achieve this, he advocated learning through enquiry, with the teacher providing guidance to accelerate children's thinking. He recommended that the early teaching of any subject should emphasise grasping basic ideas intuitively. After that, he believed the curriculum should revisit these basic ideas, building upon them incrementally until the pupil understands them fully (the spiral curriculum).

How did Bruner arrive at his ideas?

Bruner, a psychology professor at Harvard, chaired a ten-day conference in 1959 attended by 35 delegates (experts in science, psychology and education) who had gathered together to discuss how education in science might be improved in primary and secondary schools. The delegates explored conceptual questions about learning and teaching, such as, what should be taught, when and how, and how the structure of a subject could be structured so that it gave students a sense of the fundamental ideas as quickly as possible. Afterwards, Bruner wrote a report based on the views debated at the conference and the correspondence that followed it.

What are the implications?

Bruner's work suggests the importance of:

- pupils learning the 'fundamental principles' of a subject - the connections between ideas within subjects

- starting from what children know already and providing them with guidance that moves their thinking forwards
- developing children's intuitive thinking, by providing opportunities for pupils to guess at answers before checking whether their guesses are valid, whilst taking care to make them feel comfortable about sharing their hunches
- learning through discovery and problem solving, which requires pupils to hypothesise, ask questions and discuss lines of enquiry.

What do the case studies illustrate?

The case studies show the contemporary relevance and importance of Bruner's ideas. They show, for example, how:

- an ICT coordinator designed ICT training for her colleagues, which was underpinned by Bruner's progressive stage theory of learning
- a group of teachers applied Bruner's theory of teaching leading cognitive development by first observing the way their pupils approached a task - a geography 'mystery' - then showing them the next step to lead their pupils' thinking forwards
- a history teacher enabled her pupils to learn through solving a problem. They became history detectives, a role which involved asking questions, hypothesising, discovering clues and following lines of enquiry in order to solve a murder mystery that took place in 1822.

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Study

What did Bruner believe was the key purpose of learning?

Bruner believed that learning should serve the future. His starting point was that:

'Students ... have a limited exposure to the materials they are to learn. How can this exposure be made to count in their thinking for the rest of their lives?' (p.11)

'Learning should not only take us somewhere, it should allow us later to go further more easily'. (p.17)

Bruner explained that learning can serve the future in two ways, through:

- specific transfer to tasks that are similar to those originally learned
- non-specific transfer - the transfer of principles and attitudes.

The first type of transfer consists of learning a skill. The second type of transfer consists of learning a general idea that can be used as a basis for recognising subsequent problems as variations of the original idea.

Practitioners may like to read a case study we reported in an earlier RfT summary about Vygotsky which provides information about the transferability of pupils' thinking processes.

Vygotsky believed teaching and learning which involve higher mental functions can influence related mental processes in other subject areas. The case study was drawn from the Cognitive Acceleration through Science Education (CASE) project.

What kind of learning enables transfer to happen?

Bruner was clear about the kind of learning that needed to take place for transfer to happen:

'The teaching and learning of structure [principles], rather than simply the mastery of facts and techniques, is at the center of the classic problem of transfer'. (p.12)

He also indicated what this kind of learning involved:

'Mastery of the fundamental ideas of a field involves not only the grasping of general principles, but also the development of an attitude toward learning and inquiry, toward guessing and hunches, toward the possibility of solving problems on one's own'. (p.20)

Practitioners may like to read our earlier RfT summary about assessment for learning which showed how a group of teachers changed from delivering factual knowledge about their subject to helping their pupils take responsibility for their own learning.

We explore the key features of Bruner's theory which are indicated above - what Bruner meant by the structure of a subject, why he considered teaching it to be important and how he thought it could be taught, the importance of intuition and of pupils learning through enquiry, on the pages that follow.

How do the crucial connections within subjects affect learning?

Bruner explained that learning 'subject structure' is about learning how things are related. He explained how in mathematics for example, students learn basic rules, such as how multiplication is commutative (i.e. that 2x3 and 3x2 give the same answer) but that subtraction isn't (i.e. that 3-2 does not give the same answer as 2-3). They then apply the rules in different situations, although they may not know what the rules are called.

'Algebra is a way of arranging knowns and unknowns in equations so that the unknowns are made knowable. The three fundamentals involved in working with these equations are commutation, distribution and association. Once a student grasps the ideas embodied by these three fundamentals, he is in a position to recognise wherein "new" equations to be solved are not new at all, but variants on a familiar theme. Whether the student knows the formal names of these operations is less important for transfer than whether he is able to use them'. (p.7)

Practitioners may like to read a case study we featured in our earlier RfT summary about assessment for learning which shows how a teacher used effective questioning to enable his pupils to discuss their knowledge of scientific principles rather than simply check their knowledge of scientific terms and their definitions.

Bruner explained how children learn subject structures unconsciously to begin with - they have an intuitive understanding of them. Later, they are able to understand and explain the fundamental principles of a subject in formal and abstract ways. He gave the example of young children learning their native language as an illustration of this process:

'Having grasped the subtle structure of a sentence, the child very rapidly learns to generate many other sentences based on this model. And, having mastered the rules for transforming sentences without altering their meaning ... they are able to vary their sentences much more widely. Yet, while young children are able to use the structural rules of English, they are unable to say what the rules are'. (p.8)

We look at Bruner's view regarding the importance of fostering pupils' intuitive understanding as a precursor to formal understanding in later sections of this RfT summary.

Why did Bruner think it was important to teach subject structure?

Bruner discussed a number of reasons for teaching the fundamental principles of a subject. These included:

- understanding fundamental principles makes a subject more comprehensible - he suggested, for example, that pupils

will understand the novel *Moby Dick* more deeply, if they are led to understand that the novel is a study of the theme of evil

- detail is rapidly forgotten unless it is placed into a structured pattern - he suggested, for example, scientists do not try to remember the distances traversed by falling objects in different gravitational fields over different periods of time. Rather, they use formulae that allows them to regenerate the details
- learning subject structure enables the transfer of training.

Bruner suggested that an understanding of the fundamental structure of subjects is necessary for bringing knowledge to bear on problems and events they meet outside of school or later on in their education. He explained that learning subject structure involves supporting habits and skills that make it possible for pupils to make active use of the materials that they have come to understand.

Bruner considered that the task of teaching a subject to a child at any particular age involves presenting its structure in terms of the child's way of viewing things, which in turn depends on his/her stage of intellectual development. We outline Bruner's theory of how children's thinking processes develop below.

How do children's thinking processes develop and how does this affect the way they learn?

Bruner considered that children's intellectual development progressed through three stages: the pre-operational, concrete operational and formal operational stage. Although Bruner derived these stages from Piaget, Bruner, unlike Piaget, did not contend that these stages were necessarily age-dependent. Bruner's progressive stage theory of children's intellectual development relates to learning in general.

The 'pre-operational' stage: At the first stage (characteristic of the pre-school child) the child's mental work consists of establishing relationships between experience and action - the child goes about problem solving through trial and error.

The 'concrete operational' stage: At the second stage (around 6-10 years), the child can go about problem-solving directly (manipulating physical objects) or indirectly (manipulating symbols inside the head). But the child cannot deal easily with possibilities s/he hasn't already experienced or describe the problem-solving strategies s/he used.

The 'formal operational' stage: At the third stage (around 11-14 years), the child is able to form hypotheses about what might happen rather than being constrained to what s/he has experienced or what is in front of him/her. The child can also describe the ideas that guide his/her problem solving which s/he could not describe or understand before.

Stages of learning

In his subsequent book, (*Towards a theory of Instruction* - see Further Reading) Bruner presented a more general theory of learning consisting of three progressive stages, based on the stages of children's intellectual development outlined above:

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

So, whilst Bruner's theory of learning related to the way children's thinking developed, it could also be applied to adults learning new and unfamiliar material. For example, when adults encounter difficulties with learning at the symbolic stage, they sometimes revert to the earlier enactive or iconic stages in order to solve a problem. Practitioners may like to read a case study of how an ICT coordinator in a primary school designed ICT training for her 'low tech' colleagues, which was underpinned by Bruner's progressive stage theory.

Does teaching have to follow the natural course of intellectual development?

Bruner explained that the intellectual development of the child is not a clockwork sequence of events - it responds to influences from the environment. So, teaching does not have to follow the course of cognitive development, but can lead it by providing challenging, usable opportunities for the child to forge ahead in development - tempting the child into more powerful modes of thinking. Bruner was suggesting that learning should start from where the learner is already. His idea was to first match the problem to the learner's capacities or find some aspect of the problem that could be matched. Then, instruction should move the learner on from his/her current developmental level.

Bruner's notion of teaching leading, as opposed to following cognitive development is similar to Lev Vygotsky's theory of the 'zone of proximal development' (ZPD), which refers to the difference between what a person can achieve by him/herself and what s/he can achieve with the assistance from a more skilled person. Vygotsky (a Russian psychologist, whose work started to be translated into English in the 1960s) believed that the deepest learning occurred in this zone and that learning with others is crucial for cognitive development. Practitioners may like to look at Vygotsky's theory of ZPD, in our earlier RfT 'Social interaction as a means of constructing learning'.

Today, many researchers work in the area of cognitive acceleration, otherwise known as thinking skills. One of the best known examples of thinking skills is Philip Adey and Michael Shayer's CASE project. Practitioners may like to read about the project in our earlier RfT summary 'Improving learning through cognitive intervention'. Practitioners may also like to read a case study that shows how some geography teachers applied the theory of teaching leading cognitive development. First they observed the way their pupils approached a task, then showed them the next step to lead their pupils' thinking forwards.

Matching problems to the learner's current developmental level, then providing instruction that moves learners beyond what they could achieve alone is also central to assessment for learning. Practitioners may like to read a case study we featured in our earlier RfT about assessment for learning. The study showed how science teachers identified what their students needed to learn and how they used the information to break the learning of science topics into a series of steps.

How did Bruner suggest the curriculum should be designed to build upon pupils' natural thinking processes?

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. For example, young children could learn some principles of physics (such as force, mass, momentum, friction) by experiencing them through play. Later on, these same principles could be revisited in progressively more complex forms.

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 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.

Practitioners may like to read a case study that showed how young children experienced less success when they used a formal mathematical equation to solve problems than when they used their own informal methods. The study concluded that teachers should help young children to structure how they record their informal methods rather than teach them how to use formal equations and encourage pupils to be flexible so that that they choose appropriate methods to solve problems.

What did Bruner believe helped to deepen pupils' learning?

Bruner argued that children needed to be intrinsically interested in what they were learning rather than being motivated by external rewards or through competition to do better than others:

'Ideally, interest in the material to be learned is the best stimulus to learning, rather than such external goals as grades or later competitive advantage'. (p. 14)

'Motives for learning must be kept from going passive ... they must be based as much as possible upon the arousal of interest in what there is to be learned, and they must be kept broad and diverse in expression'. (p. 80)

He recognised the difficulties of finding an approach that all pupils are motivated by:

'The quest, it seems is to ... challenge the superior student while not destroying the confidence and will-to-learn of those who are less fortunate. We have no illusions about the difficulty of such a course yet it is the only one open to us if we are to pursue excellence and at the same time honor the diversity of talents we must educate'. (p.70)

Practitioners may find it helpful to read pupils' suggestions for what motivates them to learn which we reported in our earlier RfT summary, 'Consulting pupils about teaching and learning' .

Bruner argued that children would benefit from being more involved in the process of learning than they had in the past. The approach he advocated was a practical one - learning through discovery and enquiry.

What did Bruner mean by learning through discovery and enquiry?

Bruner gave an example of a geography lesson to illustrate the enquiry approach he advocated. During the lesson, the students were introduced to the geography of an area through being asked 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 a class discussion about the problem, the children produced a variety of plausible theories concerning the requirements of a city, 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
- 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 in this task was far above that of the control classes. But what he found particularly striking was 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. Not only did they experience the pleasure and excitement of pursuing a question, the discovery was worth making - at least for these urban children, who had, up until then, taken the phenomenon of the city for granted.

Practitioners may like to read a case study, which we highlighted earlier in the RfT, of another approach to teaching geography that involved students working together to solve a problem. The case study is drawn from David Leat's 'Thinking through geography programme'. Practitioners can read other case studies drawn from David Leat's 'Thinking through geography programme' in the case study section of our earlier RfT 'Improving learning through cognitive intervention'.

Underlying Bruner's conviction of learning through enquiry was the belief that intellectual activity is fundamentally the same for everyone:

'The schoolboy learning physics is a physicist, and it is easier for him to learn physics behaving like a physicist than doing something else'. (p.14)

By 'something else', Bruner was referring to textbooks that present the conclusions of research rather than centring upon enquiry, ie emphasising the acquisition of factual knowledge rather than solving problems.

Practitioners may like to read a case study which describes how a teacher helped her pupils work in the same way as academic historians. They took on the role of history detectives - asking questions, hypothesising, discovering clues and following lines of enquiry in order to solve a murder mystery that took place in 1822.

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.

Why did Bruner consider intuition an important aspect of learning?

Throughout his book, Bruner repeatedly emphasised the importance of encouraging pupils' intuitive understanding as a precursor to formal understanding. He defined intuition as:

'the act of grasping the meaning, significance or structure of a problem or a situation without explicit reliance on the analytic apparatus of one's craft'. (p.60)

To Bruner, it was more important for pupils to have an intuitive grasp of a subject - the ability to 'say how it goes' - than to know the proper terms or standard formulae, but not understand their meaning:

'[It is intuition that] yields hypotheses quickly, that hits on combinations of ideas before their worth is known'. (p.60)

He was aware that some intuitive guesses or 'hunches' are "good" and some are "bad" in terms of how they turn out and explained how analytical methods complemented intuitive thinking:

'Once [the solutions to problems have been] achieved by intuitive methods, they should if possible be checked by analytic methods, while at the same time being respected as worthy hypotheses for such checking'. (p.58)

How did Bruner suggest intuitive thinking might be developed in children?

Bruner acknowledged that what makes the development of intuitive thinking more likely isn't known, but he put forward a number of ideas of what he thought might help or hinder the process.

Modelling intuitive thinking

Bruner suggested that pupils were more likely to develop intuitive thinking if they saw their teachers thinking intuitively. But he was uncertain whether the process involved imitation or more complex processes. He thought it unlikely that a pupil would develop intuitive methods of thinking if s/he never saw them used effectively by others. Bruner suggested that a teacher who showed a willingness to guess at answers to questions asked by a class and then subject the guesses to critical analysis may be more likely to build those habits into students than would a teacher who analysed everything for the class in advance.

Encouraging pupils to guess

Bruner suggested that encouraging pupils to guess in certain kinds of situations may be another way of

helping them learn to think intuitively. He advised that guessing should always be followed up by confirmation, but felt that too stringent a penalty on guessing may restrain thinking of any sort and keep it plodding rather than make occasional leaps. He also thought it important that pupils be given training in recognising the plausibility of guesses. He felt that pupils' thinking would benefit from learning that there are alternatives lying somewhere between the truth and complete silence that could be chosen.

Building pupils' self-confidence

Bruner felt that cultivating intuitive thinking required teachers to build pupils' self-confidence. He pointed out that a person who thinks intuitively may often achieve correct solutions, but runs the risk of being proved wrong. Such thinking therefore requires a willingness to make mistakes - someone who lacks confidence may be unwilling to run such risks. But Bruner recognised that building a pupil's confidence was not easy:

'It takes a sensitive teacher to distinguish an intuitive mistake - an interestingly wrong leap - from a stupid or ignorant mistake, and it requires a teacher who can give approval and correction simultaneously to the intuitive student'. (p. 68)

Practitioners may like to read a case study we featured in our earlier RfT summary, 'Effective teachers of literacy' which shows how a teacher gave sensitive, flexible support to her pupils' intuitive ideas about writing.

What may prevent intuitive thinking?

As well as lack of self-confidence, Bruner commented that the system of rewards and punishments used in schools may actually inhibit pupils' use of intuitive thinking because assigning grades or levels to work emphasises the acquisition of factual knowledge and the "correct answer", as these aspects are the most easily evaluated.

Practitioners may like to read a case study we suggested earlier in this RfT summary which noted another apparent inhibiter of children's intuition. The study found that introducing formal methods of calculation to young children seemed to replace their intuitive procedures rather than enhance them.

How did Bruner arrive at his ideas?

Bruner was a professor of psychology at Harvard University, where he was cofounder and director of the Centre for Cognitive Studies. In 1959 he was invited to chair a 10-day conference attended by 35 delegates who included scientists, historians, psychologists and professional educators. They had gathered together to discuss how education in science might be improved in primary and secondary schools. Bruner reported that this was the first time that psychologists (with research interests in the fields of intelligence, learning, remembering, thinking and motivation) had been brought together with scientists and educators to discuss the problems involved in teaching their various disciplines. The two historians attending the conference enabled the delegates to compare the issues involved in science teaching with those in a more humanistic field.

During the opening days of the conference, various curriculum projects designed to teach mathematics, biology and physics were discussed and appraised, and several instructional techniques were demonstrated, such as how children could be taught to formulate searching questions. Then the delegates split into groups to discuss, for example:

- cognitive processes in learning
- the sequence of the curriculum
- the motivation of learning
- the role of intuition in learning and thinking.

In the process, the delegates explored conceptual questions about learning and teaching, such as:

- what should be taught, and when and how?
- what are the implications of emphasising the structure of a subject, whether mathematics or history?
- how might the structure be emphasised in a way that seeks to give a student a sense of the fundamental ideas as quickly as possible?

Each group prepared a report that was presented to, and debated by, all the delegates. As chairman, Bruner wrote a final report that drew out the major themes of the reports by the individual working groups and the most striking tentative conclusions reached during the debates. Bruner sent a draft of this report to all the conference delegates for comment and criticism. His book, The Process of Education is based on the views put forward at the conference and the correspondence that followed it.

What are the implications for teachers and leaders?

Teachers may wish to consider the following implications of Bruner's theory of teaching and learning he put forward in his book, The Process of Education.

- To Bruner, it was important that pupils learned the 'fundamental principles' of a subject, the connections between ideas within subjects. Would you find it helpful to share ideas with colleagues about connections between ideas within subjects you teach and about effective ways of helping pupils discuss and learn them?
- Like Vygotsky, Bruner believed that effective teaching involved starting from what children know already and providing them with guidance that moves their thinking forward. How do you go about identifying your pupils' current knowledge to help you identify the next steps they need to take?
- Bruner thought it important for pupils to develop intuitive thinking, although he recognised that it was difficult to foster. Could you provide more opportunities for your pupils to guess at answers before checking whether their guesses are valid, whilst taking care to make them feel comfortable about sharing their hunches?
- Bruner advocated learning by discovery and problem solving, which requires pupils to hypothesise, ask questions and discuss lines of enquiry. Could you provide more opportunities for pupils to work together in groups to solve problems? Would you find it helpful to share ideas with colleagues about kinds of problems that enthuse pupils?

Leaders may wish to consider the following implications:

- Bruner's ideas underpin current cognitive acceleration strategies. Do you have colleagues who use cognitive strategies effectively in their teaching who could coach others in their use? Or would it be possible to offer teachers time to work together to plan cognitive intervention strategies and spread good practice within and also beyond their own departments?
- The RfT summary showed how Bruner's ideas also underpin current assessment for learning practices which help pupils learn how to learn. Would professional development activities geared towards deepening and extending formative assessment practices help your colleagues to help their pupils take more responsibility for their own learning?
- Much of Bruner's writing applies as much to teachers' own professional learning as their pupils' learning. Would your colleagues find it helpful to share with each other examples of where Bruner's theory of teaching and learning underpins their own classroom practices?

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Case studies

The following case studies show the applicability of Bruner's ideas in current school settings.

- Bruner considered that children's intellectual development progressed through three stages. Case study 1 explores how Bruner's progressive stages of learning can be relevant even to adult learners.
- Bruner argued that teaching should lead cognitive development, by providing challenging opportunities for the child to forge ahead in development and that learning should start from where the learner is already. Case study 2 shows how some geography teachers set about diagnosing the stage their pupils were at, so that they could provide the next step that would move the pupils on.
- 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. Case study 3 shows how young children experienced less success when they tried to use a formal mathematical equation to solve division problems than when they used their own informal methods.
- Bruner advocated that learning should be through discovery and enquiry and believed that intellectual activity is fundamentally the same for everyone. Case study 4 shows how a teacher designed an enquiry based history project in which pupils learned to use the approach used by academic historians.

Learning to use ICT

We chose this study because it shows how even older learners - in this case primary school staff - can sometimes find it helpful to work through all three stages of learning identified by Bruner: the enactive (learning by doing), the iconic (learning by means of pictures) and symbolic (learning by words and/or numbers). The study describes the way an ICT coordinator organised ICT training for her colleagues and how her approach was underpinned by Bruner's theory of learning.

The ICT training consisted of initial explanation, plenty of 'hands on' practice and experimentation, and access to reference materials that included pictures and text. Tasks were matched to the needs and abilities of the staff. Initially, the training involved developing ICT skills and teaching ICT as a subject to pupils. As the skill level of the staff increased, the training focused more on using ICT to enhance teaching and learning in all curricular areas. The staff felt that having lots of time to practise and play around with what they had been shown was crucial for their enjoyment and acquisition of skills. The staff also felt that being shown skills relevant to their experience, so that they could use what they had learnt immediately, was important too.

At the time of the study, the primary school had recently moved to a new site - an architecturally designed 'high tech' building. Each of the classrooms had an interactive whiteboard, three high-specification desktops and access to a range of ICT peripherals, such as scanners, printers, digital cameras and web cameras. Also available was a set of laptops and PC tablets with wireless access to a managed network and a broadband connection to the Internet. The school had been set up as a test bed for new hardware and software and staff were expected to use ICT to enhance teaching and learning across the curriculum and to demonstrate best practice.

One of the biggest challenges the ICT coordinator faced was preparing her relatively 'low tech' colleagues to work in their new high tech environment. She aimed to create a training programme that responded to their personal needs as well as the skills and understanding required for teaching ICT and using ICT to enhance teaching and learning in all curricular areas. The design of the training needed to take into consideration varying skill levels and attitudes towards using computers. Some teachers and nearly all the learning support staff displayed aspects of 'computerphobia' - fear, anxiety or even hostility towards computers.

What did the ICT training involve?
Before initiating the training, the ICT coordinator carried out a simple audit of her colleague's skill levels. She used the information to create individual learning plans, to plan the content of INSET and staff meetings, and to evaluate progress. Staff were offered a range of ICT training opportunities over several terms and were given time to practice their skills. Information and Communications Technology was made a key area in the School Development Plan and a large proportion of staff meeting and INSET time was dedicated to ICT. Each teacher also received non-contact time on a rota basis, which was used specifically for developing their ICT skills.

The first part of the ICT training took place on an INSET day. The aim of the day was to address some of the feelings of fear and anxiety held by the staff by allowing the whole staff to experience ICT training in a supportive environment. A lecturer from a teacher training institution provided this initial training. The main objectives of the day were to demonstrate that computers are enjoyable and, with appropriate instructions and

guidance, easy to use. The day was planned around a framework that consisted of short instructional sessions of about 10 minutes with pictorial handouts, followed by a long time to 'play' and try things out with support. The content of the training was made relevant to the teachers on a personal level (using the Internet, for example) and on a professional level (making multimedia books, for example).

The content of the ICT staff meetings was guided by an audit of skills needed to teach the ICT curriculum and by staff requests. Sometimes, the staff meeting was split into key stages, enabling the content to directly address their different needs. At other times, staff worked in novice-expert groups. Frequently, groups met informally to continue and extend skills introduced during staff meeting, or to help each other with further ICT skills or difficulties.

The role of 'play' in the ICT training

Play formed a major part of the design of the ICT training. It soon became clear that the staff preferred an instructional style that consisted of a short explanatory session followed by a longer 'hands on' session and which was supported by visual reference material, using both words and pictorial instructions. The first, enactive mode of Bruner's stage theory of learning involves 'learning by doing'. Bruner suggested that constructive play should be a dominant activity of the pre-school years. He argued that children should be encouraged to play with objects in order to build up intuitive understanding. In this example, Bruner's notion of the importance of play was transferred to the world of the older learner.

The ICT coordinator was clear about the importance of 'play' for enabling her colleagues to learn to use ICT effectively. She saw the benefit of learning through play as:

- reducing the seriousness of the consequences of errors and setbacks - important for learners with low self-esteem and high fear of failure
- allowing learners the chance to construct their own learning path and explore what interested them
- gaining enjoyment and motivation from being able to surmount obstacles.

Since many staff members did not have access to a computer at home, the coordinator contacted local companies and several donated some of their older machines. This gave staff the opportunity to gain confidence in experimenting with computers at home. Once they had experienced the potential of computers to help with their teaching, many of the teachers bought newer machines for themselves.

Building on learners' existing knowledge

The training also implemented another important aspect of Bruner's theory of learning - matching instruction to the learner's current abilities and capacities, with the aim of moving them on. The training was designed to focus on problems that were relevant to the staff and enable them to find their own solutions for the challenging situations they felt they faced. To help them, an ICT advisory teacher provided support one day a week. His role was to give one-to-one tuition on specific skills relating to the teachers' individual learning plans, or to model the teaching of an ICT skill or to team teach with ICT in the classroom. The content and style of this training was directed by the individual teacher.

Staff were made aware that they were expected to make mistakes and were encouraged to learn from them and not to be discouraged by them. They were also made aware of the time, energy, pride and self-assurance it takes to learn to use ICT equipment. It was also pointed out to them that using ICT equipment does not initially make life easier, unlike other electronic devices, such as dishwashers; that in fact, initially, ICT can make life harder.

What factors helped to make the ICT training successful?

The ICT coordinator highlighted four aspects of the ICT training that she felt had been crucial to its success:

- finding out the attitudes and feelings of the staff towards ICT was important because it enabled her to design training that challenged those misconceptions and over time create a more open and exploratory attitude towards ICT. This new attitude laid the foundations for their future ICT learning

- the role of 'play' was important because it enabled the staff to build up their own understanding without the anxieties usually associated with making mistakes, but also because 'play' allowed them to construct their own learning path and in the process they discovered new things
- the content and relevance of the training was important. The most successful training sessions were those that focused on ideas and skills that could be transferred to the classroom the following day - they were highly valued and quickly put to use
- staff members sharing a vision of how new technology could enhance teaching and learning and working together to achieve their vision. It created a culture that encouraged and valued the exchange of ideas and skills.

Reference:
Edmondson, A. (2003) What styles of computer training enhance teachers' competence and confidence to use ICT?

Using geography mysteries to scaffold pupil learning

We chose this case study because it shows how teachers set about diagnosing their pupils' thinking and how this enabled them to provide a next step that would move their thinking forward. The geography teachers made use of 'mysteries' in this study. Mysteries offer the possibility of observing pupils working in ways that reveal their thinking processes. The first aim of the study was to identify differences in the ways that high and low achieving groups tackled the mysteries. It found that groups progressed through a series of observable stages of thinking. The second aim of the study was to see how teachers used their knowledge of these stages of thinking to scaffold pupil learning.

The metaphorical term 'scaffolding' is used for the instructional support, often in the form of adult-child dialogue that is structured by the adult to maximise the child's development or growth. As the child develops increasing mastery of a given task, the adult gradually withdraws the support, until eventually, the initial scaffolding is removed altogether. To scaffold a pupil effectively, the teacher needs to stay one step ahead of the pupil, always challenging him/her to reach beyond his/her current ability level. The first application of the word 'scaffolding' to an educational context is attributed to Bruner (1978, see Further Reading) who observed the way parents interact with their children to help them learn.

What are mysteries?
Groups of two to four pupils are presented with 15-30 pieces of information on a topic (for example, hurricanes or earthquakes, etc) with each piece of information provided on a separate slip of paper (the data items). The information includes trigger and background factors. The group is also given a question to answer. For example:

'There was an elderly couple living in Kobe, Mr and Mrs Endo. One of them died in the earthquake disaster - which one and why?'

The group is encouraged to use as much of the information they have been given as possible when formulating their answer. Not all of the information given is necessarily relevant to the question.

What stages were involved in tackling mysteries?
Five progressive stages of thinking were identified by the study:

- the display stage - simply spreading out the data items on the table so that they could all be seen and read easily
- the setting stage - organising the data items into sets with common characteristics, usually arranged as columns or blocks
- the sequencing and webbing stage - identifying relationships between the sets or between single items
- the reworking stage - the establishment of new sets of relationships between the sets or between single items
- the abstract stage - the physical manipulation of the data items ceased, but the discussion continued.

How were the stages of thinking identified?

A range of data were collected during the study:

- photographs of all the groups as they worked on a mystery on a set time interval, to provide a simple time lapse of how the pupils physically arranged the slips of paper
- videos of high and low achieving groups doing mysteries
- interviews with groups of pupils using a technique called stimulated recall, which involved showing pupils a video of their group doing a mystery and asking them to comment on what they were doing and thinking as they worked
- observation notes of the pupils that were photographed and videoed.

The data were then analysed on two fronts:

- the photographs were compared with the observation notes to define phases that pupils generally went through when physically arranging the data
- the notes and transcripts from the pupil interviews were compared wth the phases in data manipulation to calibrate these stages with pupils' descriptions of their thinking.

How did the teachers use mysteries to scaffold learning?
Through the mysteries, the teachers were able to observe their pupils' thinking skills, or lack of them, whilst they tackled the mysteries. By setting the thinking strategies they observed their pupils using within the context of the progressive stages, the teachers were able to suggest a next step that would edge the pupils onto the next stage in their ability to reason and process data.

Example 1
In one case, a low achieving group of 12 year olds were doing a mystery which concerned he disappearance of a tribe of Amazonian Indians. The slips of paper included information about :

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

The group of four boys were having great difficulty with the mystery. 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. With this action, the teacher had diagnosed a weakness shared by the whole group in classifying/grouping data and demonstrated how they could undertake the next stage in working towards a solution. When the pupils had grouped several data items about water, the teacher returned to suggest that they might form a group about diseases and health. This enabled her on a third visit to start asking them about the possible connections both within and between the two groups of data items. The pupils thus took their first steps on formulating an explanation.

Example 2
A group of 14-15 year olds of higher ability were doing a mystery that focused on who was to blame for the need to demolish a block of (public housing) flats in a British city. The data items included reference to:

- the faulty materials and technology used in the building
- the anti-social behaviour of some of the residents
- the destruction of the community which lived in the terraced houses that were cleared to build the high-rise blocks
- the physical deterioration of the building
- the fears of residents in the flats with young children.

A group of girls had initially sorted their data into two groups: one representing reasons for the demolition and the other against. But in fact, they were not addressing the task and were classifying in an unproductive way. When their teacher pointed this out to them, they began to re-sort the data bearing in mind the need to attribute blame or reasons. This time they formed groups related to the local council, the builders, the anti-

social residents and the government.

Example 3
Another group of higher ability 14-15 year olds were about to do a mystery on hurricanes. The teacher asked the students how they could go about tackling the task. They volunteered six strategies, including sorting more and less important reasons, making it into a story, working out a time sequence and sorting relevant from irrelevant information. By doing this, they revealed that not only did they have a range of strategies, they had the beginnings of a language to talk about cognitive processes.

Reference:
Leat, D. & Nichols, A. (2000) Observing pupils' mental strategies: signposts for scaffolding. International Research in Geographical and Environmental Education 9 (1) pp.19-35

Development of pupils' division strategies

We chose this case study because it demonstrates how young children can flounder if they try to use a formal mathematical equation without understanding it. The study explored the strategies Year 5 pupils used to solve division problems. It found that when the pupils used the standard algorithm they made more errors and that they experienced more success when they used efficient, but less formal methods of problem-solving. The study concluded that teachers should defer the use of formal written methods until pupils have confidence in their own informal methods and are aware of the likelihood of the correct answer.

When the researcher looked at how the children set about solving the problems, she found:

- the most frequently used method was the standard algorithm
- the most effective method was 'high level chunking' (a method for decomposing numbers in efficient ways using known relationships. For example, in the sum 432 ÷ 15, 432 can be 'chunked' as 300, 60, 60 and 12 to make division by 1 5 easier)
  'low-level chunking' (a method for decomposing numbers in less efficient ways. For example, repeatedly subtracting 60 in the sum 432 ÷ 15) was unsuccessful in three out of four cases because the large number of steps involved i ntroduced more chances for subtraction errors
- pupils were more likely to be successful at reaching the correct answer when the problem was shown in context. Giving the context influenced how the children solved the problem - for example children drew shopping baskets to help them solve a problem that involved sharing.

In between the two tests the children were taught division using the standard algorithm. When the researcher compared the pupils' scores from both tests, she found that:

- only about half the pupils (52%) had improved over the five months
- 19% answered the same number of questions correctly
- 29% answered fewer questions correctly.

When she investigated further, she found:

- many of the errors the pupils made were due to errors they made in applying the standard algorithm
- the children who used the low level chunking method in the first test were generally unsuccessful and changing to using the standard algorithm in the second test did not improve their scores
- pupils tended to use the standard algorithm with bare problems - use of the method increased by 10 per cent in the second test, but half the attempts led to the incorrect answer.

The researcher concluded that many children hadn't progressed beyond inefficient low-level methods by the end of primary school. She suggested that introducing the standard algorithm seemed to replace intuitive procedures rather than enhance them - when pupils used the standard algorithm, they recorded the answers they found even if they were bizarre. She recommended that when introducing written methods of division, teachers should focus on developing informal methods to enable children to improve without losing their

understanding. She suggested that teachers should help pupils to structure how they recorded their informal methods rather than teach the traditional method and encourage pupils to be flexible so that that they choose appropriate methods to solve problems.

Reference:
Anghileri, J. (2001) Development of division strategies for Year 5 pupils in ten English schools *British Educational Research Journal* 27 (1) pp.85-103

Learning to be history detectives

We chose this case study because it shows how a teacher introduced her class to the investigational approach used by academic historians - an approach that involves evaluating and interpreting fragmentary and sometimes contradictory evidence from a variety of primary sources. The teacher developed a week-long local history project for her class of 8-9 year olds in which the objective was to solve the mystery of the suspected murder of Samuel Whitehouse, who died in April 1822 in Warley Woods. The project emphasized whole class enquiry: the children were encouraged to take on the role of history detectives - to think of questions, follow a line of enquiry and make hypotheses. At the end of the project, the children wrote an account of the event and completed questionnaires about their experiences.

As history detectives, the pupils were involved in a number of activities:

- asking questions and hypothesizing
- discovering clues
- presenting arguments and developing reasoning skills
- writing an account.

The 'history mystery' grew from:

- the discovery of a newspaper report of a trial referring to a possible murder in April 1822
- a legend surrounding a ghost
- architect's drawings of a gothic abbey.

Asking questions and hypothesising
The teacher began the project by giving her pupils the following task:

"Murder most foul!?! - On Wednesday April 3rd 1822 the body of Samuel Whitehouse was found here, with severe head injuries. Your task is to find out if he was murdered. Who or what could have startled his horse?"

The children were shown a horseshoe that had been found at the site. In their role as history detectives, the children were asked to formulate questions that would help them work out what had happened to Samuel Whitehouse. The task was displayed and the children were given worksheets to record their questions on. To begin with, the children discussed their questions with a partner, then shared their ideas with the rest of the class. All the questions were written up and discussed by the class. Altogether, the children raised 44 different questions, for example:

- Who found him?
- Other than the horseshoe, were there any more things found lying about where the body was found?
- Why was he on a horse?
- What was he doing there?
- Which part of the wood was he found in?

Discovering clues
All the children took part in a treasure hunt on the computer in pairs or independently. The game comprised hyperlinks in MS Word to pages containing information about people, places, maps, facts and interviews

related to the trial. The history mysteries game enabled the children to revisit lines of enquiry to help them to remember relevant evidence they could later include in their written accounts.

Presenting arguments and developing reasoning skills
For this activity, the classroom was rearranged to form a court of law. The children decided who could be asked to stand as witnesses (for example, the local blacksmith and publican) and chose children from the class to take on the roles. They also chose a child to be the judge. The other children were expected to take turns in cross questioning and interviewing the key witnesses to try to establish the truth of what happened to Sam Whitehouse. The judge's role was to maintain 'order in court' when the questions came too quickly, and the jurors or the public became too excited. All the children were expected to ask questions and make notes. At the end of the session, the class discussed which questions caused the witnesses to reveal more evidence or detail.

Writing an account
The main writing task was an extended piece of writing in the genre of J. K. Rowling. The teacher began the session by introducing the Gothic building of the Abbey as Hogwarts' Field Centre for Magic Education, and the Grey Lady - Warley Abbey's ghost. The children were shown a picture of Warley Abbey and asked to think of words they could use to describe it. They were given time to reflect on their ideas in their heads, write down notes and then share their ideas with the whole class. The vocabulary they produced ranged from words to describe characters, sounds, smells, magic and mystery.

What did the children learn from the project?
At the end of the project the children were able to put forward a variety of plausible reasons for the cause of Samuel Whitehouse's death and their written accounts reflected the questioning approach they had experienced, for example:

"Grey Lady," said Harry "Is it true about the murder of Samuel Whitehouse?"
"Yes, it is true. I saw Sam's horse riding off. And that is all I saw."
"Thank you. I must go and see where he was found. Tomorrow we are going to find out some clues about when he died. I wonder if he was murdered. Who found him?"
"I didn't see that."
"Was the body dead?"
"I'm not sure about that."
"Was it the blacksmith who killed him?"
"I don't think he would do anything like that."

The children's answers to the questionnaire revealed how their ideas about history had changed and how they were more aware of bias and different interpretations of events:

"It made me think that history is a mystery, that no-one knows what happened."

"They (the questions) changed my ideas about history because now I know that people from the past can lie and be truthful."

"They (the questions) changed my ideas about history because I didn't think a murder back then would still be this serious today."

Reference:
McIlroy, C. (2004) History Mysteries: History, Literacy and ICT at Key Stages 1 and 2 Harry Potter, the Warley Woods Mystery and Literacy across the Curriculum. National Teacher Research Panel. Available at: http://www.standards.dfes.gov.uk/ntrp/lib/word/McIlroy.doc The detective enquiry can be found on www.ex.ac.uk/historyresource.
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Further reading

What else might I enjoy reading?

Bruner, J. S. (1960: revised edition 1977) The Process of Education. London: Harvard University Press.

In this book, Bruner argues that curricula should be designed to foster early intuitions and then build on them in increasingly formal and abstract ways (the spiral curriculum).

Bruner, J. S. (1966) Toward a Theory of Instruction. London: Harvard University Press.

Bruner discussed his ideas further in the essays contained in this book. For example, in the essay, 'Notes on a theory of instruction', he argued that 'Knowing is a process not a product', and in 'Patterns of growth' he explored the notion of enactive, iconic, and symbolic stages of intellectual development. The other essays explore 'The will to learn' (intrinsic motivation), 'Coping and defending' (behaviours associated with learning blocks) and 'Making and judging' (instruction/learning and evaluation).

Bruner, J. S. (1971) The Relevance of Education. London: Penguin Education.

In this book, Bruner applied the theories he put forward in 'The Process of Education' to infant development.

Bruner, J.S., (1978) The role of dialogue in language acquisition. In: Sinclair, A., Jarvella, R. J. & Levelt, W. J. M. (eds) The Child's Conception of Language. Berlin: Springer-Verlag.

Mooney, C. (2000) Theories of Childhood: an Introduction to Dewey, Montessori, Erickson, Piaget and Vygotsky
St. Paul, MN: Redleaf Press.

Palmer, J. (2001) Fifty modern thinkers on education: from Piaget to the present . London: Routledge.

Each essay in this book gives an outline of each thinker's main achievements and activities, an assessment of his/her impact and influence and a list of his/her major writings.

Wood, D. (1988; 2nd edition 1998) How Children Think and Learn. Oxford: Blackwell.

This book presents and synthesises the ideas of a number of key developmental theorists (including Vygotsky, Piaget and Bruner) about children's language acquisition and their understanding of mathematics, as well as ideas that have emerged from their theories researched in the last decade, and draws out the implications for teaching.

Online resources

Teacher research into using thinking skills (National Union of Teachers)
http://www.teachers.org.uk/

Includes case studies of teacher's research into thinking skills activities including mysteries, odd one out and mind mapping.

Cognitive acceleration (Kings College London)
http://www.kcl.ac.uk/schools/sspp/education/research/projects/cognitive.html
Information about cognitive acceleration programmes (including CASE, CAME and CATE).

About Learning (Demos)
http://www.demos.co.uk/publications/aboutlearning
Hargreaves, D. (2005) About learning. Report of the Learning Working Group Demos.

Genetic Epistemology
http://tip.psychology.org/piaget.html
Bruner derived his stages of intellectual development from Piaget. An overview of Piaget's developmental theory is available here.
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Appraisal

Robustness

In the context of the current focus in the national strategies on personalised learning, the ideas of the American educational psychologist Jerome Bruner are likely to be of interest to both classroom teachers and school leaders.

The Process of Education was the product of a 10-day conference that took place in 1959, in which 35 scientists, historians, psychologists and educators came together to discuss how education in science might be improved in primary and secondary schools. As chairman, Bruner wrote a final report that drew out the major themes of the conference and the conclusions reached during the debates. Bruner sent a draft of this report to all the conference delegates for comment and criticism. His book was representative of the views put forward during the conference and the correspondence that followed it. It was a 'landmark' text and in its emphasis on problem solving, the role of intuition in thinking and the structure of a 'spiral' curriculum for enhancing learning ran counter to existing policy in the US at the time. But it had a direct impact on policy formation in the US and influenced the thinking and practice of a wide group of teachers and scholars. His ideas continue to influence today's researchers and teachers.

The Process of Education explored four key themes:

- the role of structure in learning - Bruner argued that teaching the fundamental principles of a subject made transfer of knowledge easier
- readiness for learning - Bruner considered that children of any age can learn if the supporting material is presented in an appropriate form and that the curriculum should revisit and build upon basic ideas repeatedly (a 'spiral curriculum')
- intuitive and analytical thinking - Bruner was concerned to find how schools might create conditions for enhancing intuitive thinking which could then be checked through analysis
- motives for learning - Bruner believed these should be rooted in the learning process rather than external goals such as grades.

Relevance

The work undertaken by Bruner and his colleagues has come to underpin and inform teaching and learning strategies that are commonly referred to as enquiry based learning which involves solving problems and discussing solutions. The four key themes offer teachers a powerful pedagogic framework for analysing their own teaching and learning. They have potential for professional and pedagogic development. We think the ideas presented in this book provide a focus for reflection and action for schools and teachers - for example, looking at learning from the learners' viewpoint, building on what pupils already know and structuring the curriculum to enable pupils to think in the same way as experts do (such as scientists and historians etc).

Applicability

Reference to the ideas of Bruner and his colleagues are spread throughout a wide range of subjects and phases

of education. Bruner closely followed the teaching and educational theory of Vygotsky and contributed to the development of the practice of social construction of learning which influences much of today's teaching. Bruner's ideas also greatly influenced researchers who worked with him, such as Howard Gardener, well known for his theory of multiple intelligences.

Writing

The Process of Education is a very readable book, although its style is a little dated and readers today may find the constant references to 'him', 'his' and other masculine terms irksome. It is structured around the four key themes identified above. Each of the themes forms the basis of a chapter. Both experienced and new teachers will enjoy the way in which Bruner makes seemingly complex terms (such as, 'internalise', 'reversibility', 'formal operations') comprehensible. They will also find this helpful to their understanding of educational theory. The presentation of ideas is made lively and practical by Bruner's frequent use of examples of concepts and ideas from a wide range of subjects.

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