Thinking skill frameworks for post-16 learners: an evaluation

A research report for the Learning and Skills Research Centre

learning &skills research centre

What is a 'thinking skill'? How are thinking skills identified and classified? What kinds of thinking are needed in post-16 learning environments? This report evaluates 35 attempts to classify the skills and abilities used in thinking and makes recommendations for teachers, learners and policy-makers.

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The Learning and Skills Research Centre is supported by a grant from the Learning and Skills Council and the Department for Education and Skills. It is managed by the Learning and Skills Development Agency

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Copyedited by Helen Lund
Designed by sans+baum
Printed by Cromwell Press Ltd
Trowbridge, Wiltshire

1541/03/04/500
ISBN 1 85338 916 1

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Acknowledgements

The LSDA project steering group provided us with helpful feedback, advice and encouragement, as did its chair, John Vorhaus, throughout the project.

Members of a regional steering group similarly provided useful guidance. Jan Portillo of Gateshead College helped with the organisation of the questionnaire study reported in Section 5.

We are grateful to Robert Marzano, Paul Pintrich and Robert Sternberg for reading and commenting on drafts of this report.

Executive summary

There was a need for this project because:

- with a few exceptions, thinking skills are not explicitly built into education and training for post-16 learners in England
- there is no established basis for choosing between thinking skill frameworks for general or specific applications
- little is known, although much is claimed, about the potential of thinking skills approaches for helping to raise the quality of education and training delivery for post-16 learners.

We decided to:

- consider all kinds of thinking and learning which are to some degree under conscious control
- exclude unsystematic ways of classifying thinking skills
- include frameworks designed for different purposes and from different perspectives – broadly educational, psychological and philosophical
- apply a consistent set of evaluation criteria, focusing on underlying values, theoretical and practical aspects and communicability
- summarise and evaluate 35 thinking skill frameworks, nine of them in more detail than the rest
- explain our understanding and use of key terms, while recognising differences of opinion and trying to distinguish substantive from less substantive issues.

We recognised that:

- research reviews about what makes thinking skills approaches effective highlight (a) learner engagement, (b) thinking about thinking, and (c) the strategic management of thinking
- if teachers are to engage with and use thinking skill frameworks, these must be clearly expressed and situationally appropriate, and should convey a degree of both affirmation and challenge
- if learners are to benefit from thinking skills approaches, they need to develop a deeper understanding of learning and instruction and appreciate the value of thinking skills in daily life.

We found that:

- we could classify frameworks of thinking skills under four headings:
  - all-embracing frameworks covering personality, thought and learning
  - instructional design frameworks
  - frameworks for understanding critical and productive thinking
  - explanatory models of cognitive structure and/or cognitive development
- the largest of the four groups is the instructional design family, where the strong and continuing influence of Bloom's taxonomy of educational objectives (1956) is apparent. Anderson and Krathwohl's (2001) revision of Bloom's taxonomy has much to commend it (see Section 3.3.2)
- many critical and productive thinking frameworks include process categories which resemble Bloom's *analysis*, *synthesis* and *evaluation*; there is also *general* agreement about the need to manage thinking strategically, aided by appropriate dispositions (*habits of mind*)
- Halpern's[1] work on critical thinking skills and dispositions (see Section 3.4.2) stands out as being coherent, broad in scope and accessible for teachers and learners
- although theorists have different ideas about the structure and development of cognitive abilities, they agree that these are multidimensional and modifiable
- Pintrich's (2000) framework for self-regulated learning (Section 3.5.2) represents an integrated dynamic conception of how thinking and learning can be developed
- in recent years, a number of all-embracing frameworks have been constructed, most notably the work of Marzano (2001a, 2001b; see Section 3.2.2).

Because:

- thinking skill frameworks can be used for many different purposes; and
- thinking skill frameworks are constructed on the basis of at least 15 different classificatory principles

we recommend different frameworks for different applications:

- academic study
- instructional design
- developing pedagogical theory and practice
- consultancy
- assessment
- research and evaluation.

1 Where a date is not appended to an author's name, the reference is to his or her work overall.

We have developed a new integrated framework to bring out how:

strategic and reflective thinking can interact with and enhance the quality of information gathering, building understanding and productive thinking (see Section 4.3).

Our integrated framework has these advantages:

- it is expressed in clear, simple English
- it is consistent with, but extends the range of, Bloom's taxonomy (1956)
- it is consistent with frameworks of critical thinking, and with models which include 'habits of mind' and self-regulation
- it is consistent with conceptions of creative and caring thinking (including emotional intelligence)
- it is consistent with, although more simply structured than, Marzano's new taxonomy (2001a, 2001b)
- it is consistent with, but extends the range of, the English National Curriculum categories
- it is consistent with the ways in which a sample of college teachers think of subgroups of thinking skills as differing from each other
- it is easily understood and remembered, making it a suitable mental model for practical use by teachers and learners
- it can be consistently applied and is an adaptable multi-purpose tool.

When we applied our framework to key skills knowledge objectives, we found that:

- *building understanding* and *productive thinking* are predominant throughout
- only at the highest level (Level 4) is there a significant need for *strategic and reflective thinking*
- strategic and reflective thinking are needed more in the key skills of *Working with Others, Improving Own Learning and Performance* and *Problem Solving* than in *Communication, Application of Number and Information Technology*.

Here we summarise the results of meta-analytic research studies of thinking skills interventions.

- Thinking skill approaches with children and young people are usually very effective, especially if they are directed at metacognition, self-regulation and what we have called 'value-grounded thinking'. Their effectiveness is likely to be greater if they are used for learner self-regulation rather than coming fully under teacher control. Well-focused interventions at the cognitive level can also be very effective. These include interventions with a focus on experimental enquiry and the representation of ideas, as well as approaches to study support such as using cues and questions to aid retrieval.
- Unfortunately, we cannot yet be confident that equally impressive learning gains are achievable with post-16 learners not in higher education, as there are so few published studies.

We believe that further research with, and use of, thinking skill frameworks will lead to a better understanding of how people think and learn.

- We think that teachers should be involved in the further development of theory-based thinking skill frameworks and in deciding how to use them.
- We recommend that practical applications of the new integrated framework presented in this report should be explored and evaluated.
- The interplay between theory and practice in the development of good thinking in post-16 learners is a priority area for future research.
- We need to know more about which pedagogical interventions improve thinking in teachers and students and in which contexts.
- We need to know more about the advantages and disadvantages of encouraging creative diversity in thinking and in approaches to teaching and learning.
- We need to know more about the interpersonal aspects of thinking and learning, and especially about how to create and sustain productive learning communities, using face-to-face and distance-learning approaches.
- Using thinking skill frameworks, we need to develop new authentic, dynamic and ecologically relevant forms of assessment and evaluation.

We conclude by making a set of recommendations for policy-makers.

- The aims and objectives of post-16 education and training should be informed by explicitly stated values.
- Consideration should be given to developing new programmes focused on the study of human thinking, learning and behaviour.
- Courses and qualifications in which the demands on thinking and learning skills are incomplete, unbalanced or fragmented should be modified by applying a theoretical framework of thinking and learning.
- Teacher training courses should include a more solid grounding in theories of thinking and learning than they do at present.
- 'Community of enquiry' and 'problem-based learning' approaches should be evaluated in the context of teacher training.
- Dialogue and group discussion about how people think and learn should be available to all college students at the start of their studies and on a regular basis.
- Strategic thinking and reflection should form part of all education and training.
- Productive, strategic and reflective thinking – and not simply the reproduction and use of information to demonstrate understanding – should be assessed at all levels of education and training.
- Practitioner enquiry through action research should be directed at finding ways of enabling people to build on previous learning and to make use of their skills and abilities in more areas of their lives.
- Research and evaluation should be seen as collaborative activities, involving all stakeholders, not least the learners themselves.

Section 1
Introduction

1.1 Aims

In this report, we aim to review and advance knowledge of systematic ways of classifying thinking skills. We concentrate on taxonomies and theory-based frameworks, in the belief that studying and using them will promote better understanding of how people think and learn at the age of 16 or above. Our overarching interest is in how that understanding can inform instructional design, course and lesson planning, teaching, learning and assessment. In particular, we aim to identify:

- key principles on which teaching approaches designed to develop thinking skills depend
- helpful ways for teachers and learners to classify and talk about thinking skills.

1.2 Scope

While there are some theorists who have specifically addressed thinking skills in teenagers and adults, most classificatory systems apply across the lifespan and in a wide variety of contexts. Some are intended to apply to the entire domain of thinking, some to only part of it, and some are part of a more broadly conceived theoretical framework for understanding individual differences and contextualised processes of thought and learning. Here we evaluate 35 frameworks which offer the prospect of improving understanding and practice in the post-16 context. We use the generic term 'framework' to refer to a taxonomy, a theory or a model.

Because thinking is a human activity which involves cognition (knowing), affect (feeling) and conation (wanting and willing), we have not excluded from consideration frameworks which extend beyond the cognitive domain.

1.3 The research team

The research team included members conversant with educational, philosophical and psychological discourse – the three main disciplines represented in the literature on thinking skills. One team member was involved in training college teachers, using a *community of enquiry* approach. The team also included people who are knowledgeable about multicultural issues, social exclusion and individual differences in learners. We drew on the experience of practitioners and academics in a number of countries. In addition, we received feedback and guidance from a regional advisory group and a steering group acting on behalf of the Learning and Skills Research Centre (LSRC).

1.4 Rationale

Empirical work on teaching and assessing thinking provides a sound evidence base for theory building and testing. There is a good deal of evidence to support the following points.

- There are broad and narrow thinking skills, as well as general psychological factors which affect how people think and learn.
- Thinking skills can be developed by means of teaching practices.
- Learning progress can be encouraged by thinking skills approaches.
- The value of thinking skills approaches stems from attention given to:
  - pedagogy emphasising learner engagement – in particular, beliefs and feelings that help determine the motivation to learn
  - metacognitive knowledge (knowledge of one's cognitive functioning, including knowledge developed through reflection)
  - the strategic management of thinking and learning through self-regulation (involving planning, conscious direction, monitoring and evaluation).

Education and training are purposeful activities through which participants can develop knowledge, skills and personal qualities. If a broad and balanced set of principles is used in the planning and delivery of education and training, processes and outcomes can be evaluated with reference to those principles. However, rational approaches to the planning, implementation and evaluation of education and training become ineffective where there is a kaleidoscopic array of *ad hoc* ideas and practices, influenced by academic or pedagogic fashion and commercial interests.

Each of the many existing frameworks for understanding thinking is based (explicitly or implicitly) on particular value judgements about what is important in life or in lifelong learning. In a pluralistic society, with open access to information and with few restrictions on thinking and learning, it is highly unlikely that any single coherent framework for developing thinking in post-16 learners will prove adequate. We have worked on the assumption that there is value in a diversity of approaches, which suggests that educators should be encouraged to select frameworks which are fit for different purposes (eg improving communication skills, planning a vocational training course, developing problem-solving skills, encouraging creativity in product development, developing reflective judgement about current issues of global concern).

Our approach has been to bring some order to a highly complex field, by identifying common features as well as differences between frameworks. We have focused on the organising principles on which the frameworks are based, noting that some emphasise progression in complexity of thought while others make qualitative distinctions between different kinds of thinking.

In each evaluation, we applied criteria grouped under the following headings:

- scope and intended use
- underpinning values and theories
- practical relevance.

1.5 Context

There is currently unprecedented political interest in the impact of education and training on social and economic development. The perceived need to improve standards, to widen access to higher education, and to minimise social exclusion (eg through the Skills for Life strategy and by participation in lifelong learning) is being addressed through many government initiatives. As in many other countries, there is in England a politically driven preoccupation with testing and with other measurable educational outcomes. Policy-makers favour target setting and have, over the last 20 years, increasingly sought to prescribe curricula and methods of teaching and assessment, believing that this will lead to improved performance. Although the evidence base for what politicians, government-related agencies and inspectorates claim to be good practice is not always made explicit, government has made significant moves towards evidence-based policy and practice in education and in other public services.

Research evidence about the value of teaching thinking skills was summarised by McGuinness (1999), and thinking skills now form a recognised part of the National Curriculum in schools in England and Wales. In Qualifications and Curriculum Authority (QCA) documents, thinking skills are conceptualised under five headings:

- information processing
- reasoning
- enquiry
- creativity
- evaluation.

Although these headings do not correspond with those used in an identifiable taxonomy or theoretical framework, they are clearly broad in scope. We shall revisit the QCA categories in Section 4.3.

Using these QCA categories, we identified the thinking skills needed to achieve National Curriculum learning objectives at Key stage 4 (14–16 years), limiting ourselves to subject areas where the objectives are available in electronic form. We found that thinking skills feature explicitly in the following National Curriculum subjects (listed here in rank order of word count, with mathematics having the largest number of objectives which make demands on thinking skills):

- mathematics
- science
- personal, social and health education
- citizenship
- physical education
- design and technology.

Of course, broad thinking skills such as recalling prior knowledge, constructing an understanding and using knowledge are present in all areas of the National Curriculum.

In post-16 education and training, our impression is that although there are many opportunities for developing thinking (notably through key skills[2] as well as in subject areas), relatively little has been done to embed thinking skills in pedagogy and in assessment. We see only a modest emphasis on thinking skills in the Adult Literacy Core Curriculum (Basic Skills Agency 2001). Soden and Pithers (2001) found that this is equally true of many FE college courses which lead to degrees. Because students have to understand and use a good deal of discipline-specific knowledge for examination purposes, they rely on close direction from lecturers.

2
In England, key skills are assessed in post-16 learners by tests and portfolios. There are six key skills specifications: Communication, Application of Number, Information Technology, Working with Others, Improving Own Learning and Performance, and Problem Solving.

There was very little evidence that students were gaining the experience of processing and interrogating knowledge independently which is associated with learning to think critically.
(Soden and Pithers 2001,102)

The same lack of attention to critical thinking by learners in adult education is apparent from an examination of the American Association for Adult and Continuing Education's (AAACE) *Handbook of adult and continuing education* (Wilson and Hayes 2000), where 'thinking' does not feature at all in the index and where the discourse of social constructivism is used to express ideas and ideals rather than to describe actual communities of learners.

1.6 Implications of contextual issues for the evaluation

According to Andrich (2002), outcomes-based education has drawn heavily on the pioneering work of Bloom. Bloom and his colleagues created their taxonomy of educational objectives (cognitive domain) because they wanted to classify intended behaviours 'related to mental acts or thinking', occurring 'as a result of educational experiences' (1956, 12). Bloom's taxonomy, which has been more influential than any other, was originally designed in order to categorise examination questions at college level. Although the way in which thinking skills have been embedded in the Key stage 4 National Curriculum is not based on a single theoretical framework, there are clear links with the work of Bloom. Accordingly, we have given particular attention to Anderson and Krathwohl's revision of Bloom's taxonomy (2001).

A simple framework, like the one used in the Key stage 4 National Curriculum, is likely to be more useful to teachers than a more complicated one, because it can be more easily grasped and applied in a person's working memory. Another advantage of the National Curriculum framework is that it does not contain specialised technical terms, making it accessible to all learners. We therefore looked for frameworks which are compatible with those already in use and which use relatively familiar terminology. We take seriously the work of Corson (1995), who showed that the use of language outside the vocabulary range of everyday speech limits access to learning by introducing a socio-cultural bias in favour of learners from more highly educated backgrounds.

Believing, as government does, in the need to base practice on sound empirical evidence, we looked at: (a) factor analyses of cognitive abilities and skills; and (b) meta-analyses of the benefits attributable to pedagogical approaches based on various conceptions of thinking skills. We also noted the power of generic problem-solving tools (such as Altshuller's TRIZ; see Appendix 2) to help produce inventive solutions which draw on knowledge outside the area of application. We find the weight of evidence about the meaning, structure and operation of generic thinking skills compelling. From an empirical viewpoint, McPeck's selectively supported argument (1981) that there is no such thing as a generic thinking skill looks very much like word-play.

We are aware that practitioners are subject to many pressures to change and improve their practice, and that there is a tension between traditional teacher-directed pedagogy and the orientation towards learner empowerment with which thinking skills approaches are often associated. In a crowded, externally driven curriculum, will teachers have the time and thinking space to accommodate yet another innovation? Because we were unclear as a team as to how teachers and post-16 learners view thinking skills, we set up three consultative meetings with college lecturers and followed this up with a questionnaire. We also learned about an LSDA-funded pilot project at Gateshead College in which a *community of enquiry* approach was introduced to various course groups at Key Skills Levels 1 and 2 (Duffy 2003). These experiences helped us to evaluate frameworks for classifying thinking skills in terms of their applicability in the post-16 sector.

1.7 Method

Our first step was to carry out a comprehensive and systematic literature search of electronic and paper-based sources. Over 400 articles and books were identified as relevant. We also found a large number of useful websites, many of which are gateways to further sources. We have listed many of these at www.ncl.ac.uk/ecls/about/resource/thinking.htm.

We identified 55 thinking skill frameworks by reading our source material, checking references or learning about them at conferences. We prepared brief summaries of each and located them on a chart within four 'family groups' and by decade of publication (see Appendix 1).

We decided not to evaluate 20 of the frameworks, rejecting those which differ only in minor detail from more established conceptualisations, those [like Piaget's (1952) genetic epistemology] which have been developed and extended by other theorists specifically for post-16 use, and those which have little relevance for the post-16 sector.

In order to ensure a consistent approach to evaluation, team members prepared and discussed briefing papers on core concepts and two working papers on: (a) evaluation criteria; and (b) the relevance of key taxonomies for post-16 learners. Team members wrote descriptions and evaluations, referring to established models and receiving feedback from colleagues. We used an argument mapping software tool called Reason!Able (van Gelder 2000) to help us to support, qualify and compare the strength of claims formulated for or against each framework.

The team then had to decide which frameworks to include in the main text of this report, bearing in mind the project aims stated in Section 1.1 and the criteria referred to in Section 1.4 above. We also wanted to ensure a representative coverage of the field and to avoid undue overlap. This was done through a voting procedure, with votes supported by reasons, and by group discussion in which we again drew on our evaluation criteria.

After a preliminary evaluation midway through the project, two frameworks – those of Anderson and Krathwohl (2001) and Marzano (2001a, 2001b) – stood out as being strongly grounded in theory and practice. They address instructional design in similar ways, but Marzano's new taxonomy of educational objectives is broader in scope, well grounded in psychological theory and supported by a large-scale meta-analysis of research into educational interventions. The two frameworks are compatible with others which focus in greater detail on, for example, critical and creative thinking.

In order to test out our ideas about the practical relevance of these and other frameworks for post-16 teachers and learners, we asked 37 FE teachers to rate the importance of 69 different thinking skills found in the frameworks we had evaluated. We established that both the Anderson and Krathwohl and the higher-level Marzano categories correspond quite closely with how practitioners already think about thinking skills. We were able to use the results to help create a new framework. This is compatible with many others, including the National Curriculum categories, but is especially relevant for post-16 teachers and learners because of its emphasis on orchestrated *productive thinking*[3] skills and on *strategic and reflective thinking*.

We tested out a simplified version of the new framework by using it to classify key skills knowledge objectives, finding that this was both feasible and illuminating. We were then in a position to assemble arguments to support recommendations for general and specific uses of certain frameworks.

1.8 How the report is organised

The research is presented in Sections 2–5. Section 6 provides a summary of what is known and indicates the need for further research in the post-16 sector. The following section outlines will help with navigation.

Section 2 Surveying and mapping the field

Here we clarify the key concepts which are fundamental to an understanding of the field. We do this by referring to widely accepted definitions and views, and by providing our own description of how 'teaching thinking skills' is widely understood in educational discourse. In order to facilitate understanding, we clarify the meaning of all key concepts, either in the text or in a Glossary.

We then explain why and how we grouped the 55 frameworks into 'families'. After briefly introducing each 'family group', we list the frameworks that belong to it and are evaluated later in the report.

Section 3 Thinking skill frameworks evaluated

Nine full accounts and evaluations are included in Section 3, again grouped by family and with some mention of family resemblances, special features and overlaps. Some readers will want to refer to Appendix 2 at this point in order to consider frameworks not included in the main text.

Section 4 Making sense of thinking and learning

Here we pull out the principles used to establish categories in all the frameworks we evaluated. We look closely at the frameworks in which at least four different kinds of principle are used. We identify common features in a number of these frameworks, and use them as the basis for constructing a new integrated framework. We show how we began with a six-level categorisation, which we then validated and further developed by finding out how college teachers mentally group thinking skills (see Section 1.7 above).

We end the section by identifying three frameworks which best represent the field, are compatible with our new integrated framework and have the most to offer in terms of general use in the post-16 sector.

3
By *productive thinking*, we mean purposive thinking which results in a new and valued outcome that is more than basic understanding. For a fuller exposition, see Section 3.4.

Section 5
Some ideas for using the frameworks

We begin this section by reporting on the key skills study referred to in Section 1.7 above. We then bring together the findings of our evaluations to assess the potential value of a number of thinking skill frameworks for a variety of purposes in post-16 education and training. Taking account of contextual factors and present levels of knowledge about thinking skills and pedagogy, we identify a range of possibilities for practical application and development.

Section 6
Summary of what is known and the need for further research

We summarise what we believe to be well-founded and less well-founded knowledge about thinking skill frameworks and about thinking, learning and instruction in a broader sense. We then identify areas where new research is needed, beginning with teacher and learner understanding and the practical application of central concepts, frameworks and theories. We end by making recommendations about how the well-founded knowledge should be applied and extended in the post-16 context.

Section 2

Surveying and mapping the field

2.1 Why classify?

Trying to understand how people think and learn is in some ways an impossible challenge, since we can only try to understand these things by using the very processes that we do not fully understand. In such circumstances, however, choices are available. We can choose to focus on measurable aspects of human behaviour rather than on lived experience; or we can resort to metaphors which have personal or group appeal; or we can do what scientists have often done when entering a new and complex field – look for patterns. All three approaches are evident in the theoretical frameworks and taxonomic approaches to thinking and learning that we have studied, and they all involve classification. Moreover, they all result in accounts which focus on certain aspects at the expense of others, since the human mind can only operate consciously with limited amounts of information, especially when communicating with others. Minds are intrigued by the richness of immediate experience as well as by patterns and the power of communicable ideas.

2.2 An inclusive approach

Cognitive psychologists typically study thinking in other people – a third-person perspective in which the metaphor of the brain as a computer has been dominant. First-person introspective accounts of thinking have a different feel about them, since we all have the impression that we can consciously control our thoughts and actions. We experience wanting, will, effort and emotion in a holistic manner as we think, and it is only through subsequent analytical reflection that we can view these aspects dispassionately. Indeed, a case can be made that while we are thinking (with our attention focused on certain elements), we are not aware of the thinking process itself (much of which is unconscious). It is only after the event that we can reflect on the products of our thinking and to a certain extent, reconstruct and analyse the process. Like Velmans (2000), we have taken the view that first-person and third-person accounts of thinking are complementary and that one cannot be reduced to the other.

A teacher has a third-person perspective on the learner's thinking and can only make inferences about it on the basis of what the learner does. Some earlier approaches to instructional design focused on precisely formulated, externally imposed behavioural objectives in place of goals which learners set for themselves or agree with others. Goal setting and ways of monitoring and evaluating progress are under-researched in the post-16 field, but it is likely that an inclusive and flexible approach will prove most effective. First-person goal setting may be desirable in some contexts and with certain types of content; whereas group negotiation of goals may be preferred in other contexts; and teacher- or other externally driven instruction may be most effective in yet other contexts, where mastery learning and accurate performance is expected. This argument applies just as much to the development of thinking skills as to any other kind of learning.

2.3 What are thinking skills?

When there is some uncertainty that a satisfactory end is achievable, it is useful to think. The word 'thinking' is usually used to mean a consciously goal-directed process, such as remembering, forming concepts, planning what to do and say, imagining situations, reasoning, solving problems, considering opinions, making decisions and judgements, and generating new perspectives. Controlling what we call conscious thought presumably influences unconscious processes, some of them internalised and automatic as a result of practice. These processes also help to generate desired thinking products. When we refer to thinking skills, we do not exclude the unconscious elements, any more than when we refer to the skills of an Olympic athlete.

'Skill' commonly means 'expertness', 'practical ability' or 'facility in doing something' (*Oxford English Dictionary*). The term refers to what you have to know and what you have to be able to do to succeed in a task. The concept of 'skill' overlaps with 'ability', but the term 'skill' is more often used to refer to specific rather than to general areas of performance. Having a skill implies that most performances are of a high standard and are adapted to the requirements of particular situations.

On this basis, 'thinking skill' means expertness, practical ability or facility in the process or processes of thinking (processes that occur spontaneously or naturally, or which are acquired through learning and practice). Whether or not a particular instance of thinking is skilled cannot be judged by others without a great deal of contextual knowledge, including knowledge of the prior experiences of the individual or group.

In educational discourse, 'teaching thinking' or 'teaching thinking skills' is often used to refer to pedagogic approaches through which specific strategies and procedures may be taught and used by learners in a controlled, conscious way to make their thinking more effective. These strategies and procedures may be what some use spontaneously and/or they may be otherwise contrived. Many such skills and abilities have been suggested – specific, broad, or general in nature. Ashman and Conway (1997) conclude that thinking skills programmes typically involve six related types of thinking:

- metacognition
- critical thinking
- creative thinking
- cognitive processes (such as problem solving and decision making)
- core thinking skills (such as representation and summarising)
- understanding the role of content knowledge.

We conceptualise 'thinking skills approaches' as *courses* or *organised activities which identify for learners translatable*[4] *mental processes and/or which require learners to plan, describe and evaluate their thinking and learning*. This usage of the term 'thinking skills' implies that there are activities that can induce processes which produce desired mental products. It is underpinned by a judgement that thinking can be improved with practice and/or teaching (ie ability, or at least performance, can be improved). It also implies the use of mental processes to plan, describe and evaluate thinking and learning. One way of looking at this *metacognitive* aspect is to consider thinking skills as ways of managing attention and working memory so that conscious and unconscious processes together are more likely to produce desired outcomes (Newton 2000).

2.4 What is metacognition?

Perry (1970) spoke about 'meta-reason' and 'meta-thought', but the coining of the term 'metacognition' is usually attributed to Flavell (1976, 232):

Metacognition refers to one's knowledge concerning one's own cognitive processes and products or anything related to them … For example, I am engaging in metacognition (metamemory, metalearning, metaattention, metalanguage, or whatever) if I notice that I am having more trouble learning A than B; if it strikes me that I should double-check C before accepting it as a fact; … if I sense that I had better make a note of D because I may forget it; … Metacognition refers, among other things, to the active monitoring and consequent regulation and orchestration of these processes … usually in the service of some concrete goal or objective.

Metacognition involves two major dimensions (Boekaerts and Simons 1993). First, it involves an awareness of one's own cognitive functioning (metacognitive knowledge); and second, the planning, monitoring and evaluation of one's thinking and learning. It is important to note that 'metacognition' is used narrowly by some (simply to mean 'thinking about thinking') and more broadly by others (to include the conscious self-regulation of thinking and learning).

Are there metacognitive thinking skills? Swartz and Parks (1994, 520) believe that there are, as they write about 'skillful metacognition' and provide a list of the components. But what does it mean to say that a person is skilled at (for example) goal specification, process specification, process monitoring or disposition monitoring? Within a specific context or domain, we can understand that, for example, an air-traffic controller can be skilled at monitoring his or her level of vigilance. However, when we think about cross-domain competence in (say) goal setting, we may or may not have sufficient knowledge to be able to assess a person's metacognitive skills; and it may be equally, if not more, appropriate to think in terms of a well-established disposition to plan systematically. So when Mayer (1998) describes the ability to control and monitor cognitive processes as a 'metaskill', we understand that this author is referring to very much the same capacities as Perkins, Jay and Tishman (1993, 6) when they write about 'the disposition to be metacognitive'.

4 'Translatable', unlike 'transferable', does not imply that exactly the same process is used in different contexts. It suggests that the process or processes are adaptable, but still retain a 'family resemblance' across situations, so that the meaning of a process like 'summarising' or 'evaluating' is preserved.

2.5 What is self-regulation?

Most researchers agree that self-regulation is a systematic process involving the setting of personal goals and the channelling of one's behaviour towards their achievement. Self-regulation involves *cognitive*, *motivational*, *affective* and *behavioural* components that enable individuals to adjust their actions and/or their goals in order to achieve desired results in changing environmental circumstances. Such adjustment presupposes metacognition and cannot take place without some conscious awareness of the ongoing thinking and learning processes. It should be noted that self-regulation is widely considered to be highly context-specific.

According to Schunk and Ertmer (2000), self-regulation comprises such processes as:

- setting goals for learning
- attending to and concentrating on instruction
- using effective strategies to organise, code and rehearse information to be remembered
- establishing a productive work environment
- using resources effectively
- monitoring performance
- managing time effectively
- seeking assistance when needed
- holding positive beliefs about one's capabilities, the value of learning, the factors influencing learning, and the anticipated outcomes of actions
- experiencing pride and satisfaction with one's efforts.

Classroom interventions based upon theories of self-regulation emphasise the importance of helping students to develop a positive orientation to learning and a belief that they are capable of succeeding if they work hard and use appropriate strategies. While these elements also feature in many thinking skills programmes, they are sometimes more implicit than explicit.

2.6 What is critical thinking?

The literature on critical thinking is extensive. The term is used in different ways and has developed over time (eg see the review by Pithers and Soden 2000). In the US, *critical thinking* is often considered to be synonymous with *thinking skills*.

Descriptive definitions of critical thinking tend to be psychological in origin. They specify cognitive skills and the mental processes involved in different aspects of thinking, often equating them with the *higher-order* categories of Bloom's taxonomy. Implicit in this approach is that being good at critical thinking is being proficient at particular mental processes such as analysing, inferring, evaluating. By contrast, philosophers argue for a normative definition. By this they mean that critical thinking is inextricably connected with values and essentially means 'good thinking'. From this perspective, purely descriptive accounts omit the central issue of the quality of the thinking.

So, for example, consider making a decision about whether or not to adopt a local recycling scheme. From a descriptive perspective, critical thinking involves analysing the issue, generating possible resolutions, evaluating these and synthesising the information to reach a decision. However, the decision may not be a good one, as the issue may have been analysed from superficial perspectives (residents do not have space for a second rubbish bin or may be confused about which bin to use), or the options may have been evaluated from a biased perspective (the local factory which makes recycling bins argues for each household to have a bin for each kind of recyclable rubbish).

One of the influential and enduring definitions of critical thinking comes from Ennis (1985, 45): 'reflective and reasonable thinking that is focused on deciding what to believe or do'. Ennis believes that critical thinking depends on two overarching *dispositions*: caring to get it right to the extent possible, and caring to present positions honestly and clearly (Ennis 1998). It also depends on the process of evaluation (applying criteria to judge possible answers).

The conceptualisation and teaching of critical thinking were greatly influenced in the US by the publication of *The Delphi Report* (Facione 1990). This sought to provide a consensual account of the nature and dynamics of critical thinking arrived at by a panel of leading figures in the field, including Costa, Ennis, Lipman and Paul (reviews of the theories of Ennis, Paul and Lipman are presented in Section 3.4.1, Section 3.4.3 and Appendix 2 respectively).

The Delphi Report identifies elements of critical thinking in terms of the following skills and sub-skills:

Skill	Sub-skill
Interpretation:	categorisation decoding significance clarifying meaning
Analysis:	examining ideas identifying arguments analysing arguments
Evaluation:	assessing claims assessing arguments
Inference:	querying evidence conjecturing alternatives drawing conclusions
Explanation:	stating results justifying procedures presenting arguments
Self-regulation:	self-examination self-correction

An important element of the *critical thinking* approach is its emphasis upon the close relationship between abilities and dispositions. The Delphi panel emphasised the importance of dispositions in the self-examination and self-corrective aspects of critical thinking and argued that the appropriate exercising of each cognitive skill could be related to the cognitive disposition to do so.

2.7 Classifying the frameworks

As we became increasingly familiar with the thinking skill frameworks, four main 'family groups' emerged. These are:

1
models and theories of personality, thought and learning (the all-embracing family)

2
models and theories of instructional design (the designer family)

3
models and theories of critical or productive thinking (the higher-order family)

4
models and theories of cognitive structure and/or cognitive development (the intellect family).

We decided to place each framework in one of the four groups, finding that this helped us to understand how the field has developed and also made it easier to evaluate similar frameworks more consistently. Although there is a good deal of overlap between the groups, the completed classification brings out differences between families as well as common features and underlying principles which they sometimes share.

The resulting chart (see Appendix 1) gives brief descriptions and shows which frameworks deal with the cognitive domain, the affective domain, conation and metacognition. It also indicates the academic discipline of each framework's main author and whether or not it was designed for educational use. As can be seen from the chart, most of the all-embracing frameworks were created in recent years, three of the seven members appearing in the present century. We think of them as all-embracing in that they deal with emotional and motivational influences on thinking and learning as well as with the structure of cognition. 'All-embracing' is not meant to suggest that they encompass all the main features of the other families.

We placed a framework in the instructional design family if it was created primarily for that purpose and has a cognitive rather than a more comprehensive theoretical emphasis. The criterion for assigning a framework to the critical/productive thinking family was whether it is concerned with higher-order processes leading to a judgement or decision. Dispositions, as well as abilities and skills, feature in many critical thinking frameworks. The members of the fourth family – explanatory models of cognitive structure and/or development – are of two main types: some simply specify sets of intellectual aptitudes or abilities, and others describe stages of progression towards more complex or mature ways of thinking.

To a certain extent, groups 2, 3 and 4 can be seen to reflect the concerns and interests of different disciplines: education (instructional design), philosophy (critical thinking) and psychology (mental activity and development).

2.8 The family groups

The 35 frameworks evaluated in this report are listed below in approximate chronological order, with a brief introduction to each family group. *The titles of the nine frameworks which we evaluate in the main text of the report are untinted*. Descriptions and summary evaluations of the other 26 frameworks can be found in Appendix 2.

2.8.1
Group 1: all-embracing frameworks, covering personality, thought and learning

While all five authors within this group seek to provide a comprehensive account of thinking and learning in which emotions and beliefs play a part, only Hauenstein (1998), Jonassen and Tessmer (1996/97) and Marzano (2001a, 2001b) classify educational goals within and beyond the cognitive domain. Sternberg's model (2001) was not designed for this purpose, although it does have significant pedagogical implications. Romiszowski's writing (1981) has a broad theoretical scope as well as a focus on course planning and curriculum design. His analysis of skills in the form of a learning cycle was not designed to replace existing taxonomies of educational objectives, but as a 'conceptual tool to analyse the causes of poor performance' (1981, 257).

1980–1989

Romiszowski's analysis of knowledge and skills
Romiszowski distinguishes between reproductive and productive learning in four skill domains: cognitive, psychomotor, reactive and interactive. He identifies 12 abilities which may be used in perception, recall, planning and performance.

1990–1999

Hauenstein's conceptual framework for educational objectives
Acquisition, assimilation, adaptation, performance and aspiration are successive levels of learning in the cognitive, affective and psychomotor domains. At each level, and within each domain, Hauenstein identifies processes which help to build understanding, skills and dispositions.

Jonassen and Tessmer's taxonomy of learning outcomes (see Section 3.2.1)
The major categories in this taxonomy are: declarative knowledge, structural knowledge, cognitive component skills, situated problem solving, knowledge complexes, ampliative skills, self-knowledge, reflective self-knowledge, executive control, motivation (disposition) and attitude.

Vermunt and Verloop's categorisation of learning activities
The cognitive categories are: relating/structuring, analysing, concretising/applying, memorising/rehearsing, critical processing, selecting. The affective categories cover motivation and the management of feelings. The regulative categories are an elaboration of 'plan–do–review'.

2000–

Marzano's new taxonomy of educational objectives (see Section 3.2.2)
The *self system* examines the importance of new knowledge, efficacy (ability to learn) and emotions associated with knowledge and motivation. The *metacognitive system* specifies learning goals and monitors execution, clarity and accuracy. The *cognitive system* deals with retrieval, comprehension, analysis and knowledge utilisation.

Sternberg's model of abilities as developing expertise
This model includes the analytical, creative and practical aspects of successful intelligence, metacognition, learning skills, knowledge, motivation and the influence of context.

2.8.2
Group 2: instructional design frameworks

Bloom's well-known taxonomy (1956) has been used throughout the world as a framework for designing instruction, and many similarities, if not direct influence, can been seen in the work of Ausubel and Robinson (1969), Gagné (1965, 1985), Hannah and Michaelis (1977), Stahl and Murphy (1981), and Anderson and Krathwohl (2001). All these authors provide frameworks for formulating and classifying educational goals in terms of the thinking and learning processes which can be inferred from observed behaviour or task performance. Anderson and Krathwohl (2001) explicitly revised Bloom's cognitive domain taxonomy.

A second group of authors – Biggs and Collis (1991), Quellmalz (1987), Presseisen (1991, 2001), and Gouge and Yates (2002) – share an interest in designing instruction so as to develop *higher-order thinking*, and have built conceptual frameworks for understanding how thinking skills are orchestrated for purposes such as decision making, problem solving, critical and creative thinking. The focus here sometimes extends beyond the cognitive domain, and in most cases includes an account of metacognition.

Feuerstein's Instrumental Enrichment (IE) programme (1980) represents an individual approach to instructional design, in which practitioners base their work on a specific set of cognitive tasks and pedagogical principles.

1950–1959

Bloom's taxonomy of educational objectives (cognitive domain)
This framework is a way of classifying educational goals in terms of complexity. The intellectual abilities and skills of comprehension, application, analysis, synthesis and evaluation are applied to and help build knowledge.

Feuerstein's theory of mediated learning through Instrumental Enrichment
Building on his belief in cognitive modifiability, Feuerstein developed the concept of a mediated learning experience in which the mediator uses prescribed tasks to promote thinking rather than rote learning.

1960–1969

Ausubel and Robinson's six hierarchically ordered categories
These are: representational learning, concept learning, propositional learning, application, problem solving and creativity.

Gagné's eight types of learning and five types of learned capability
Gagné set out an eight-level hierarchy of learning types, with problem solving at the top. He also identified five domains of learning: motor skills, verbal information, intellectual skills, cognitive strategies and attitudes.

1970–1979

Hannah and Michaelis's comprehensive framework for instructional objectives
The cognitive, psychomotor and affective domains are covered. Interpreting, comparing, classifying, generalising, inferring, analysing, synthesising, hypothesising, predicting and evaluating are listed as intellectual processes.

Williams' model for developing thinking and feeling processes
This three-dimensional cross-curricular model seeks to encourage creativity. Teachers can use 18 teaching modes to promote fluency, flexibility, originality, elaboration, curiosity, risk taking, complexity and imagination.

1980–1989

Biggs and Collis's SOLO taxonomy (see Section 3.3.1)
This is an assessment tool looking at the structure of the observed learning outcome. *Prestructural* responses betray limited understanding compared with *unistructural* and *multistructural* responses. *Relational* and *extended abstract* responses are qualitatively superior.

Quellmalz's framework of thinking skills
This framework lists five cognitive processes (recall, analysis, comparison, inference/interpretation and evaluation) and three metacognitive processes (planning, monitoring and reviewing/revising).

Stahl and Murphy's domain of cognition taxonomic system
These authors set out a multi-stage model of information processing from *preparation* to *generation*. They also identify 21 cognitive processes (eg classifying, organising, selecting, utilising, verifying), which may be used singly or in combinations at different levels.

1990–1999

Presseisen's models of essential, complex and metacognitive thinking skills
Presseisen lists five basic processes which are used in problem solving, decision making, critical thinking and creative thinking. She also lists six metacognitive thinking skills involved in strategy selection, understanding and monitoring.

2000–

Anderson and Krathwohl's revision of Bloom's taxonomy (see Section 3.3.2)
Bloom's taxonomy (1956) has been refined and developed into a two-dimensional framework using six cognitive processes and four knowledge categories. There is an emphasis on aligning learning objectives with learning activities and assessment.

Gouge and Yates' ARTS Project taxonomies of arts reasoning and thinking skills
A matrix of Piaget's levels (concrete, concrete transitional and formal operational thinking) and reasoning skills is used to create educational objectives for the visual arts, music and drama.

2.8.3 Group 3: frameworks for understanding critical and productive thinking

This is a fairly homogeneous group where the main emphasis is on the quality of higher-order thinking and reasoning. Good thinking is aided by reflection and metacognition. All authors identify dispositions which they believe to be extremely important in the development of critical and/or productive thinking, with the exception of Allen, Feezel and Kauffie (1967) (who limit themselves to argument analysis) and Gubbins (1986) (whose purpose was to make a composite list of critical thinking skills for a school district).

1950–1959

Altshuller's TRIZ theory of inventive problem solving

There are four main steps: problem definition; problem-solving tool selection; generating solutions; evaluating solutions. A specific problem is an instance of a generic problem which is solved when the appropriate generic solution is returned to a specific solution.

1960–1969

Allen, Feezel and Kauffie's taxonomy of concepts and critical abilities related to the evaluation of verbal arguments

Twelve abilities are involved in the recognition, analysis and evaluation of arguments. Truth claims depend on testimony and reasons. People should not be misled by rhetoric or the misuse of language.

1970–1979

Lipman's three modes of thinking and four main varieties of cognitive skill

Judgement and reasoning can be strengthened through critical, creative and caring thinking. In education, the four major varieties of higher-order thinking relate to: enquiry, reasoning (preserving truth), information organising and translation (preserving meaning).

1980–1989

Baron's model of the good thinker

The most important components of the model are the three conscious search processes – for goals, for possibilities and for evidence. Good thinking and the dispositions underlying it are to some extent teachable.

Ennis's taxonomy of critical thinking dispositions and abilities (see Section 3.4.1)

'Critical thinking is reasonable reflective thinking that is focused on what to believe or do' (1985, 45). For Ennis, the basic areas of critical thinking are clarity, basis, inference and interaction. He lists 12 relevant dispositions and 15 abilities.

Gubbins' matrix of thinking skills

This is a composite list of 'core' critical thinking skills, based on other published lists. The skills are grouped under the following headings: problem solving, decision making, inferences, divergent thinking, evaluating, philosophy and reasoning.

Halpern's reviews of critical thinking skills and dispositions (see Section 3.4.2)

Halpern's skill categories are: memory, thought and language; deductive reasoning; argument analysis; hypothesis testing; likelihood and uncertainty; decision making; problem solving; and creative thinking. She also lists six relevant dispositions.

Paul's model of critical thinking (see Section 3.4.3)

The model has four parts: elements of reasoning, standards of critical thinking, intellectual abilities and intellectual traits. The first three parts focus on what is essential to critical thinking and the fourth on what it is to be a critical thinker.

1990–1999

Jewell's reasoning taxonomy for gifted children

Jewell's taxonomy has three fields: objectives of reasoning, reasoning strategies and reasoning dispositions. The disposition to adopt thinking about thinking (metacognition) as a habit is very important.

2.8.4
Group 4: explanatory models of cognitive structure and/or cognitive development

This family group is the most diverse and includes different approaches to analysing the concept of intelligence. Some theorists (Carroll 1993, Guilford and Gardner) categorise thinking and problem-solving processes in similar ways in school-aged children and in adults, but have different views about genetic and environmental influences on the structure of intellect. Stage theorists argue for qualitative changes in thinking as the learner develops or progresses (Perry 1968, 1970; Belenky *et al*. 1986; King and Kitchener 1981, 1994; Koplowitz 1987). Pintrich (2000) focuses exclusively on metacognition and self-regulation.

1960–1969

Guilford's structure of intellect model
This is a three-dimensional model in which five cognitive operations work with four types of content to produce six types of product. The operations are: cognition, memory, divergent thinking, convergent thinking and evaluation.

Perry's developmental scheme
The scheme consists of nine positions which liberal arts college students take up as they progress in intellectual and ethical development. They move from the modifying of 'either or' dualism to the realising of relativism and then to the evolving of commitments.

1980–1989

Belenky's 'women's ways of knowing' developmental model
Women in adult education tended to progress from: silence (a reaction to authority), to received knowledge, to subjective knowledge, to procedural knowledge (including separate and connected knowing), and finally to constructed knowledge.

Gardner's theory of multiple intelligences
Gardner identifies nine kinds of intellectual ability: verbal/linguistic, mathematical/logical, musical, visual/spatial, bodily/kinaesthetic, interpersonal, intrapersonal, naturalist and existential.

King and Kitchener's model of reflective judgement (see Section 3.5.1)
This is a seven-stage model of progression in adolescent and adult reasoning. Assumptions about knowledge and strategies for solving ill-structured problems can move from pre-reflective through quasi-reflective to reflective stages.

Koplowitz's theory of adult cognitive development
Koplowitz builds on Piaget's stage theory, but adds two postmodern stages beyond the formal operations stage – post-logical and unitary thinking. The stages reflect changes in how people understand causation, logic, relationships, problems, abstractions and boundaries.

1990–1999

Carroll's three-stratum theory of cognitive abilities
This theory has a well-founded empirical basis for thinking of cognitive tasks as making demands on narrow and/or broad abilities as well as on general intelligence.

2000–

Pintrich's general framework for self-regulated learning (see Section 3.5.2)
Pintrich identifies four phases of self-regulation. Cognition, motivation/affect, behaviour and context can be regulated by: (1) forethought, planning and activation, (2) monitoring, (3) control, and (4) reaction and reflection.

Section 3

Thinking skill frameworks evaluated

3.1 Evaluation criteria

We established a set of criteria in order to evaluate each framework in terms of the purpose(s) for which it was devised and the use(s) to which it has been put. We decided to organise our evaluation reports using four main headings: *description and intended use*, *scope and structure*, *theory and values*, and *communicability and practical relevance*.

The following aspects were taken into account:

- description and intended use
- nature and function: taxonomy/framework/model/map/list
- stated purpose
- scope and structure
- the domains and/or sub-domains addressed
- the principle or principles used in constructing the framework
- structural complexity and level of detail
- the thinking skill categories
- the thinking skill elements
- how well the domains and/or sub-domains are covered
- extent to which categories overlap
- overall coherence
- distinctiveness
- theory and values
- justification for choice of underlying principles
- explanatory power
- compatibility with similar systems
- consistency with well-supported theories
- pedagogical stance (if any)
- values: explicit/non-explicit; descriptive/prescriptive
- communicability and practical relevance
- clarity of formulation
- accessibility for teachers and learners
- actual and potential areas of application
- implications for understanding teaching and learning
- match with a range of post-16 learning activities
- implications for practice in post-16 learning contexts
- actual and potential use in research.

We applied our evaluation criteria to systems of classification which are variously described as taxonomies, conceptual frameworks or models. Some strict criteria, such as the need to have comprehensive and non-overlapping categories, and to apply classificatory principles in an entirely consistent manner are applicable to taxonomies, but less so to frameworks and models. We found some cases where we felt that what the author describes as a taxonomy is really a framework or a model, and in such cases we were more interested in clarity and heuristic value than in theoretical elegance.

3.2 Evaluation of all-embracing frameworks

The two broad frameworks considered here offer ways of classifying the knowledge and skills required to achieve educational objectives. Three other frameworks in which learning features as much as thinking can be found in Appendix 2. They were devised by Romiszowski (1981), Hauenstein (1998) and Sternberg (2001).

3.2.1 Jonassen and Tessmer's taxonomy of learning outcomes

Description and intended use

This taxonomy was created by Jonassen and Tessmer (1996/97) 'for the development and evaluation of computer-based learning systems for higher order thinking skills' (Jonassen, Tessmer and Hannum 1999, 30). However, the authors believe that it has wider uses and regard it as an evolving entity. They argue that current research taxonomies should be adapted to take account of developments in educational research and instructional technology, particularly the development of multimedia and internet-based instruction (Jonassen *et al*. 1999). They specifically seek to include integrated knowledge, ampliative (knowledge enhancement) skills, self-awareness and self-control in their taxonomy.

The authors seek to combine the steps of task analysis and outcome classification to make them 'a concurrent design process' (Jonassen, Tessmer and Hannum 1999, 31). They suggest that knowledge of a taxonomy can facilitate task analysis in instructional design (Jonassen, Hannum and Tessmer 1989). Ten years later, they make the stronger claim that 'if you are unable to articulate the kind of thinking (by classifying the kind of learning outcome required) that you expect learners to accomplish, you have no business trying to design instruction to support that learning.' (Jonassen, Tessmer and Hannum 1999, 31)

The taxonomy, as shown below, has 11 broad categories of learning outcome, with a total of 34 sub-categories:

- declarative knowledge
  - cued propositional information
  - propositional information
  - acquiring bodies of information
- structural knowledge
  - information networking
  - semantic mapping/conceptual networking
  - structural mental models
- cognitive component skills
  - forming concepts
  - reasoning from concepts
  - using procedures
  - applying rules
  - applying principles
  - complex procedures found in well-structured problems
- situated problem solving
  - identifying/defining problem space
  - decomposing problems
  - hypothesising solutions
  - evaluating solutions
- knowledge complexes
  - mental modelling
- ampliative skills
  - generating new interpretations
  - constructing/applying arguments
  - analogising
  - inferencing
- self-knowledge
  - articulating content (prior knowledge)
  - articulating socio-cultural knowledge
  - articulating personal strategies
- reflective self-knowledge
  - articulating cognitive prejudices or weaknesses
- executive control strategies
  - assessing task difficulty
  - goal setting
  - allocating cognitive resources
  - assessing prior knowledge
  - assessing progress/error checking
- motivation (disposition)
  - exerting effort
  - persisting with task (tenacity)
  - engaging intentionally (willingness)
- attitude
  - making choices.

Evaluation: scope and structure

This is a broad-brush framework which can be applied to all kinds of learning outcome, whether cognitive, motor or psychosocial. It brings together cognitive, metacognitive, affective and conative (motivational) dimensions, some of which are not included in widely used instructional design taxonomies. While it can be argued that the main categories are comprehensive, some areas are treated in more detail than others, the section on motivation (dispositions) being far from complete. In a later paper, Jonassen (2000) provides more detail about problem solving, setting out 11 types of problem-solving outcome along the well-structured to ill-structured dimension.

The authors do not specify a single organising principle that they used to construct the taxonomy, although they do see task analysis in terms of creating learning hierarchies in which a higher-order outcome (such as problem solving or constructing a mental model) depends upon lower-order outcomes (such as concept formation or information processing) which need to be mastered by the learner first. As it stands, however, the taxonomy is not strictly hierarchical and is therefore best seen as a framework.

We concur with the authors' claim to have improved on the taxonomies of Bloom (1956), Gagné (1965, 1985) and Merrill (1983) by including learning outcomes which:

1
reflect learned behaviours (by which they seem to mean abilities rather than skills) including inferencing, analogising, assessing task difficulty and decomposing problems

2
reflect cognitive structures acquired in learning such as structural knowledge, self-knowledge and mental models

3
are traditional, such as attitudes, procedures, rules, concepts and problem solving.

In each of the main categories there are some headings and terms which are somewhat different from those used in other taxonomies, such as 'ampliative skill' and 'structural knowledge' (Jonassen, Beissner and Yacci 1993). However, it is possible to relate these to other conceptualisations. For example, a 'conceptual network' is what other theorists have called a 'schema' and 'ampliative skills' refer to aspects of critical and creative thinking.

The overall structure of the framework is compatible with that of Marzano (2001a, 2001b) in that it has categories that can be fitted into Marzano's self, metacognitive and cognitive sytems.

Evaluation: theory and values

Gagné's taxonomy (Gagné 1985) and Merrill's component display theory (1983) are acknowledged by the authors as influencing their own thinking (Jonassen, Tessmer and Hannum 1999). Cognitive and constructivist ideas predominate and the analytic assumption is made that 'knowledge and human activity can be characterised as discrete cognitive states' (Jonassen, Tessmer and Hannum 1999, 30). All of the learning outcomes are expressed in mentalistic rather than behavioural terms and some (such as 'allocating cognitive resources' and 'defining problem space') would be very difficult to operationalise.

The theoretical constructs for the framework come from contemporary educational research in psychology and sociology, as well as drawing on philosophical concepts. Some of the underpinning approaches are similar to those influencing other taxonomists, such as Marzano (2001a, 2001b). For example, the importance given to metacognitive and motivational aspects of learning implies an active model of knowledge construction. The authors also acknowledge the importance of context for learning, by including a category of situated problem solving (see Jonassen 1997, 2000).

By having an 'ampliative skills' category (by which they mean how a learner reasons beyond given information through analogy and inference), Jonassen and Tessmer imply that the issue of transfer in learning is not included or well covered in other accounts. Here they draw on Moore's work (1968) in critical and creative thinking and claim that these 'knowledge enhancement skills' aim to make learning more efficient and personally relevant, as learners generate new knowledge and make meaningful connections within what they already know.

Evaluation: communicability and practical relevance

As the framework explicitly draws on a number of fields, the terminology includes some unfamiliar terms, which may make it challenging for teachers. On the other hand, the inclusion of 'traditional' learning outcomes such as attitudes and concepts makes it more accessible. The authors have a possible communicative advantage in that they talk about self-knowledge and executive control strategies instead of metacognition and self-regulation.

The framework was specifically developed to aid instructional designers in tasks such as mapping a curriculum and developing materials and assessments, so it is likely to be well received by practitioners. Jonassen and Tessmer include, for example, the idea of 'ill-structured' problems in their list, arguing that teachers and learners need to engage in real-world or situated problem solving where there may be a range of solutions (or even no solution at all). One example of the successful application of the taxonomy is a task analysis of what is involved in understanding the structure, functions and powers of the US Department of Defence.

As the authors point out, the usability, comprehensive-ness and productivity of a taxonomy can only be properly assessed by applying it in many contexts. We believe that their framework offers considerable promise, especially in the field of computer-assisted learning for which it was designed. Although it has more categories than Marzano (2001a, 2001b) uses, it is a serious contender for widespread use in post-16 as well as school-age contexts. It is broad in scope, focuses on a range of learning outcomes and can cope with the application of knowledge and skills in complex situations such as problem solving and work-based learning.

3.2.2 Marzano's new taxonomy of educational objectives

Description and intended use

Marzano's initial purpose (1998) was to produce a theory-driven meta-analysis of educational instruction using categories specific and functional enough to provide guidance for classroom practice. In his later book (2001a), the theory is presented as a taxonomy for designing educational objectives, spiral curricula and assessments.

As illustrated in Figure 1, the theoretical model is a hierarchical system in which the *self system* controls the *metacognitive system* which in turn controls the *cognitive system*. Each of these operates on the retrieved content of an individual's knowledge domain, which comprises stored information and knowledge of mental and psychomotor procedures. This knowledge can be represented linguistically, non-linguistically or in an affective (emotional) form.

The three systems are said to form a hierarchy in terms of the downward flow of information, once the self system has decided to engage in a task (Marzano 2001b). Marzano (2001a) makes the additional claim that each level requires more conscious thought than the one below it.

Figure 1
The hierarchical control structure of Marzano's theory-based taxonomy

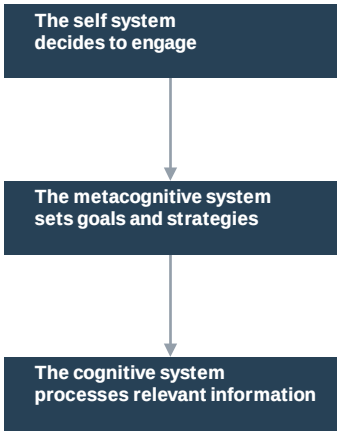


Table 1
Marzano's new taxonomy

System	Level		
Self	6	Examining the importance of the knowledge Examining efficacy (ability to learn) Examining emotions associated with knowledge and motivation	
Metacognitive	5	Specifying learning goals Monitoring the execution of knowledge Monitoring clarity Monitoring accuracy	
Cognitive	4	Knowledge utilisation	Decision making Problem solving Experimental enquiry Investigation
	3	Analysis	Matching Classifying Error analysis Generalising Specifying
	2	Comprehension	Synthesis Representation
	1	Retrieval	Recall Execution

At the top of the hierarchy of consciousness and control is the self system, in which attention and motivation are controlled in accordance with beliefs and calculations of discrepancies between perceived and desired states. 'Because the mechanisms in the self-domain are the working elements that define motivation and volition in human behaviour, they have historically been referred to as conative structures' (2001a, 10). The self system is said to exert control over the metacognitive system, which is concerned with goal specification, process specification, process monitoring and disposition monitoring. The metacognitive system in turn 'exerts control over the cognitive system that operates in the knowledge domains' (2001a, 65). The functions of Marzano's three systems are shown in Table 1, grouped into six levels.

Marzano (2001b) sees Levels 1–4 within the cognitive system as hierarchical, in that knowledge retrieval is a prerequisite for comprehension, which is a prerequisite for analysis, without which knowledge cannot be used.

For each of the functions at the six levels of his taxonomy, Marzano (2001b) provides for teachers illustrative instructional objectives, cues or questions. These, however, add little further meaning, as the question for *generalising* shows: 'What generalisations can be inferred from this knowledge?' (2001b, 187).

The knowledge domain is comprised of declarative and procedural knowledge. Declarative knowledge is subdivided into *organising ideas* (principles and generalisations) and *details* (episodes, cause–effect sequences, time sequences, facts and vocabulary terms). Procedural knowledge is said to consist of more or less complex mental and psychomotor processes and skills. Mental skills are broken down into *tactics*, *algorithms* and *single rules*.

Evaluation: scope and structure

The scope of Marzano's taxonomy is certainly very broad, based as it is on a theory of thinking and learning which aims to be comprehensive. It covers objectives which relate to mental activity, values, beliefs and dispositions as well as observed behaviour. It builds on his earlier work (eg Marzano *et al*. 1988; Marzano 1992), but differs in that it has relatively little to say about creative thinking. It takes account of conative and affective aspects of thinking, but does not attempt to account for individual and situational differences in those domains.

The knowledge categories proposed by Marzano appear to be comprehensive, not least because they are said to contain all 'facts' and 'vocabulary terms'. However, he does not include 'pattern' or 'system' in his list, nor terms which refer to probabilistic knowledge of social situations. Marzano's treatment of sub-categories is generally in need of greater justification: for example, it is not self-evident that the sub-categories of *knowledge utilisation* are mutually exclusive nor that they offer comprehensive coverage.

The taxonomy has not been tested to see whether its structure is sufficiently robust to ensure consistent classification of instructional objectives and/or thinking skills. One possible area of confusion is the inclusion of *error analysis* in the cognitive rather than the metacognitive system. Marzano uses this heading to cover the evaluation of the logic and reasonableness of knowledge claims and provides a list of informal fallacies which can be detected through critical thinking. However, while the evaluation of another person's thinking is a cognitive activity, monitoring and detecting errors in one's own thinking involves metacognition.

Marzano (2001a, 2001b) makes many comparisons between his new taxonomy and Bloom's taxonomy of educational objectives (cognitive domain) (1956). The main differences are his addition of the metacognitive and self systems and his replacement of *complexity* with *flow of information* as an organising principle. Other differences lie largely in the detail, but especially in Marzano's treatment of *analysis* which incorporates elements from Bloom's higher-order categories of *analysis*, *synthesis* and *evaluation*.

The three-tier structure of Marzano's taxonomy has only a modest level of empirical support from his own highly ambitious meta-analysis of research on instruction (1998). The mean differences in achievement gain produced by educational interventions making use of the three systems are not great (27 percentile points for the self system, 26 for the metacognitive system and 21 for the cognitive system). The standard deviations are so large that it is simply not possible to argue that it is better to aim for change via the self system rather than through the cognitive system. Conative, affective and cognitive aspects of thought are not easily separable and all three are involved in planning, monitoring and evaluating. Marzano seems to think of the metacognitive system as a sort of computer, unlike the self system which deals with motivation, beliefs and feelings. This does not accord with subjective experience, in which motivation, beliefs and feelings are not disassociated from planning, monitoring and evaluating, either when engaging in an activity or when seeing it through.

The flow of information is more complex and interactive than Marzano suggests. It cannot all be downwards, as Marzano claims. There are many examples in the literature of self-concept and self-efficacy being enhanced as a result of cognitive skill acquisition. The brain does not function like a strictly hierarchical military organisation. Representations of the self are formed through experiences at all levels of consciousness and control. In Demetriou's empirically supported model of the mind, there is a great deal of dynamic interaction between levels and modules (Demetriou and Kazi 2001).

Marzano's claims about the flow of information, the amount of conscious thought needed at each level and the dependence of each level on those below are largely open for experimental enquiry. When he states that without a clear goal, task execution will break down (2001b), he is evidently not thinking about many stages of creative thinking; and when he states that decision making requires analysis, he is ignoring the widespread use of heuristics that reduce mental effort.

Evaluation: theory and values

Marzano began by constructing a theory to support his taxonomic framework. He does not discuss the values implicit or explicit in his theory, but it is certainly not value-neutral, as it is highly individualistic, using the metaphor of a control system with a powerful authority in charge. At the same time, the taxonomy seems designed to support the authoritative role of the teacher who introduces knowledge objectives and tries to enthuse learners into adopting them as their own. The hierarchical control feature of the taxonomy seems less compatible with a participatory, enquiry-based approach to learning.

In Marzano's writing, there is an all-pervasive emphasis on rationality, to such a degree that emotions seem to be there not to be experienced, but to be analysed to see if they are reasonable. At the same time, he is a pragmatist, suggesting that teachers should base their practice on the research evidence of 'what works', as established through meta-analysis.

So far as the school curriculum is concerned, Marzano argues against simply using information load as an index of progression, suggesting that his levels should be built into a spiral curriculum that emphasises process more than content.

We have here a largely coherent theory which draws on a wide range of research in cognitive and educational psychology, rather than on theory development in the fields of critical and creative thinking. Its basic three-tier structure is similar to that developed independently by Demetriou and Kazi (2001). Both Marzano and Demetriou distinguish between *cognitive*, *metacognitive* (termed *hypercognitive* by Demetriou) and *self systems* (*self-representation* for Demetriou). Demetriou and Kazi have accumulated an impressive amount of empirical support for their model, which is even broader in scope than Marzano's. Unlike Demetriou and Kazi, Marzano pays little attention to non-cognitive aspects of personality and says little about sensitivities to the situational and interpersonal factors which affect learning. It remains to be seen how far his theory will yield verifiable predictions and findings with practical implications for teachers and learners.

Although he provides clear definitions and examples, there are some instances in which Marzano defines terms in unfamiliar ways. For example, he defines *synthesis* as 'the process of distilling knowledge down to its key characteristics' (2001a, 34), which contrasts with the more familiar idea of putting together parts so as to form a (sometimes complex) whole. For Marzano, *matching* involves the detection of differences as well as similarities and in this case the term 'compare' or 'compare and contrast' would be more appropriate.

Evaluation: communicability and practical relevance

Marzano's theory has considerable potential for use in instructional design, teaching, assessment, research and evaluation. He summarises both general and specific instructional implications for practitioners, many of which are applicable irrespective of the age range of learners. His inclusion of a *knowledge utilisation* level, dealing with the orchestration of thinking, makes the taxonomy meaningful in real-life problem-solving contexts and this feature, together with the importance given to the metacognitive and self systems could help to bring about improvements in formative and summative assessment of the kind that is already being developed in relation to higher-level key skills objectives.

The important features of Marzano's new taxonomy are as follows.

- It provides a coherent framework for classifying instructional goals, though some category boundaries are unclear and there are some weak areas, such as the affective aspects of learning.
- It promotes the use of clear statements of educational goals.
- It is applicable in all contexts of teaching and learning.
- It is not too complex for everyday use.
- It may have the effect of limiting creativity.
- It may not support collaborative learning effectively because of its individual focus.
- It is likely to prove meaningful and useful to teachers and other educational professionals, to stimulate various forms of enquiry, and to help teachers to systematise and improve their practice.

3.3 Evaluation of instructional design frameworks

Here we describe and evaluate two very different frameworks, although both sets of authors are concerned about the complexity of thought. The SOLO taxonomy of Biggs and Collis (1982) is primarily an assessment tool, whereas Anderson and Krathwohl's (2001) revision of Bloom's taxonomy is broader in scope. In Appendix 2, we present six other frameworks, including the ground-breaking work of Bloom and his team in 1956. We include Feuerstein's framework (1980), which illustrates his distinctive *Instrumental Enrichment (IE)* approach to developing thinking and learning. Williams (1970) is one of the few authors to concentrate on creativity.

3.3.1 Biggs and Collis's SOLO taxonomy: structure of the observed learning outcome

Description and intended use

The taxonomy was devised by Biggs and Collis (1982; Biggs 1995, 1999). According to the authors, it provides a systematic way of describing how a learner's performance grows in complexity when mastering many tasks, particularly the sort of tasks undertaken in schools and colleges. They argue for a general sequence in the growth of the structural complexity of many concepts and skills; that sequence may then be used to identify specific targets or to help teachers to assess particular outcomes. It therefore attempts to describe the level of increasing complexity in a student's understanding of a subject through five stages, and it is claimed to be applicable to any subject area. Not all students get through all five stages, and not all teaching (and even less 'training') is designed to take them all the way. The stages are described in outline below and with additional criteria in Table 2.

Table 2
The SOLO taxonomy levels, with descriptors and criteria

SOLO description	Capacity	Relating operation	Consistency and closure
Pre-structural	Minimal: cue and response confused	Denial, tautology, transduction Bound to specifics	No need felt for consistency: closure without seeing the problem
Uni-structural	Low: cue and one relevant datum	Can generalise only in terms of one aspect	No need felt for consistency: closed too quickly; jumps to conclusions, so can be very inconsistent
Multi-structural	Medium: cue and isolated relevant data	Can generalise only in terms of a few limited and independent aspects	Feeling for consistency: closure too soon on basis of isolated fixations so can reach different conclusions with same data
Relational	High: cue and relevant data and interrelations	Induction: can generalise within given or experienced context using related aspects	No inconsistency in given system, but closure is unique to given system
Extended abstract	Maximal: cue and relevant data and interrelations and hypotheses	Deduction and induction: can generalise to situations not experienced	Inconsistencies resolved: no need for closed decisions; conclusions held open or qualified to allow logically possible alternatives

1
Pre-structural: here students are simply acquiring bits of unconnected information which have no organisation and make no sense.

2
Uni-structural: simple and obvious connections are made, but their significance is not grasped.

3
Multi-structural: a number of connections may be made, but the meta-connections between them are missed, as is their significance for the whole.

4
Relational: the student is now able to appreciate the significance of the parts in relation to the whole.

5
Extended abstract: the student makes connections not only within the given subject area, but also beyond it, and is able to generalise and transfer the principles and ideas underlying the specific instance.

The taxonomy (see Table 2 above) explicitly draws on a Piagetian framework, but differs from Piaget's (1952) classical stage theory in that Biggs and Collis argue that each stage does not so much *replace* the previous stage as *add* to the repertoire of available cognitive responses. In different situations, learners may 'regress' to an earlier mode of functioning or use a higher cognitive function in the learning of a lower-order one, adopting a 'multi-modal' approach to the task at hand (Biggs and Collis 1991). The taxonomy is based on an analysis of the work of several hundred pupils of different ages across a range of subjects and the identification of recurring patterns in pupils' thinking. Biggs and Collis found a general age-related progression through secondary schooling, from *multi-structural* to *relational* to *extended abstract* thinking (equivalent to Piaget's formal operations stage and not usually reached before the age of 16).

The purpose of the SOLO taxonomy is to provide a systematic way of describing how a learner's performance grows in structural complexity when tackling and mastering a range of tasks. It can therefore be used to identify and define curriculum objectives that describe performance goals or targets, as well as for evaluating learning outcomes, so that the levels at which individual students are performing or operating can be identified.

Evaluation: scope and structure

The SOLO taxonomy can be used to classify the quality of students' responses to assessment items, at least as represented by identifying the sophistication of the assumed underlying logic. It has been used experimentally in a wide range of studies; for example, to evaluate the learning associated with the use of the computer language LOGO (Hawkins and Hedberg 1986) as well as in the context of higher education (Boulton-Lewis 1995). The key terms and definitions have remained the same for over 20 years, as it has been developed and applied. It offers a framework for the assessment of challenging aspects of learning such as the understanding of concepts, and for problem solving (Collis and Romberg 1991: for an overview and summary of research, see Prosser and Trigwell 1999). The taxonomy has also proved effective as a means of planning and developing curricula based on the cognitive characteristics of the learners.

Evaluation: theory and values

The SOLO taxonomy identifies a developmental progression of a student's cognitive responses, based on Piaget's theory of genetic epistemology. It is therefore open to some of the same criticisms that have been levelled against stage theories (in terms of the relationship between, and progression through, the stages) and makes some implicit assumptions about the nature of knowledge. The taxonomy does not take into account the social nature of interactions or the influence of affective and conative dimensions of thinking, because its focus is on students' performance (in a particular context at a particular time). It therefore assumes that the tasks used are understood by students and offer effective contexts for such assessment.

There are links between the approach of Biggs and Collis and other work on learning, such as Säljö's conceptions of learning (1979a, 1979b), and Bateson's levels of learning (1973).

Evaluation: communicability and practical relevance

The wide and effective application of the SOLO taxonomy by educational researchers, curriculum designers and teachers at all levels of education and across a wide range of subjects indicates its practical value and the ease with which it can be understood. It was designed to improve the quality of learning and the quality of feedback given to students, or for use by students in self-assessment. The five levels are easy to grasp, although the qualitative nature of judgements needed to assign observed outcomes to the appropriate categories or levels of the taxonomy can make it challenging to apply the taxonomy consistently.

Although the formative value of the SOLO taxonomy is apparent, there is some risk that it could be used to devise curricula for novice learners in the belief that they are not ready to build connections between related ideas.

3.3.2 Anderson and Krathwohl's revision of Bloom's taxonomy of educational objectives

Description and intended use

This revision of Bloom's framework for categorising educational objectives was undertaken to refocus attention on Bloom's taxonomy (1956) and to incorporate the many advances in knowledge since the original publication. The revision took account of international feedback and Bloom, together with several of his co-authors, contributed to several chapters in this work.

The original framework comprised the following six categories: *knowledge*, *comprehension*, *application*, *analysis*, *synthesis* and *evaluation*. With the exception of knowledge, all categories were labelled as 'abilities and skills'; and for each of these, knowledge was deemed a prerequisite. The categories were presumed to constitute a cumulative hierarchy; that is, each category was conceived as building on and comprising a more advanced achievement than its predecessor.

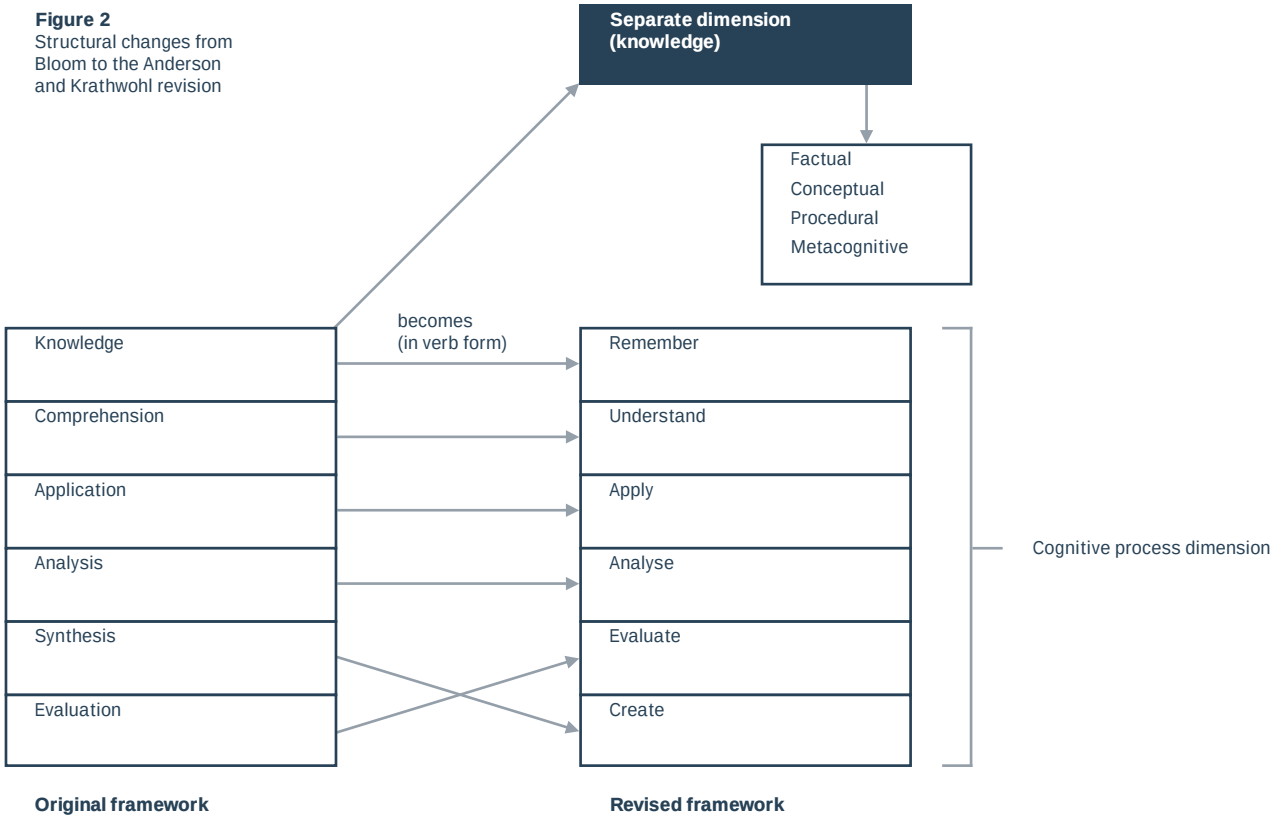
The Anderson and Krathwohl revision (2001) retains six cognitive process categories: *remember*, *understand*, *apply*, *analyse*, *evaluate* and *create*. These correspond closely to the Bloom categories, and since the revision draws heavily on Bloom, it is worth identifying the changes incorporated into the revision.

Changes in emphasis

The revision emphasises the use of the taxonomy in course planning, instruction and assessment; and in aligning these three. The authors view this as a major shift from the original handbook, where the focus was on providing extensive examples of test items in each of the six categories. Other significant changes are listed below.

- While the original handbook was developed by college examiners, the revision is designed to be of use by elementary and high-school teachers.
- Sample assessment tasks contained within the revision are designed to illustrate and clarify the meaning of the various sub-categories. They are not included as model test items, as in the original handbook.
- The original handbook made use of test items to clarify the meaning of definitions; in the revision, meanings are clarified through extensive descriptions of sub-categories and case vignette illustrations.
- It is no longer claimed that the process categories form a cumulative hierarchy where the learner cannot move to a higher level without mastering all those below it.

Figure 2
Structural changes from Bloom to the Anderson and Krathwohl revision



Changes in terminology

- Educational objectives indicate that a student should be able to do something (verb) to or with something (noun). In the original framework, nouns were used to describe the knowledge categories (eg *application*). In the revision, the major categories in the cognitive process dimension have been relabelled with verb forms (eg *apply*). Knowledge as a cognitive process is renamed *remember*. Sub-categories in the cognitive process dimension have also been labelled with verbs, such as *checking* and *critiquing* (sub-categories of *evaluate*).
- The revision has renamed and reorganised the knowledge sub-categories as four types of knowledge: *factual*, *conceptual*, *procedural* and *metacognitive*.
- Two of the major categories in the original framework have been renamed: *comprehension* has become *understand* and *synthesis* has become *create*.

Changes in structure

Anderson and Krathwohl's taxonomy (2001) involves a two-dimensional table, with six cognitive processes and four types of knowledge. Figure 2 summarises the structural changes from Bloom's original framework; the examples of learning objectives, activities and assessment shown in Figure 3 illustrate why it is useful to separate the 'knowledge' and 'cognitive process' dimensions.

The revised framework orders the six cognitive process categories according to their degree of complexity. In the original framework, it was claimed that mastery of a more complex category required mastery of all the preceding, less complex categories. Anderson and Krathwohl state that empirical evidence only supports a cumulative hierarchy for Bloom's middle three categories of *comprehension*, *application* and *analysis*. However, they confirm that the revised framework remains hierarchical in overall complexity.

Throughout the book, the authors use four organising questions to show how the taxonomy framework can be used to support teachers in the classroom.

- *The learning question*: what is important for students to learn in the limited school and classroom time available?
- *The instruction question*: how does one plan and deliver instruction that will result in high levels of learning for large numbers of students?
- *The assessment question*: how does one select or design assessment instruments and procedures that provide accurate information about how well students are learning?
- *The alignment question*: how does one ensure that objectives, instruction and assessment are consistent with one another?

Figure 3
Taxonomy table with illustrative examples

Knowledge dimension	Cognitive process dimension					
	1 Remember	**2 Understand**	**3 Apply**	**4 Analyse**	**5 Evaluate**	**6 Create**
	1 Recognising 2 Recalling	1 Interpreting 2 Exemplifying 3 Classifying 4 Summarising 5 Inferring 6 Comparing 7 Explaining	1 Executing 2 Implementing	1 Differentiating 2 Organising 3 Attributing	1 Checking 2 Critiquing	1 Generating 2 Planning 3 Producing
Factual knowledge knowledge of terminology knowledge of specific details and elements	*Example assessment* Quiz on addition facts					*Example activity* Rewrite a scene from Macbeth in a modern idiom
Conceptual knowledge knowledge of classifications and categories knowledge of principles and generalisations knowledge of theories, models and structures		*Example learning objective* Understand the theory of plate tectonics as an explanation for volcanoes		*Example learning objective* Select sources of information related to writing about a historical figure	*Example learning objective* Evaluate food commercials from a set of principles	*Example activity* Rewrite a scene from Macbeth in a modern idiom
Procedural knowledge knowledge of subject-specific skills and algorithms knowledge of subject-specific techniques and methods knowledge of criteria for determining when to use appropriate procedures			*Example learning objective* Gain a working knowledge of memorisation strategies			*Example learning objective* Create a commercial that reflects understanding of how commercials are designed to influence people
Metacognitive knowledge strategic knowledge knowledge about cognitive tasks, including appropriate contextual and conditional knowledge self-knowledge		*Example learning objective* Understand the efficiency of memorisation strategies (in certain circumstances)			*Example learning objective* Check the influences of commercials on students' 'senses'	

A series of vignettes based on actual classroom practice is used to demonstrate how the taxonomy table can be used to aid understanding of the complex nature of classroom instruction. It is claimed that increased understanding of the framework can result in improving the quality of classroom instruction, not least by encouraging teachers to include more complex cognitive process categories in classroom instruction. First and foremost, the taxonomy table should be used as an analytical tool to enable teachers to conduct a deeper examination of the alignment of learning objectives, instruction and assessment.

Evaluation: scope and structure

While acknowledging that almost every cognitive objective involves an affective component, the authors judged that inclusion of the affective domain would create an overly complex taxonomy, which would not, for that reason, become widely adopted. However, the authors consider that their revised cognitive domain taxonomy 'does contain some seeds for future affective development' in that *metacognitive knowledge* goes some way to bridging the cognitive and affective domains (2001, 301). Mayer (2002) argues that in addition to the new category of *metacognition*, the revised taxonomy recognises the role of metacognitive and motivational processes in that it clarifies their role within the cognitive process dimension and in particular, within the categories of *create* and *evaluate*.

The widely used terms 'critical thinking' and 'problem solving' have not been included as major categories within the taxonomy, since the authors view these terms as having similar characteristics to their category *understand*. However, they maintain that, unlike *understand*, critical thinking and problem solving tend to involve cognitive processes in several categories across their cognitive process dimension.

The creation of a matrix whereby cognitive processes operate with different types of subject matter content (ie *knowledge*) provides teachers with a useful tool to help them to analyse their teaching objectives, activities and assessment. Classifying learning objectives within the framework is likely to increase a teacher's understanding of each objective and help them to plan ways to ensure that pupils succeed. Classifying longer units of work allows teachers to make choices relating to coverage across both dimensions. We note, also, that this approach has been taken by several other theorists: Romiszowski (1981), Jonassen and Tessmer (1996/97), for example.

There is little to choose between Bloom (1956) and Anderson and Krathwohl (2001) in their treatment of three sub-categories of knowledge. The revised term for Bloom's *knowledge of specifics* is *factual knowledge*. What Bloom calls *knowledge of ways and means* is now called *procedural knowledge*, and Bloom's *knowledge of the universals and abstractions in a field* is now labelled as *conceptual knowledge*. However, while Bloom made implicit references to what we now call metacognition, Anderson and Krathwohl explicitly list 'metacognition' as a type of knowledge. But it is open to question whether the term 'metacognition' refers to knowledge of a different type. It is not uniquely distinguished by the processes involved (knowing that, knowing how and understanding ideas), but rather by its content.

While Anderson and Krathwohl give weight to the separate classification of metacognitive knowledge, they do not explicitly address the monitoring, control and regulation of students' cognition, arguing that this involves 'different types of cognitive processes and therefore fits into the cognitive process dimension' (2001, 43). When addressing metacognition within the knowledge dimension, the authors provide a rationale for the inclusion of metacognitive knowledge – a comprehensive overview of each of the three types of metacognitive knowledge together with illustrative examples. Their treatment of metacognition within the cognitive process dimension attracts little attention and provides the reader with only two examples. This decision results in an inconsistent treatment of the two aspects of metacognition (knowledge and self-regulation).

Evaluation: theory and values

Theoretical advances in educational psychology and, to a lesser extent, in cognitive psychology have contributed to this revision of Bloom's framework. The focus on knowledge types and the delineation of process categories into specific cognitive processes is based largely on 'an examination of other classification systems' (2001, 66), dating from 1969 to 1998, and including Sternberg's model (1998) of 'successful intelligence'. While acknowledging that the framework should ideally be based on a single, widely accepted, and functional theory of learning, the authors note that, despite recent advances, we are still without a single psychological theory that adequately provides a basis for all learning. The framework reflects the authors' belief that knowledge is structured by the learner in line with a rationalist-constructivist tradition. They do not adhere to the idea that knowledge is organised in stages or in system-wide logical structures, as in traditional 'developmental stage' models of thinking.

Anderson and Krathwohl claim that their taxonomy is 'value neutral and therefore can be used by those operating from a variety of philosophical positions' (2001, 296). This is broadly true, despite the implication (equally present in Bloom's taxonomy) that more complex thinking is usually more highly valued.

Evaluation: communicability and practical relevance

The terminology is clear and accessible, and teachers already familiar with the original taxonomy will find little difficulty in assimilating the revised structure and terminology. The inclusion of a series of vignettes helps to illustrate the key concepts and elements in the taxonomy table. Although these examples are taken from school contexts, the taxonomy is also suitable for post-16 application, as was Bloom's original framework.

The taxonomy was designed to help teachers to understand and implement a standards-based curriculum. The authors expect the framework to be used mainly by teachers who are given a set of objectives and are expected to deliver instruction that enables a large proportion of pupils to achieve the expected standard. The dominant theme running throughout the text is the alignment of learning objectives, instruction and assessment. The taxonomy encourages teachers to focus on coverage, thereby allowing students to experience learning opportunities across the cognitive domain. The purpose of the framework is to help teachers to clarify and communicate what they intend their students to learn. The authors are less concerned with how teachers teach, since it is their view that most instructional decisions depend on the teacher's creativity, ingenuity and wisdom.

There are several reasons why the taxonomy may prove attractive to practitioners. It does not seek to change radically how they teach or to challenge their beliefs about teaching and learning. The authors use language that teachers are familiar with, and exemplify use of the taxonomy with detailed case studies that reflect current classroom practice.

This revision of Bloom's taxonomy – with its emphasis on helping teachers to align learning objectives, instruction and assessment – is a strong contender for use in post-16 education.

3.4 Evaluation of critical/productive thinking frameworks

Here we present for comparison two highly influential critical thinking frameworks (those of Ennis and Paul) and one that is more descriptive (by Halpern). Ennis and Halpern both include creative thinking skills in their treatment, but to a lesser extent than Lipman (see Appendix 2). Also in Appendix 2, Jewell (1996) accepts Lipman's 'three C's' framework of *critical*, *creative* and *caring* thinking, while Allen, Feezel and Kauffie (1967) are concerned only with argument analysis and informal logic. We also evaluate two overviews, those of Baron (1985) and Gubbins (1986).

3.4.1 Ennis's taxonomy of critical thinking dispositions and abilities

Description and intended use

Ennis's views have developed over time (he has been publishing in this area since 1962) and there have been significant changes in his thinking, particularly in the area of critical thinking dispositions (eg 1996). However, his basic definition has remained constant, worded as follows: 'Critical thinking is reasonable and reflective thinking that is focused on deciding what to believe or do' (1985, 45). His intention is to provide a rationale for the teaching of critical thinking and a taxonomy of 'goals for critical thinking' (1985, 46) or an 'outline of a conception of critical thinking' (1998, 17). He claims that the significant features of this taxonomy are as follows.

- It focuses on belief and action.
- It contains statements in terms of things that people actually do or should do.
- It includes criteria to help evaluate results.
- It includes both dispositions and abilities.
- It is organised in such a way that it can form the basis for a thinking-across-the-curriculum programme as well as a separate critical thinking course at the college level.

Although Ennis includes creative thinking in this definition, he considers that critical thinking is not equivalent to higher-order thinking, since critical thinking also involves dispositions. He proposes a set of six criteria for judging a set of critical thinking dispositions: *simplicity*, *comprehensiveness*, *value*, *comprehensibility*, *conformity of its language to our everyday meanings* and *the fitting of subordinates (if any) under superordinates*. He rejects a further criterion, mutual exclusivity, on the basis of comprehensibility (1996). He claims that in order to ensure that categories in a critical thinking taxonomy do not overlap, it becomes necessary to redefine words with such precision that they can no longer be easily understood.

The 1998 version of his taxonomy, which is summarised below, consists of three main dispositions (with sub-categories) and 15 abilities presented as a list (some with sub-categories) to provide a 'content outline' for a critical thinking curriculum. The original 1987 version contained a longer and more complex list of abilities and sub-categories. Ennis does not claim that either list is exhaustive.

Dispositions

Critical thinkers:

1
Care that their beliefs are true, and that their decisions are justified; that is care to *'get it right' to the extent possible, or at least care to do the best they can*. This includes the interrelated dispositions to do the following:

- seek alternatives (hypotheses, explanations, conclusions, plans, sources) and be open to them
- endorse a position to the extent that, but only to the extent that, it is justified by the information available
- be well informed
- seriously consider points of view other than their own.

2
Represent a position honestly and clearly (their own as well as others'). This includes the dispositions to do the following:

- be *clear* about the intended meaning of what is said, written, or otherwise communicated, *seeking as much precision as the situation requires*
- determine and maintain focus on the conclusion or question
- seek and offer *reasons*
- take into account the total situation
- be reflectively *aware of their own basic beliefs*.

3
Care about the dignity and worth of every person. This includes the disposition to:

- discover and listen to others' views and reasons
- take into account others' feelings and level of understanding, avoiding intimidating or confusing others with their critical thinking prowess
- *be concerned about others' welfare*.

Abilities

Ideal critical thinkers have the ability to:

clarify

1
identify the focus: the issue, question, or conclusion

2
analyse arguments

3
ask and answer questions of clarification and/or challenge

4
define terms and judge definitions and deal with equivocation.

judge the basis for a decision

5
judging the credibility of a source

6
observe and judge observation reports

infer

7
identify unstated assumptions

8
deduce and judge deductions

9
induce and judge inductions

- to generalisations
- to explanatory conclusions

10
make and judge value judgements.

make suppositions and integrate abilities

11
consider and reason without letting the disagreement or doubt interfere with their thinking (suppositional thinking)

12
integrate the other abilities and dispositions in making and defending a decision.

use auxiliary critical thinking abilities

13
proceed in an orderly manner appropriate to the situation; for example,

- follow up problem-solving steps
- monitor their own thinking
- employ a reasonable critical thinking checklist

14
be sensitive to the feelings, level of knowledge, and degree of sophistication of others

15
employ appropriate rhetorical strategies in discussion and presentation.

Evaluation: scope and structure

Ennis defines the basic areas of critical thinking as *clarity*, *basis*, *inference* and *interaction*, which he has then broken down into the list of abilities. He acknowledges the importance of the content domain in which critical thinking is applied. He acknowledges that his taxonomy does not incorporate suggestions for 'level, sequence and repetition in greater depth, emphasis or infusion in subject matter area, which might be either exclusive or overlapping'. He claims that the first two dispositions are 'essential' for critical thinking and that the third, sensitivity to others, is 'correlative' and desirable rather than 'constitutive' (1996, 171). The 'taxonomy' is therefore a list of dispositions and abilities relevant to critical thinking. Ennis does not include reflection as a major heading, despite its explicit role in his definition of critical thinking.

Evaluation: theory and values

The underpinning values of Ennis's work are those of rationality and logical thinking, with little attention paid to the impact of feelings on thinking. Although he acknowledges the importance of recognising and valuing others, application of his taxonomy requires a level of detachment. Ennis has been challenged by Martin (1992) on the potential creation of such a 'dangerous distance' required for critical thinking which does not accommodate affective motives and reasons. Ennis defends critical thinking against cultural bias (1998), though accepting that culture and context have serious implications for such an approach because of the difficulty of balancing competing cultural perspectives. He has also vigorously defended the concept of critical thinking dispositions against subject specificity [eg McPeck's (1992) concerns] and considers this objection from empirical, epistemological and logical perspectives.

Evaluation: communicability and practical relevance

Ennis aimed to produce a taxonomy which enables critical thinking to be used practically. He says that his taxonomy is 'simple and comprehensible' (1996, 173); and states that he considers that it can be implemented successfully in different ways, though he acknowledges that it needs further research to validate detailed aspects. As it stands, it should be particularly useful for analysing curriculum units in critical thinking or for auditing subject-specific critical thinking programmes. However, the number and relevance of the broad categories and their sub-categories to particular fields may make it somewhat daunting to apply. Its strength is its identification of a helpful framework for use in formulating particular educational goals, or, as Ennis states: 'In engaging in such thinking, one is helped by the employment of a set of critical thinking dispositions and abilities' (1998, 17).

Finally, as Ennis himself argues, the assessment of critical thinking is problematic. He analyses different approaches to assessing critical thinking, rejecting multiple-choice assessment for all but self-assessment and research. He also questions performance-based assessment on grounds of cost, focus and context (the more realistic the performance, the more complex the problem). Context-based assessments require information gathered over time and across a range of situations (Blatz 1992).

3.4.2 Halpern's reviews of critical thinking skills and dispositions

Description and intended use

Much of the material presented here first appeared in Halpern's influential book on critical thinking (1984), and was later developed into 'a taxonomy of critical thinking skills' (1994, 31). The taxonomy was intended to provide a basis for the national assessment of critical thinking skills in adults in the US. At a government-sponsored workshop held in 1992, Halpern referred to the thinking skills 'needed to compete in a global economy and in the exercise of citizenship' (1994, 29), but chose to focus on what is often referred to as 'higher-order thinking' – 'thinking that is reflective, sensitive to context and monitored'. She used the following category headings:

- verbal reasoning skills
- argument analysis skills
- skills in thinking as hypothesis testing
- using likelihood and uncertainty
- decision-making and problem-solving skills.

The 1992 workshop was set up in response to the following US national objective (National Education Goals Panel 1991, 237): 'The proportion of college graduates who demonstrate an advanced ability to think critically, communicate effectively, and solve problems will increase substantially.'

However, the workshop participants failed to agree on a single theoretical framework on which to base the proposed national assessment and the idea was eventually abandoned. Halpern subsequently revised her lists and presented them not as a taxonomy, but as a set of chapter reviews in her book *Critical thinking across the curriculum* (1997). This book, which closely follows the chapter structure of her 1984 volume on critical thinking, includes material on memory skills and on creative thinking as well as on the types of thinking included in her 1992 taxonomy.

Halpern (1997, 4) employs the following working definition of critical thinking as 'the use of cognitive skills or strategies that increase the probability of a desirable outcome … thinking that is purposeful, reasoned, and goal-directed …and effective for the particular context and type of thinking task'. This definition is so broad that it covers almost all thinking except basic arithmetical calculation and other automatised procedures. Halpern justifies her inclusion of memory skills by claiming (1997, 19) that 'All thinking skills are inextricably tied to the ability to remember.'

All the thinking skills described by Halpern in separate chapters of her book are listed in Table 4 (see page 30), together with some category descriptors from Halpern (1994). What is omitted are more detailed descriptions and examples of use, all of which were written for a general readership and for 'any course where critical thinking is valued' (1997, vii). Table 3 illustrates the level of detail provided throughout, using a single example taken from Halpern's review of decision-making skills.

As Halpern's overriding purpose is to have her readers *use* critical thinking skills, she provides a general-purpose framework to guide the thought process. This amounts to asking people to adopt a metacognitive approach in order to become more knowledgeable about their own thinking and to be better able to regulate it. The framework consists of four questions.

1
What is the goal?

2
What is known?

3
Which thinking skills will get you to your goal?

4
Have you reached your goal?

Recognising that it takes time and conscious effort to develop the attitude and skills of a critical thinker (to the point where the approach becomes habitual), Halpern recommends that teachers provide many opportunities to use critical thinking and that teachers and learners alike value the development of the following six critical thinking dispositions:

- willingness to plan
- flexibility (open-mindedness)
- persistence
- willingness to self-correct
- being mindful (metacognitive monitoring)
- consensus seeking.

Table 3
An example of one of the critical thinking skills specified by Halpern

Skill	Description	Example of use
Avoiding the entrapment bias	Entrapment occurs when a course of action requires additional investments beyond those already made	Shana decides to stick with her boyfriend who treats her badly because she has already invested several years in the relationship

Evaluation: scope and structure

As Halpern no longer claims that her reviews of critical thinking skills constitute a taxonomy, we cannot evaluate it as such. We have included it here because it can certainly be described as a framework and because Halpern's work is wide in scope and rich in detail. She also makes use of a superordinate guiding principle – metacognition.

When considered in relation to Marzano's classificatory framework (2001a, 2001b), Halpern's reviews address the cognitive and metacognitive systems. In particular, there is a close correspondence between some of Halpern's main categories and Marzano's *knowledge utilisation* categories. When compared with Bloom's taxonomy (1956), Halpern's reviews cover all aspects of the cognitive domain with the exception of *application*. This is not because the use of procedures is excluded from the skill areas she covers, but because of her emphasis on *critical* thinking which, unlike most routine application, is essentially metacognitive in nature. There is one sense, however, in which she is extremely interested in *application*, not as a separate category, but for its importance in all skill areas. Indeed, her main focus is on the conscious application of a 'plan–do–review' or 'plan-decide-act-monitor-evaluate' cycle to all thinking skills and orchestrated uses of skills.

Table 4
Halpern's categorisation of critical thinking skills

Memory skills

Skills that are needed when learning, during retention and at retrieval

- monitoring your attention
- developing an awareness of the influence of stereotypes and other beliefs on what we remember
- making abstract information meaningful as an aid to comprehension and recall
- using advance organisers to anticipate new information
- organising information so that it can be recalled more easily
- generating retrieval cues at both acquisition and retrieval
- monitoring how well you are learning
- using external memory aids
- employing keywords and images, rhymes, places, and first letters, as internal memory aids
- applying the cognitive interview techniques (Geiselman and Fisher 1985)
- developing an awareness of biases in memory

Thought and language skills

Skills that are needed to comprehend and defend against the persuasive techniques that are embedded in everyday language

- recognising and defending against the use of emotional and misleading language
- detecting misuse of definitions and reification
- understanding the use of framing with leading questions and negation to bias the reader
- using analogies appropriately
- employing questioning and paraphrase as a skill for the comprehension of text and oral language
- producing and using a graphic representation of information provided in prose form

Deductive reasoning skills

Skills used to determine if a conclusion is valid – ie it must be true if the premises are true

- discriminating between inductive and deductive reasoning
- identifying premises and conclusions
- reasoning with 'if, then' statements
- using linear ordering principles
- avoiding the fallacies of denying the antecedent and confirming the consequent
- using tree diagrams with branches and nodes to represent information

Argument analysis skills

Skills that are needed to judge how well reasons and evidence support a conclusion, including considering counter-evidence, stated and unstated assumptions, and the overall strength of the argument

- identifying premises (reasons), counter-arguments and conclusions
- making strong arguments that show good thinking and communication skills
- judging the credibility of an information source and judging the difference between expertise in factual matters and in value matters
- understanding the difference between opinion, reasoned judgement and fact
- recognising and avoiding common fallacies, such as straw person, appeals to ignorance, slippery slope, false dichotomy, guilt by association, and arguments against the person
- identifying psychological effects on reasoning
- remembering to consider what could be missing from an argument

Skills in thinking as hypothesis testing

The skills used in scientific reasoning – the accumulation of observations, formulation of beliefs or hypotheses, and then using the information collected to decide if it confirms or disproves the hypotheses

- recognising the need for, and using, operational definitions
- understanding the need to isolate and control variables in order to make strong causal claims
- checking for adequate sample size and possible bias in sampling when a generalisation is made
- being able to describe the relationship between any two variables as positive, negative, or unrelated
- understanding the limits of correlational reasoning

Likelihood and uncertainty critical thinking skills

The correct use of objective and subjective estimates of probability

- recognising regression to the mean
- understanding and avoiding conjunction errors
- using base rates to make predictions
- understanding the limits of extrapolation
- adjusting risk assessments to account for the cumulative nature of probabilistic events
- thinking intelligently about unknown risks

Decision-making skills

The skills involved in the generation and selection of alternatives and in judging among them

- framing a decision in several ways to consider different sorts of alternative
- generating alternatives
- evaluating the consequences of various alternatives
- recognising the bias in hindsight analysis
- using a decision-making worksheet
- avoiding the entrapment bias
- seeking disproving evidence
- awareness of the effects of memory on decisions

Problem-solving skills

Skills needed to identify and define a problem, state the goal and generate and evaluate solution paths

- restating the problem and the goal to consider different sorts of solution
- recognising the critical role of persistence
- using a quality representation of a problem (eg graphs, trees, matrices, and models)
- understanding world-view constraints
- selecting the best strategy for the type of problem
- actively seeking analogies

Skills for creative thinking

- redefine the problem and goal (in several different ways)
- find analogies (across different domains of knowledge)
- list relevant terms
- brainstorm (without censoring or evaluation)
- generate and use lists of ways in which a solution can vary
- list attributes
- list the positive, negative and interesting attributes of various solutions
- visualise from other perspectives

Halpern deals almost incidentally with the affective aspects of thinking, as illustrated by the cognitive emphasis in her treatment of creative thinking and from her rather limited list of critical thinking dispositions (compared with those proposed by Costa, Ennis, Paul or Perkins, Jay and Tishman 1993). She takes conative aspects more seriously, as can be seen from her use of the terms 'willingness' and 'persistence'.

The inclusion of memory as an area where critical thinking, in the form of self-knowledge and self-regulation, is important is worthy of comment, since it is ignored by many other theorists, despite being a well-established area of research in cognitive psychology.

Halpern does not claim to have provided comprehensive lists of critical thinking skills. It is possible to identify many gaps in her lists, some in relation to other work in the same area (eg Allen, Feezel and Kauffie's (1967) more detailed treatment of argument analysis skills), and even in relation to other lists provided by Halpern herself in the same chapter [eg 'seeking converging validity to increase your confidence in a decision' and 'considering the relative "badness" of different sorts of errors', (1997, 158)]. There are also some examples of skills included in the 1992 taxonomy, but not appearing explicitly in the 1997 reviews [eg 'solving problems with proportional and combinatorial (systematic combinations) reasoning' (1994, 34)]. Moreover, as the 'plan–do–review' feature of critical thinking is presented as an overarching principle, these types of skill are in many cases missing from each of the review sections. This is especially true of her treatment of problem solving.

It is not surprising that there is a considerable amount of overlap between sections, since complex sets of skills are being described. For example, decisions are often taken in the course of problem solving or creative thinking, and deductive and inductive reasoning as well as the use of analogy can be valuable in many types of thinking.

One point of difference between Halpern's 1992 taxonomy and her 1997 reviews is that in the earlier version, deductive reasoning was not separated from argument analysis skills. At first sight, the separate treatment given to deduction seems inconsistent with Halpern's general exclusion of mechanical procedural applications (such as the rules of formal logic and the analysis of syllogisms). To some extent it is, but in her book (1997), Halpern considers the psychological factors which militate against human beings being as logical as computers, and the need to guard critically against psychologically-induced distortions.

Overall, Halpern provides a detailed, but not comprehensive account of thinking skills within the cognitive domain. She asks the reader to apply a superordinate organising principle – metacognition – in order to develop an effective critical thinking approach. This is virtually equivalent to defining critical thinking as 'mindful thinking'.

Evaluation: theory and values

Halpern is a strong believer in the application of rational methods in problem solving, including the use of controlled experiments. She points to the need for people to learn how to learn and to be critically selective in responding to the barrage of information (including advertisements and political rhetoric) around them (1997). She argues that teaching and assessing critical thinking will improve the quality of teaching and learning at college level and will increase social capital and economic competitiveness (1994). These are pragmatic arguments, in support of which she cites a number of studies to illustrate the transferability of critical thinking skills.

More than any author whose work we have reviewed, Halpern has succeeded in her intention to translate theory and research from cognitive psychology into a form where it can be useful in everyday life and, more importantly, can help people to cope responsibly with the important decisions on which the future of the world depends. In doing so, she has also drawn on relevant sources outside psychology, citing, for example, the work of Polya (1945) on problem solving, Norris and Ennis (1989) on the assessment of arguments and de Bono (1976) on creative thinking.

Evaluation: communicability and practical relevance

The communicability of Halpern's writing about critical thinking is demonstrated by the fact that there have been four further versions of her book *Thought and knowledge* since 1984. She writes in an accessible style for a student audience as well as for a more general adult readership, and makes use of many engaging real-life illustrations to explain concepts and develop arguments. She has also produced up-to-date teaching material to accompany the main text (2002).

Halpern explicitly designed a wide range of problems and exercises to maximise transfer across subject boundaries and from academic to other settings. Materials of this kind can be included in free-standing modules or can be built into subject teaching for post-16 learners. For example, Halpern's 'skills in thinking as hypothesis testing' category includes content traditionally taught in research methods courses in a range of disciplines. This could be taught within a particular discipline, on an interdisciplinary basis, or as part of a free-standing module on critical thinking.

3.4.3
Paul's model of critical thinking

Description and intended use

Richard Paul is a passionate reformer who sees educational transformation as the key to solving social and economic problems. He is part of a philosophical movement that calls for the engagement of each individual in thinking about their beliefs and a change in teaching methods to make this possible. Paul (1989, 15) views lecture-orientated, didactic and drill-based models of instruction as instrumental in producing 'students who do not learn how to work by or think for themselves'. Apart from his work with educators, he has provided critical-thinking seminars for business executives, theologians, doctors, nurses and other professionals.

Paul's (1993, 33) definition of critical thinking gives an insight into his philosophy of education.

Critical thinking is disciplined self-directed thinking which exemplifies the perfections of thinking appropriate to a particular mode or domain of thinking. It comes in two forms. If the thinking is disciplined to serve the interests of a particular individual or group, to the exclusion of other relevant persons and groups, I call it sophistic or weak sense critical thinking. If the thinking is disciplined to take into account the interests of diverse people or groups, I call it fair-minded *or* strong sense *critical thinking. In thinking critically, we use our command of the* elements of thinking *to adjust our thinking successfully to the logical demands of a type or mode of thinking. As we come to habitually think critically in the strong sense we develop* special traits of mind*: intellectual humility, intellectual courage, intellectual perseverance, intellectual integrity, and confidence in reason. A sophistic or weak sense critical thinker develops these traits only in a restricted way, consistent with egocentric and sociocentric commitments.*

Paul's model of critical thinking has evolved over a number of years and remains a work in progress. It is illustrated in Figure 4, which includes Paul's original 35 elements of critical thought, which have subsequently been renamed 'a strategy list for redesigning lessons'. The original 35 elements contained nine affective strategies which Paul called 'the traits of a disciplined mind'. These traits have been retained in Paul's most recent model of critical thinking (1993) under the heading of 'intellectual traits'. The micro skills and macro abilities no longer feature in the latest critical thinking model.

The current model has four parts: *elements of reasoning* (sometimes referred to as elements of thought), *standards of critical thinking*, *intellectual abilities* and *intellectual traits*. The first three categories focus on what is essential to critical *thinking*, while the last dimension focuses on what it is to be a critical *thinker*.

Elements of reasoning

This is what Paul refers to as the 'parts' of thinking or *the fundamental structures of human thought*. He maintains that these eight elements are always present in human thinking and that the ability to recognise these elements of reasoning is essential to critical thinking. Paul and Elder (2001, 53) attempt to condense this interrelated set of eight elements in the following statement:

Whenever you are reasoning, you are trying to accomplish some purpose*, within a* point of view*, using* concepts *or ideas. You are focused on some* question*,* issue *or* problem*, using* information *to come to* conclusions*, based on* assumptions*, all of which has* implications*.*

Standards of critical thinking

The standards in Paul's model are an attempt to identify what constitutes the *quality* component of critical thinking. Unlike the *elements of reasoning* which Paul claims to be universal, the list of standards seeks to encompass those that are the most fundamental. In order to learn to reason well, it is necessary to gain mastery of both the *elements of reasoning* and the *standards of critical thinking* described in Figure 4.

Intellectual abilities

According to Paul, an ability is composed of a process, plus an object, plus a standard. Someone can have the *ability* to drive (process) a truck (object) safely (standard). Nosich (2000) proposes that an *intellectual ability* would be the ability, for instance, to identify (process) a conclusion (object) accurately (standard). In Paul's model, *abilities* (higher-order thinking skills) rest on a prior understanding of the elements and standards of critical thinking.

Intellectual traits

The final dimension of Paul's model focuses on what it is to *be* a critical thinker. He has identified a number of affective traits that he considers to be essential to 'strong sense' critical thinking. These are not things a person does, but describe how a person is or can be. These 'traits of a disciplined mind' (see below) are what Paul calls the affective and moral dimensions of critical thinking. Paul (1991) claims that there are many ways in which teachers can foster these traits of mind. To do this successfully, he advocates a complete re-conceptualisation of the nature of teaching and learning in every context of school life, involving a move from a didactic to a critical theory of education.

Intellectual humility
Having a consciousness of the limits of one's knowledge, including a sensitivity to circumstances in which one's native egocentricity is likely to function self-deceptively; sensitivity to bias, prejudice and limitations of one's viewpoint. Intellectual humility depends on recognising that one should not claim more than one actually knows. It does not imply spinelessness or submissiveness. It implies the lack of intellectual pretentiousness, boastfulness, or conceit, combined with insight into the logical foundations, or lack of such foundations, of one's beliefs.

Intellectual courage
Having a consciousness of the need to face and fairly address ideas, beliefs or viewpoints towards which we have strong negative emotions and to which we have not given a serious hearing. This courage is connected with the recognition that ideas considered dangerous or absurd are sometimes rationally justified (in whole or in part) and that conclusions and beliefs inculcated in us are sometimes false or misleading. To determine for ourselves which is which, we must not passively and uncritically 'accept' what we have 'learned'. Intellectual courage comes into play here, because inevitably we will come to see some truth in some ideas considered dangerous and absurd, and distortion or falsity in some ideas strongly held in our social group. We need courage to be true to our own thinking in such circumstances. The penalties for non-conformity can be severe.

Intellectual empathy
Having a consciousness of the need to imaginatively put oneself in the place of others in order to genuinely understand them, which requires the consciousness of our egocentric tendency to identify truth with our immediate perceptions of long-standing thought or belief. This trait correlates with the ability to reconstruct accurately the viewpoints and reasoning of others and to reason from premises, assumptions, and ideas other than our own. This trait also correlates with the willingness to remember occasions when we were wrong in the past despite an intense conviction that we were right, and with the ability to imagine our being similarly deceived in a case at hand.

Intellectual integrity
Recognition of the need to be true to one's own thinking; to be consistent in the intellectual standards one applies; to hold one's self to the same rigorous standards of evidence and proof to which one holds one's antagonists; to practise what one advocates for others; and to honestly admit discrepancies and inconsistencies in one's own thought and action.

Intellectual perseverance
Having a consciousness of the need to use intellectual insights and truths in spite of difficulties, obstacles, and frustrations; firm adherence to rational principles despite the irrational opposition of others; a sense of the need to struggle with confusion and unsettled questions over an extended period of time to achieve deeper understanding or insight.

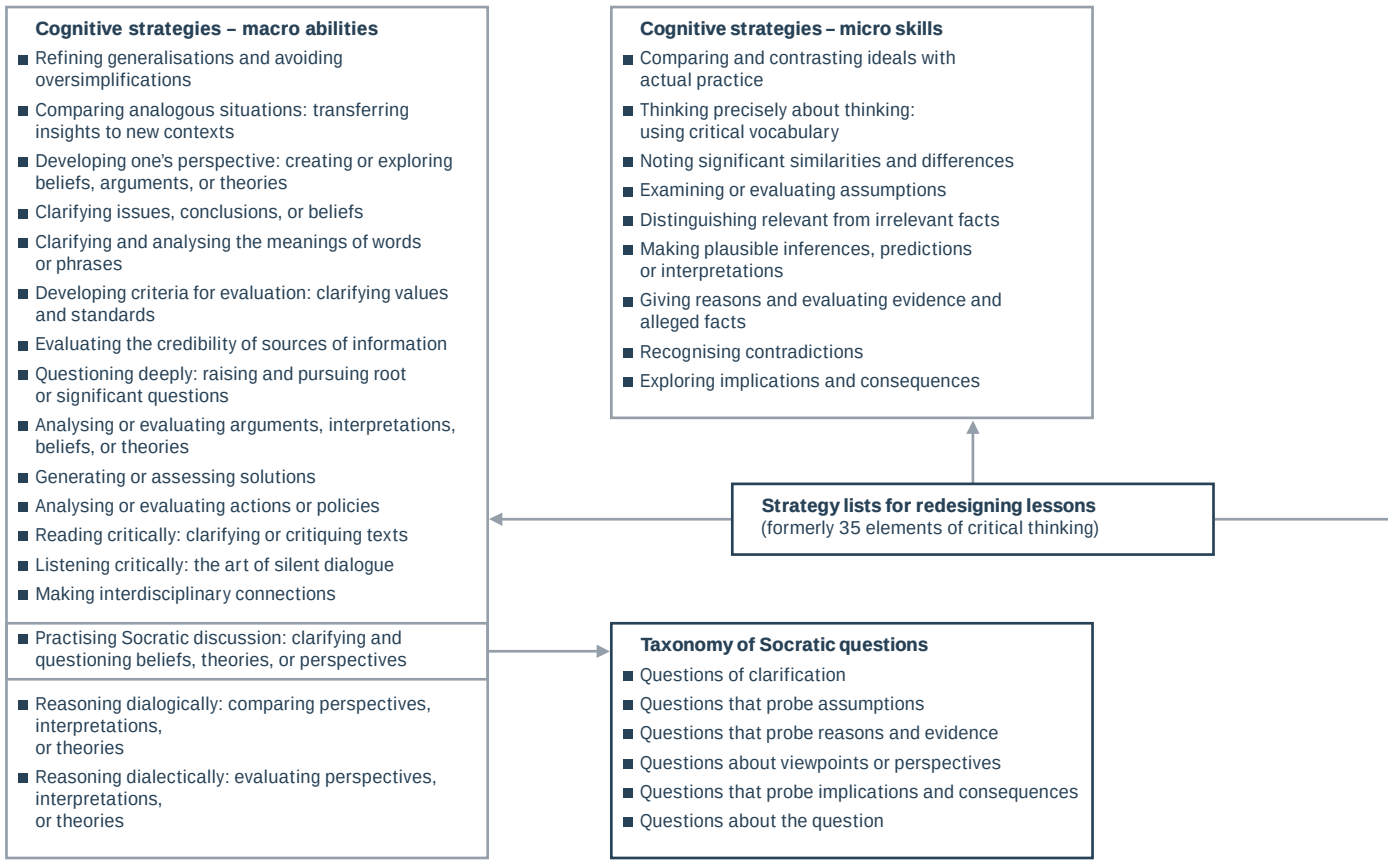
Faith in reason
Confidence that, in the long run, one's own higher interests and those of humankind at large will be best served by giving the freest play to reason, by encouraging people to come to their own conclusions by developing their own rational faculties; faith that, with proper encouragement and cultivation, people can learn to think for themselves, to form rational viewpoints, draw reasonable conclusions, think coherently and logically, persuade each other by reason and become reasonable persons, despite the deep-seated obstacles in the native character of the human mind and in society as we know it.

Fairmindedness
Having a consciousness of the need to treat all viewpoints alike, without reference to one's own feelings or vested interests, or the feelings or vested interests of one's friends, community or nation; implies adherence to intellectual standards without reference to one's own advantage or the advantage of one's group.

Elder and Paul (1998, 34)

Paul presents the traits of the disciplined mind as ideals to strive towards. He outlines six stages of critical thinking, moving from the unreflective thinker to the master thinker. Master thinkers are: conscious of the working of their mind, highly integrated, mentally powerful, logical, far-sighted, deep, self-correcting and mentally free. According to Paul, master thinkers will only emerge when society begins to value and reward these qualities of thinking. Given the extent of deep social conditioning, he believes it unlikely that anyone currently meets his definition of master thinker.

Figure 4
Paul's model
of critical thinking



Affective strategies

- Thinking independently
- Developing insight into egocentricity or sociocentricity
- Exercising fair-mindedness
- Exploring thoughts underlying feelings and feelings underlying thoughts
- Developing intellectual humility and suspending judgement
- Developing intellectual courage
- Developing intellectual good faith or integrity
- Developing intellectual perseverance
- Developing confidence in reason

1
Elements of reasoning

- To be clear about the problem or the question at hand
- To be clear about the goal or purpose
- To be clear about the point of view or frame of reference
- To be clear about assumptions
- To be clear about the claims we are making
- To be clear about the reasons or evidence upon which we base our claims
- To be clear about our inferences and line of reasoning
- To be clear about the implications and consequences that follow from our reasoning

2
Standards of critical thinking

- Clarity
- Precision
- Specificity
- Accuracy
- Relevance
- Consistency
- Logical
- Depth
- Completeness
- Significance
- Adequacy (for purpose)
- Fairness

3
Intellectual abilities

Composed of a process, object and a standard, eg drive a truck safely = drive (process) truck (object) safely (standard)

Essential to critical thinking

4
Intellectual traits

Affective traits as described in 'Traits of the disciplined mind'

Essential to what it is to *be* a critical thinker

Evaluation: scope and structure

Paul's model of critical thinking takes account of cognitive, affective and conative components. He is aware of the importance of being sensitive to the circumstances in which thinking occurs. His lists of abilities and traits do not have any significant omissions when compared with those of Ennis and Perkins, Jay and Tishman (1993). Although Paul does not use the term 'metacognition', his account of intellectual integrity does recognise it, as it stresses applying the same standards to one's own thinking as one does to other people's.

Nosich (2000) believes that it is because Paul's model of critical thinking is concept-based (as opposed to having rules, procedures or steps to follow), that it is effective in curriculum development. The model is extremely flexible, applicable to any subject matter and to any level of thinking. Nosich uses Paul's concept of evidence to illustrate his point. Asking a student to 'identify the evidence a conclusion is based upon' is a critical thinking step. The ability to do it well is a higher-order thinking skill, but is limited in that there are many other things students should be able to do with evidence; for example:

- evaluate the evidence
- clarify the evidence
- realise the need for more evidence
- contrast one account of the evidence with another account
- see how the evidence arises out of certain background assumptions
- understand the nuances of the evidence
- ask how this evidence in this case fits in with the actual observations.

This list, which is by no means exhaustive, gives an insight into what Paul means by his concept of evidence. The goal is to make the concept of evidence an essential part of all thinking processes. Nosich (2000) believes that the ability to think in terms of the concept of evidence allows one to think about evidence in a range of settings, at any level of expertise and to gain further insight into the concept of evidence.

Nosich maintains that Paul's standards of critical thinking also function as concepts. We are once again asked to consider the skill 'identify the evidence a conclusion is based upon'. Nosich claims that implicit in the skill is using the standards of accuracy, clarity, adequacy and relevance. When one adopts these concepts in relation to the concept of evidence, there is an increased ability to think in terms of the standards across the other elements of reasoning.

Evaluation: theory and values

Thayer-Bacon (1998) notes that until recently, critical thinking, with its valuing of reason over other qualities, has had few detractors in the literature. She claims (1998, 125):

This valuing of reason over other tools is not new with current critical thinking philosophers, it reflects a Euro-western cultural bias that can be traced all the way back to ancient Greece. The valuing of reasoning over all other abilities is also a gender bias, as reasoning (the ability to think logically) has been considered predominantly a male ability in the Euro-western world, while intuition, imagination, and emotional feelings have been associated with women's abilities.

Paul is one of a number of philosophers whom Thayer-Bacon criticises for their belief in rational thought as the dominant mode of thinking within a critical thinking framework. It is evident from Paul's definition of critical thinking and his other work, including the development of a taxonomy of Socratic questioning, that he sits firmly in the rationalist camp. For Paul, the spirit of critical thinking is to have the confidence in one's ability to figure out the logic of anything. He acknowledges that there have been criticisms of critical thinking for being too Western in its orientation, not dealing with creativity, ignoring the role of emotion in thought and failing to address feminist or sociological insights. However, he claims that previous attempts to widen the scope of critical thinking to accommodate these concerns meant sacrificing some of the rigour and exactitude found in formal and informal logic courses. Paul proposes that his philosophy is a response to the problems inherent in the critical thinking courses initiated in the 1970s with their emphasis on pure logic, and to subsequent criticisms of these courses as outlined above.

Paul's major contribution to the area of critical thinking would appear to be his ideas of 'weak' versus 'strong sense' thinking. The latter is what Paul refers to as the ability to discover and contest one's own egocentric and socio-centric habits of thought. Paul (1991, 77) claims that these nine traits of thought, which are moral commitments and intellectual virtues, transfer thinking from 'a selfish, narrow-minded foundation to a broad open-minded foundation'.

Evaluation: communicability and practical relevance

The clear language and writing style are commendable in Paul's work. It is unlikely that his writing would prove a barrier to anyone with an interest in critical thinking. Practitioners teaching courses in critical thinking may find Paul's work inspirational, given its emphasis on 'strong sense' thinking.

Paul will find less resonance with those teachers not involved with critical thinking courses. While Paul offers some teaching strategies to support the development of pupils' thinking, his aim is not to tinker with classroom practice by proposing thinking skills programmes. His goal is a reworking of education, a move from a didactic to a critical theory of education, one where students construct knowledge through the application of their own logic rather than through teacher transmission. He calls for a re-evaluation of what is judged important in both education and society.

3.5 Evaluation of cognitive structure and/or development frameworks

King and Kitchener (1994) make epistemological (theory of knowledge) claims about how the nature of knowledge changes as people progress through their stages, while Pintrich provides a theoretical framework for understanding self-regulation. In Appendix 2, we present brief evaluative summaries of three models of intelligence – those of Guilford (1958), Gardner (1983) and Carroll (1993); together with three developmental frameworks – those of Perry (1970), Belenky *et al*. (1986) and Koplowitz (1987).

3.5.1 King and Kitchener's model of reflective judgement

Description and intended use

King and Kitchener propose a seven-stage model of reflective judgement in their book *Reflective judgment: understanding and promoting intellectual growth and critical thinking in adolescents and adults* (1994). The model is aimed at those who work in the area of critical thinking at college level, particularly in regard to its development and assessment, though the authors also indicate that it should be of value for use in schools and in other adult learning contexts. The model is based on Dewey's (1933, 1938) conception of reflective thinking and the epistemological issues resulting from attempts to resolve 'ill-structured problems'. It draws on other work, such as Fischer's (1980) skill theory and is related to the work of Perry (1970) and Baron (1985). It is summarised in Table 5 opposite.

Table 5
King and Kitchener's seven-stage model

Stage 1	Knowing is limited to single concrete observations: what a person observes is true. Discrepancies are not noticed	**Pre-reflective thought**
Stage 2	Two categories for knowing: right answers and wrong answers. Good authorities have knowledge; bad authorities lack knowledge. Differences can be resolved by more complete information	
Stage 3	In some areas, knowledge is certain and authorities have knowledge. In other areas, knowledge is temporarily uncertain; only personal beliefs can be known	
Stage 4	The concept that knowledge is unknown in several specific cases can lead to the abstract generalisation that knowledge is uncertain. Knowledge and justification are poorly differentiated	**Quasi-reflective thought**
Stage 5	Knowledge is uncertain and must be understood within a context; thus justification is context-specific. Knowledge is limited by the perspective of the person who knows	
Stage 6	Knowledge is uncertain, but constructed by comparing evidence and opinion on different sides of an issue or across contexts	**Reflective thought**
Stage 7	Knowledge is the outcome of a process of reasonable enquiry. This principle is equivalent to a general principle across domains. Knowledge is provisional	

Evaluation: scope and structure

King and Kitchener (1994) distinguish reflective judgement from logical, verbal and moral reasoning. Their model is based on 15 years of theory building and empirical research into the development of reflective judgement in late adolescence and middle adulthood. It shows further development from their original study of reflective judgement (Kitchener and King 1981). On the basis of more than 30 studies, they claim – we believe fairly – that the model is complex, inclusive and integrated, with qualitative differences that are stable across domains observable in reasoning about knowledge.

Hofer and Pintrich (1997) have pointed to structural similarities between King and Kitchener's model, Perry's account (1968, 1970) of intellectual and ethical development and the work of Belenky *et al*. (1986) on 'women's ways of knowing'. King and Kitchener's concept of stages is heavily influenced by Piaget's genetic epistemology and is also not unlike the model on which Biggs and Collis (1982) base their SOLO taxonomy.

There are two related issues which King and Kitchener do not fully address. The first is the extent to which reflective judgement, as assessed by being asked to solve a set of ill-structured problems, relates to thinking and performance in other fields – personal and professional. The second issue is a concern about whether the 'stage theory' is genuinely about broad epistemological assumptions and beliefs; or whether, in a series of reflective judgement interviews, respondents learn to provide more sophisticated answers to a specific set of increasingly familiar questions.

Evaluation: theory and values

The model identifies a progression of seven distinct sets of judgements about knowledge and how knowledge is acquired. Each set has its own logical coherence and is called a stage, with each successive stage 'posited to represent a more complex and effective form of justification, providing more inclusive and better integrated assumptions for evaluating and defending a point of view' (King and Kitchener 1994, 13). Individuals pass through these stages in the order specified, though they may operate across a range of stages at any point in time. This still leaves questions about how individuals progress through the stages and about the relationship between maturation, education and culture.

King and Kitchener have studied the relationship between reflective judgement and moral reasoning. While they endorse the view that the college experience should provide an education in character development, they see progress through the seven stages of development in reflective judgement as furnishing necessary, but not sufficient, conditions for corresponding progress in moral reasoning.

The model of reflective judgement is a coherent, well-argued and extensively researched account of the development of epistemological reasoning, though there are some issues that remain unresolved. The authors acknowledge limitations in their sample selection, which may not make it representative of a larger population outside US mid-western high-school and college students. Also, the epistemological assumptions in the final level of 'reflective thought' in stages 6 and 7 may be less prevalent in some cultures (Bidell and Fischer 1992).

There is evidence from other sources that assumptions about knowledge do alter according to the subject context (eg Schoenfeld 1992). This suggests that the confidence of the authors that students' scores on subject-based problems are almost identical to standard reflective judgement interview scores may need further investigation across disciplines.

Evaluation: communicability and practical relevance

Chapter 9 of King and Kitchener's book contains explicit recommendations for teaching, using the reflective judgement model as a 'heuristic tool' to help teachers and other educators to develop courses or activities to help learners to think more reflectively and make more reasoned judgements. The basis for using the model is set out in a series of assumptions, supporting activities to develop personal relevance and a detailed breakdown of each of the stages 2–7 with characteristics, instructional goals, difficult tasks, sample activities or assignments and developmental support. These are sufficiently clear and detailed to be applicable to educational practice in a range of settings. The main challenge in using the model is how to develop a clear understanding of each of the seven stages and how to recognise learners' behaviours at each stage.

3.5.2 Pintrich's general framework for self-regulated learning

Description and intended use

Pintrich (2000) defines self-regulated learning (SRL) as '…an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate and control their cognition, motivation and behaviour, guided and constrained by their goals and the contextual features in the environment.' Table 6 opposite, reproduced from Pintrich's chapter, displays a framework for classifying the different phases of, and areas for, regulation. It can be seen that he differentiates between four domains, *cognition*, *motivation*, *behaviour* and *context*.

Table 6
Phases and areas for self-regulated learning

	Areas for regulation			
Phases	**Cognition**	**Motivation/affect**	**Behaviour**	**Context**
1 Forethought, planning and activation	Target goal setting Prior content knowledge activation Metacognitive knowledge activation	Goal orientation adoption Efficacy judgements Ease of learning judgements; perceptions of task difficulty Task value activation Interest activation	Time and effort planning Planning for self-observations of behaviour	Perceptions of task Perceptions of context
2 Monitoring	Metacognitive awareness and monitoring of cognition	Awareness and monitoring of motivation and affect	Awareness and monitoring of effort, time use, need for help Self-observation of behaviour	Monitoring and changing task and context conditions
3 Control	Selection and adaptation of cognitive strategies for learning, thinking	Selection and adaptation of strategies for managing motivation and affect	Increase/decrease effort Persist, give up Help-seeking behaviour	Change or renegotiate task Change or leave context
4 Reaction and reflection	Cognitive judgements Attributions	Affective reactions Attributions	Choice behaviour	Evaluation of task Evaluation of context

Regulation of cognition

Although cognitive skills are clearly central to thinking skills, they also play a part in the regulation of motivation, affect, behaviour and context.

Cognitive planning and activation

The framework proposes three general types of planning or activation.

- *Target goal setting*: once task-specific goals have been identified, they can then be used to guide cognition and monitoring processes. These goals may need to be adjusted or changed during task performance as part of the monitoring, control and reflection processes.
- *Prior content knowledge activation*: refers to when learners actively search their memory for relevant prior knowledge (both content and metacognitive) before performing the task.
- *Metacognitive knowledge activation*: metacognitive task knowledge concerns understandings about the influence of different types and forms of task upon cognitive demands (eg the more information that is provided, the easier the task becomes). Knowledge of strategy variables concerns those procedures that might help with cognitive processes such as memorising and reasoning. As with prior content knowledge, this activation can be automatic, can be prompted by particular features of a given task or context, or can be employed in a more controlled and conscious fashion.

Cognitive monitoring

This involves both being aware of and monitoring one's cognition, so it closely resembles what has traditionally been understood by the term 'metacognition'. Pintrich contrasts *metacognitive knowledge*, a relatively static element that one can claim either to have or to lack, with *metacognitive judgements and monitoring*, which tend to be more dynamic and relate to processes that occur as one undertakes a given task.

Pintrich highlights two important types of monitoring activity: *judgements of learning* which refer to gauging personal success at learning something and *feeling of knowing* (eg when one feels one knows something but cannot quite recall it – the 'tip of the tongue' phenomenon).

Cognitive control and regulation

This refers to the cognitive and metacognitive activities that individuals engage in to adapt and change their cognition. These are closely tied to monitoring and involve the selection and use of various cognitive strategies for memory, learning, reasoning, problem solving and thinking. Specific techniques include the use of visual imagery, mnemonics, advanced organisers, and specialised methods of note taking. Located within this cell are the strategies that learners employ to help them with their learning, though, as Pintrich indicates, these can be both cognitive and metacognitive.

Cognitive reaction and reflection

These processes are concerned with personal reflection on performance and involve both evaluation and attribution. According to Zimmerman (1998), evaluating one's performance is a characteristic of superior self-regulation. Similarly, 'good' self-regulators are more likely to make attributions for performance outcomes that emphasise the influence of the learner's efforts and strategies (internal and controllable), rather than features beyond the learner's control, such as a lack of ability.

Regulation of motivation and affect

While there has been much research examining awareness and control of cognition (metacognition), there has been much less work concerning similar processes with respect to motivation.

Motivational planning and activation

Bandura's work on self-efficacy (1997) has highlighted the way an individual's beliefs about likely success in undertaking a particular task will influence the effort subsequently employed. Other factors highlighted in the motivation literature, such as the value of the task to the learner, personal interest in the task or content domain, and fear of failure, can all be made susceptible to student regulation and control in ways that can improve the quality of the learning.

Motivational monitoring

While the literature in this domain is more sparse than that for metacognitive awareness and monitoring, it is reasonable to assume that to engage effectively in the control and regulation of efficacy, value, interest and anxiety, students need first to be consciously aware of their beliefs and feelings and to monitor them. Approaches that have been employed in the scientific literature include attempts to make explicit, and subsequently change, students' maladaptive self-efficacy and attributional beliefs. Other studies have sought to reduce student anxiety by increasing coping skills or by showing how one may change aversive environmental conditions.

Motivational control and regulation

Pintrich lists several methods that students can employ to heighten their motivation. These include increasing your sense of self-efficacy (eg telling yourself that you can succeed in the task), promising yourself extrinsic reinforcers (eg going to the pub once the assignment has been completed) or attempting to heighten intrinsic motivation by restructuring the task to make it more interesting. Other strategies involve overcoming the tendency to avoid working hard because of a concern that poor performance may suggest a lack of natural ability, a phenomenon known as self-worth protection (Covington 1992).

Motivational reaction and reflection

Drawing on attribution theory (Weiner 1986), Pintrich suggests that individuals will try to understand the reasons for success or failure by attributing the outcome to such factors as skill, luck and effort. A belief that failure occurred through lack of natural ability is likely to undermine a student's motivation. Attribution retraining, therefore, generally tries to help the student to see learning as something that he/she can achieve and control by working hard and using effective strategies. Pintrich argues that changing attributions for life events will lead to new beliefs that will have a bearing on new tasks at the planning phase.

Regulation of behaviour

Behavioural forethought, planning and action

Pintrich recognises that planning one's behaviour in a purposive manner is essentially a cognitive function. However, he considers it reasonable to locate student attempts to plan their behaviour in an intentional fashion within the column dealing with behavioural regulation. Strategies for learners may include various time-management activities (eg planning an examination revision schedule or deciding when to tackle homework) and self-observation and monitoring (eg recording how many new French vocabulary words are learned each week, or how many pages of a new novel are read). Such information may result in further planning and action.

Behavioural monitoring and awareness

This involves relating the monitoring of behaviour and effort levels in the light of progress made. A student may, for example, plan to work at French course assignments on two evenings each week, but may find that this is insufficient and that additional time or greater effort is required.

Behavioural control and regulation

Here Pintrich refers to the learner's actual control and regulation of behaviour; for example, applying persistence and effort. It is important to know when, and from whom, to seek help. The skilled learner does not wish to become overly dependent on others, but does obtain assistance in dealing with particularly difficult problems.

Behavioural reaction and reflection

This concerns student evaluations of the effectiveness of their current behaviour (eg that studying in 4-hour blocks is not the best use of time, or that putting off homework to the last minute often results in poor marks). Students may react by changing their time management, level of effort or, indeed, the course they are following.

Regulation of context

Contextual forethought, planning and activation

This concerns the individual's perception of task and context. Students may, for example, have different ideas about collaborative learning, the type of answer expected, or about classroom climate. Pintrich points out that perceptions may not be highly accurate, yet these may still have a major influence.

Contextual monitoring

Often students experience difficulty when moving from school to college or university because they fail to grasp fully the different requirements of adult learning, and thus do not adjust their learning strategies or general behaviour. Examining and monitoring contextual factors that may have bearing upon achievement is therefore also important, particularly as such rules, routines and criteria are rarely made explicit.

Contextual control and regulation

Adult learning provides greater opportunities to control and regulate classroom environments, although less confident students often prefer to retain a more passive role. Outside the lecture hall or workshop, students need to take responsibility for regulating their study environment to facilitate their learning (eg removing distractions and having an organised study space).

Contextual reaction and reflection

This involves the student in evaluating aspects of the task or classroom environment. Evaluations may concern feelings about engaging in the activities concerned, or be more focused upon aspects of the student's learning and achievement. As with cognition and motivation, such evaluations can have an important influence upon the student's approach to new tasks (at phase 1 –forethought, planning and activation).

Evaluation: scope and structure

Pintrich's synthesis of current SRL theories and approaches covers cognition, affect, conation and behaviour, as well as contextual factors. He successfully synthesises the work of leading theorists, notably Boekaerts and Niemivirta (2000), Butler and Winne (1995), Corno (1993), Pintrich and De Groot (1990), Pintrich, Wolters and Baxter (2000), Pressley (1986), Schunk (1994), Schunk and Zimmerman (1994), Winne (1995) and Zimmerman (2000).

As a synthesis of current theorising, his framework differs from other leading theorists such as Boekaerts (1997) whose model is divided into cognitive and motivational self-regulation; and Zimmerman (2000) whose triadic model emphasises personal self-regulation (which involves monitoring and regulating one's thoughts and feelings to aid performance), behavioural self-regulation (where one observes and modifies one's performance), and environmental self-regulation (which involves gauging and altering one's current environment). In addressing the comprehensiveness of his framework, Pintrich points out that not all academic learning falls within the four phases outlined, as there are many occasions when students learn implicitly or unintentionally, rather than in a focused, self-regulatory fashion. The phases are presented as a heuristic device to organise thinking and research on SRL. They can also be seen as an organising 'plan–do–review' principle for classifying the thinking skills involved in SRL.

It is also important to recognise that the four phases are not necessarily passed through in a linear sequence, and often phases may operate simultaneously. Indeed, Pintrich argues that recent research provides little evidence that monitoring (Phase 2) and control (Phase 3) are separate in people's experiences. The appropriateness of the fourth column, *context*, might seem questionable to some, as in many conceptions, self-regulation refers only to aspects of the self that are being controlled or regulated. In line with Zimmerman (2000), however, Pintrich's model is based upon a belief that one's attempts to monitor and control the environment are an important aspect of SRL. Perhaps the most valuable part of Pintrich's framework, for those with a good knowledge of the field, is his discussion of motivational factors – an area where he is a leading theorist.

Evaluation: theory and values

Pintrich's framework draws extensively on leading-edge psychological research about SRL, a field in which he has a substantial reputation. His own contribution draws heavily upon goal theory (where he is a major contributor). As an empirical researcher, he will look for accumulating evidence from well-controlled studies and field trials about the benefits for learners of pedagogical initiatives designed to encourage self-regulation and independent learning.

Evaluation: communicability and practical relevance

Pintrich's main focus is essentially academic: theory building and empirical research. His classificatory framework is a useful introduction to self-regulation and is helpful for those who wish to examine similarities and differences between different theoretical models. Pintrich also hopes that his formulation will draw attention to areas which are currently under-researched and may require further investigation. While there are likely to be important implications for practitioners, he tends to leave the detailed articulation of these to others. For practitioners, each of the various cells (see Table 6) may need to be fleshed out in greater detail through reference to other publications.

Section 4

Making sense of thinking and learning

4.1 Introductory outline

As we have seen, there have been several attempts to produce an integrated framework for understanding thinking and learning. Those we called 'all embracing' have variously taken into account cognitive, affective and conative aspects of thinking. Whether explicitly or implicitly, they also include metacognition as an important feature. Here we look at the entire range of principles used to establish categories in the 35 frameworks we have evaluated, and comment on how they are used within each of the four family groups. We then identify a set of core features and use them to develop a new integrated framework suitable for post-16 applications, using clear and simple English. We also commend three frameworks which best represent the field as a whole and which are compatible with our integrated framework. (Later, in Section 5.3, we make recommendations about using a number of other frameworks for specific purposes.)

4.2 How are thinking skills classified?

Altogether, we identified a total of 15 different kinds of principle that were used in the frameworks we evaluated to classify thinking and/or its outcomes. As can be seen from the evaluative summaries in Appendix 2, most frameworks are structured by only two or three principles and none by a comprehensive set. We list the principles used in all 35 frameworks under four main headings as follows:

- domain
  - area of experience
  - subject area
- content
  - types of objective
  - types of product (including knowledge products)
- process
  - steps/phases in a sequence or cycle
  - complexity
  - level in a hierarchy
  - type of thinking or learning
  - quality of thought/action
- psychological aspects
  - stage of development
  - structural features of cognition
  - strength of dispositions
  - internalisation of learning
  - orchestration and control of thinking
  - level of consciousness.

It was no surprise to find that the most comprehensive frameworks (according to the number and range of principles they embody) are members of the all-embracing and instructional design families. We found eight frameworks which are based on a selection of principles from each of the generic categories: *domain*, *content*, *process* and *psychological* aspects. Four of these are the all-embracing frameworks of Romiszowski (1981), Jonassen and Tessmer (1996/7), Hauenstein (1998) and Marzano (2001a, 2001b). The other four are the instructional design frameworks of Gagné (1965, 1985), Williams (1970), Hannah and Michaelis (1977) and Gouge and Yates (2002). It is worth noting that Bloom's taxonomic achievements (1956) would have placed him in this group, if we had considered his work in the affective and psychomotor domains.

The all-embracing frameworks are more likely than others to include some coverage of the affective and conative domains as well as cognitive skills. The more recent frameworks also include an explicit treatment of metacognition.

Several instructional design frameworks also extend beyond the cognitive domain, but members of this family are distinctive because their purpose is to categorise different kinds of learning objective and subject content and/or how far knowledge and skills are internalised.

Our examination of the classificatory principles used in critical/productive thinking frameworks showed that the presence or absence of reflective and metacognitive processes and of dispositions with conative and affective features are often highlighted (as in the frameworks of Ennis, Paul and Lipman; see Section 3). However, there are some frameworks which are limited to the cognitive/metacognitive domain; for example, Allen, Feezel and Kauffie (1967) and Gubbins (1986). Another feature of critical thinking frameworks is that (apart from valuing progress toward better critical thinking) their authors do not specify different kinds of objective (eg global or specific, short-term or long-term).

Among the frameworks dealing with cognitive structure and/or development there are some in which classificatory principles from only one category are used (Belenky *et al*. 1986, Koplowitz 1987, and King and Kitchener 1994). Again, within this type of framework, with the exception of Guilford's (1958) products dimension, different types of objective or outcome are not identified.

As at least 15 different kinds of principle have been used to classify thinking skills, it is most unlikely that a manageable 'meta-taxonomy' can be constructed which uses all of them. It is perhaps for this reason that Romiszowski (1981) presents three separate models: a categorisation of knowledge, a skill cycle and a schema of skill categories. Romiszowski, Gagné (1965, 1985), Hannah and Michaelis (1977), Hauenstein (1998) and Marzano (2001a, 2001b) all come close to providing comprehensive coverage of thinking and learning in all areas of experience, but all have too many weaknesses to be regarded as 'off-the-shelf' solutions for use in post-16 education and training as they stand.

4.3 Can several frameworks be fitted into a single conceptual system?

We found that the seven all-embracing frameworks have certain structural features in common and share all or some of these with every other framework, especially with those directed at instructional design. We saw features related to Bloom's taxonomy of educational objectives for the cognitive domain (1956) in many other frameworks and this gave us a starting point.

Bloom's taxonomy is basically a three-tier model, which we can describe in the following way. Thinking starts with and ends with *knowledge*, whether in the form of facts, concepts, rules or skills. *Basic thinking* consists of relatively simple ways of understanding, elaborating and using what is known. *Higher-order* thinking is essentially a learning process which leads to a deeper understanding of the nature, justification, implications, and value of what is known.

All the frameworks we have evaluated include classifications of *higher-order* or what (following Romiszowski 1981) we prefer to call *productive* thinking. By *productive thinking* we understand what Bloom refers to as *analysis*, *synthesis* and *evaluation* and various combinations of these and other processes when they lead to a productive outcome. A productive outcome may be a deeper understanding of a topic; a judgement, decision or solution; or a tangible product, such as an invention or work of art. Productive thinking may involve planning what to do and say, imagining situations, reasoning, solving problems, considering opinions, making decisions and judgements, or generating new perspectives. *Critical thinking* abilities are subsumed by the more general term *productive thinking*. Productive thinking is supported by critical thinking dispositions and related *habits of mind*. It may become so well practised as to be taken for granted, but when energised by feelings and determination, it is, in Lipman's terms (1995), *critical*, *creative* and *caring*.

Although the three-tier model of *knowledge*, *basic thinking skills* and *productive thinking* is useful, we found it necessary to add three more categories. In line with several authors, we made a distinction between *perceiving* and *recalling* knowledge as ways of accessing information. In seeking to identify what makes for good thinking and what facilitates meaningful learning, many theorists draw attention to reflection and motivation as well as to relevant abilities and dispositions. We use the terms *reflective thinking* and *self-engagement* to capture these elements. In this way, we arrived at a provisional six-level model and found that this worked well as a way of classifying the levels of thinking included in each of the frameworks described and evaluated in Appendix 2.

In Table 7 opposite, we show how our six-level model corresponds to the National Curriculum categories and to the six types of thinking identified by Ashman and Conway (1997). It is clear that our model provides more detail at the lower and higher levels, but considerably less detail under what we call *productive thinking*. It is also noticeable that the reflective and self-engagement aspects of thinking do not feature very strongly in the National Curriculum (except in a limited number of *evaluation* objectives).

Our next step was to try to achieve a rather more detailed breakdown, especially of the *basic thinking skills* and *productive thinking* categories. We decided to do this by finding out how practitioners conceptualise thinking skills. We carried out a pilot questionnaire study with the cooperation of Gateshead College, to find out whether college teachers tend to share a mental model of the thinking required of students; and if so, how those thinking skills are grouped. This study is fully reported elsewhere (Moseley 2003).

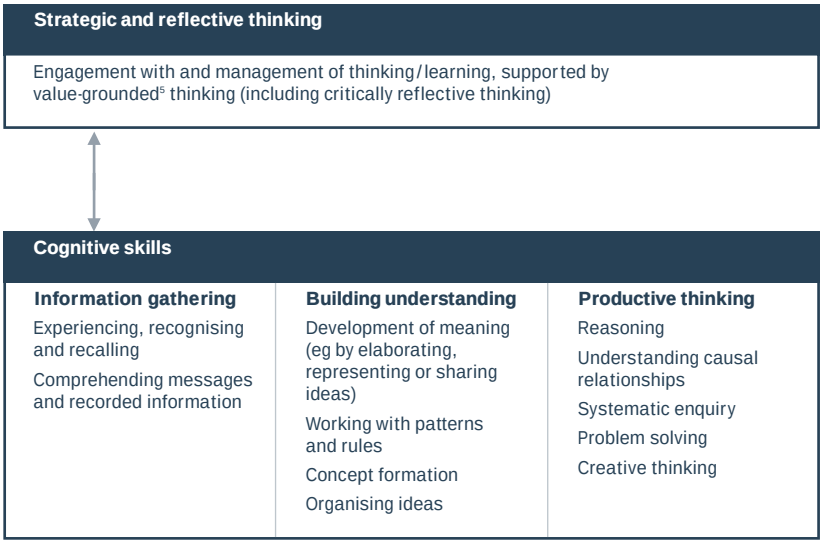
We created a composite 69-item list of all the thinking skills identified in the evaluated frameworks. Each item was expressed in two phrases, the second phrase being in the simplest possible language, as illustrated in the following two items:

- *Paraphrasing*: saying or writing information in your own words
- *Monitoring thinking*: checking to see if you are 'getting somewhere'.

Table 7
Comparison of three sets of categories

National curriculum	LSDA project team	Ashman and Conway (1997)
Information processing	Perception	
	Knowledge recall	Content knowledge
	Basic thinking skills	Core thinking skills
Reasoning Enquiry Creativity Evaluation	Productive thinking	Cognitive processes Critical thinking Creative thinking
	Reflective thinking	Metacognition
	Self-engagement	

Figure 5
An integrated framework for understanding thinking and learning



We then asked 37 college teachers to consider these skills in relation to a particular course for which they are responsible. Using a four-point scale, they indicated how strongly each thinking skill features in the course as a whole (objectives, teaching and learning, and assessment). Ten groups of thinking skills were identified through exploratory factor analysis, which we labelled in the following way:

- internalising knowledge and skill
- working with patterns and rules
- concrete (accurate observation and representation) versus conceptual thinking
- understanding and organising ideas
- reasoning
- understanding causal relationships
- planned systematic enquiry
- problem solving
- creating
- value-grounded thinking (or caring thinking).

Although this study was small in scale, the categories listed above proved helpful in confirming and extending the basic structure developed by the project team. We were finally able to create a restructured version of the six-level model, this time including sub-categories of *basic thinking skills* (which we renamed *building understanding*) and *productive thinking* as shown above in Figure 5. This involved a number of small adjustments. We split concrete versus conceptual thinking into its two components and substituted *caring*, *value-grounded thinking* for the original *reflective thinking*. Value-grounded thinking is really about what makes for *good* thinking, and includes the use of metacognition. Some other minor adjustments were made to the wording and, following Hannah and Michaelis (1977), we adopted the term *information gathering* to subsume skills involved in perception, recognition and knowledge retrieval.

5
This term is not meant to imply that values and beliefs are rigid or static.

All the components of the six-level structure shown in Table 7 are retained in our revised integrated framework. The new framework has the advantage of containing rather more detail, but at the same time having a simpler structure, with only four main categories and two levels. In essence, it is made up of the three cognitive components which we identified in Bloom's taxonomy (1956) plus a superordinate self-regulatory/metacognitive level. This does not mean that it is restricted to the cognitive domain, since it is intended to accommodate Lipman's *critical*, *creative* and *caring thinking* (1995). The two levels illustrated in Figure 5 represent the distinction between *cognitive skills* and *strategic and reflective thinking*. We decided to use the terms strategic and reflective because they are accessible and relatively uncontentious. We also use the terms *engagement* and *value-grounded* to convey the idea that we are interested in the conative and affective aspects of thinking, and see our framework as applying to all kinds of thinking, including the 'emotional intelligence' areas which Gardner (1983) describes as *interpersonal* and *intrapersonal intelligence*.

In the cognitive skill part of the framework, the three components (*information gathering*, *building understanding* and *productive thinking*) are ordered from left to right, but this is not meant to imply that all thinking processes include the middle level of building understanding, as it is possible to go straight from information gathering to productive thinking. Information gathering is a prerequisite for either building understanding or productive thinking, but it is not necessarily a simpler or less conscious process. Although it very often happens that thinking develops through distinguishable (if overlapping) phases, from information gathering to building understanding to a sound judgement or deeper understanding, this is not always the case, since these phases can take place in parallel or in complex systems with movement in both directions (as when it is found at a late stage of problem solving that a vital piece of information is missing).

The structure of our integrated model brings out the fact that *strategic* and *reflective thinking* can be used in conjunction with *information gathering*, *building understanding* or *productive thinking*. We can, for example, decide to engage in the task of trying to retrieve early memories, do it carefully in order to minimise memory distortion, and monitor and manage the process through reflection and by checking accuracy against external criteria. Equally, we can reflect on our understanding of how emotions are expressed, move on to develop a more productive understanding of emotions (people get angry when…) and develop more effective strategies for managing emotions when we interact with others. We believe that the two-level structure of the model is a more accurate representation of how people think than a multilevel hierarchy. It also easily accommodates the various ways in which young and novice learners think strategically and reflectively as they develop information-gathering skills and build understanding.

The relationship between the two levels of *strategic and reflective thinking* and *cognitive skills* is, nonetheless, hierarchical in the sense that strategic and metacognitive thinking cannot take place unless there is or has been information gathering, building understanding or productive thinking going on. There is another difference between the two levels, in terms of the nature and quality of experience involved. Cognitive skills are procedures which can become automatised and are not necessarily associated with effort or emotion. However, strategic and reflective thinking are always highly conscious and are often experienced as involving will and/or emotion as well as cognition.

The two-way arrow between *strategic* and *reflective thinking* and *cognitive skills* does not fully represent the possible relationships between them. In many thinking and learning situations there certainly is two-way interaction, often in such a dynamic manner that the experience is a holistic one. However, this does not always apply, since cognitive skills can be exercised in non-strategic and unreflective ways. On the other hand, it is impossible to operate at the level of strategic, value-grounded thinking without knowledge access and other cognitive skills coming into play. It is important to note that we are not making any claims about how thinking starts or about causality. The impetus for strategic or reflective thought may be situationally specific, as when a particular problem causes cognitive conflict, or it may flow from a well-established disposition or 'habit of mind'. What we do claim is that when thinking is *strategic and reflective* (involving the exercise of conscious purpose and a carefully executed plan), meaningful learning – to use Ausubel's phrase (1968) – is more likely to occur.

Strategic and reflective thinking are not easy, since they require sustained concentration, not only on the matter in hand, but also on how a task is conceived and whether or not there should be a change of strategy in the light of new and previous experience. Strategic and reflective thinking may involve considering the meaning of an activity in holistic as well as analytic ways. This kind of thinking is important when embarking on activities which make considerable demands on a person, such as an academic or vocational course or project. It can also be extremely valuable in dealing with much smaller issues; for example, when there is a challenge to an assumption or belief, or a communication problem. Most significantly, it is often what changes what could be a routine process into a learning experience. The development of strategic and reflective thinking is acknowledged to be a major goal of higher education. We see it as equally important in lifelong learning.

The integrated framework proposed here is in some respects similar to the map of the thinking domain created by Swartz and Parks (1994). However, Swartz and Parks do not deal with information gathering and use rather more categories to cover what we have called *building understanding* and *productive thinking*. Although they constantly stress the importance of metacognition, Swartz and Parks do not represent it on their map. Our new integrated framework is not only simple in structure, but is compatible with the National Curriculum categories as well as with leading theories about thinking and learning. The motivational and regulatory aspects of thinking (which cognitive psychologists think of as functions involving the 'central executive') are distinguished from cognitive skills; but, unlike Marzano, we do not see the need to distinguish between a *self system* and *metacognitive system*. As argued in Section 3.2.2 of this report, conscious planning, monitoring and evaluating functions are not neatly separable into two components, as presented in Marzano's model. This is recognised by Pintrich, who includes Marzano's *self-system* and *metacognitive-system* functions within a unified framework of self-regulated learning.

4.4 Which frameworks have the most to offer for general use with post-16 learners?

By 'general use', we mean 'widespread application as a way of giving purpose and structure to the experience of teaching and learning'. What is needed are accessible accounts of thinking and learning which are compatible with the integrated framework shown in Figure 5.

We have not found a single author who meets this requirement, although at an earlier stage of our research we thought that we might be able to recommend Marzano's work above all others. His framework has two main advantages. It is built on psychological theory, and has been used to classify the outcomes of educational interventions in the largest meta-analysis of its kind ever undertaken (Marzano 1998). However, as explained in our evaluation (Section 3.2.2), there are certain problems with his approach. First, we do not believe that it is helpful to distinguish between the *self system* and the *metacognitive system*. Second, Marzano's set of knowledge utilisation categories omits *reasoning* and *creative thinking*. Third, in his first three cognitive categories, he defines some terms in ways which diverge from common usage and from the well-known meanings in Bloom's taxonomy (1956) and its later revision by Anderson and Krathwohl (2001).

For these reasons, we decided that three complementary frameworks are needed rather than one. Pintrich's framework of self-regulated learning (described and evaluated in Section 3.5.2) best conveys the meaning of what we have called *strategic and reflective thinking*, using a variation of the familiar 'plan–do–review' cycle. Halpern (see Section 3.4.2) provides a popular *productive thinking* framework, accompanied by resource materials designed for post-16 learners. Anderson and Krathwohl's updated and extended revision of Bloom's taxonomy (see Section 3.3.2), which can be used with any age and ability group, provides a vocabulary for describing specific knowledge and skill objectives. It covers basic thinking skills as well as single processes, which, especially when combined, constitute productive thinking. Readers who wish to consider points for and against each of these three frameworks are referred to the graphically structured arguments in Appendix 3.

Section 5

Some ideas for using the frameworks

5.1 Using a five-category framework to classify key skills objectives

If a framework of thinking skills is to be of practical value in preparing and communicating curriculum objectives, users must be able to apply it consistently. As a first step towards evaluating the applicability of the new framework presented in Figure 5 (page 45), we used a five-category version of it to classify Key Skills knowledge objectives, Levels 1–4[6]. We did this because this widely used national set of objectives incorporates generic thinking and learning skills, especially in what are known as the 'wider key skill' areas of Working with Others, Improving Own Learning and Performance and Problem Solving. We were interested not only in whether the new framework could be applied consistently, but also in what our analysis would tell us about the importance given to different types of skill at different levels. The thinking skill categories that we used to classify the objectives are shown in Table 8.

Having decided on the five categories and their defining characteristics, the research team undertook an analysis of the relevant key skills documents. Our first aim was realised in that full agreement was reached about the categorisation of all knowledge objectives across the six key skills areas. It was possible to resolve the small number of differences of opinion by referring back to the definitions in Table 8.

Figure 6 shows the relative emphasis given to five types of thinking across all six key skills areas. *Building understanding* (39%) and *productive thinking* (42%) are predominant. Figure 7 shows the proportional emphasis within each level and reflects the more demanding nature of successive levels. It is noteworthy that only at Key Skills Level 4 is there a significant need for *reflective thinking* and for the *strategic management of thinking* which it is reasonable to expect of independent learners.

Figure 8 charts the percentage of each type of thinking found within each of the key skills areas. It is apparent from the chart that Communication, Application of Number and Information Technology contain a higher percentage of *building understanding skills* than Working with Others, Improving Own Learning and Performance and Problem Solving. The first three also contain lower percentages of *reflective thinking* and *strategic management of thinking*.

In the classification exercise reported above, we found it feasible to make the broad distinction between *building understanding* and *productive thinking*. If we had attempted to make distinctions between sub-categories, we should have had much more difficulty. This is because the sub-categories inevitably overlap, and because what is problem solving for one person may be creative thinking for another. Nevertheless, we believe that the simplified version of our framework has potential as a tool for use in planning and evaluating courses and curricula, and constructing and grading of assessment tasks. We give examples below to illustrate how our five categories were able to accommodate all the key skills objectives.

Information gathering: identify the person you will see to review your progress and where and when this will take place.

Building understanding: make changes suggested by your supervisor.

Productive thinking: seek and actively use feedback and support from relevant sources to help you to meet targets.

Reflective thinking: monitor and critically reflect on what you are learning and how you are learning, noting the choices you make and judging their effectiveness.

Strategic management of thinking: adapt your strategy to overcome difficulties and produce the quality of outcomes required.

Table 8
Five types of thinking skill and their definitions

Category of thinking	Characteristics
Information gathering	Obtaining information from memory, or by observing, listening or reading
Building understanding	Understanding situations and carrying out simple procedures
Productive thinking	Thinking which leads to deeper understanding, or to a judgement, solution or product
Reflective thinking	Monitoring or reviewing one's thinking to improve performance
Strategic management of thinking	Thinking that leads to a change in plans or approach to a problem

6

Figure 6
Percentage distribution of five types of thinking across key skills

- Strategic management of thinking 5%
- Reflective thinking 10%
- Productive thinking 42%
- Building understanding 39%
- Information gathering 4%

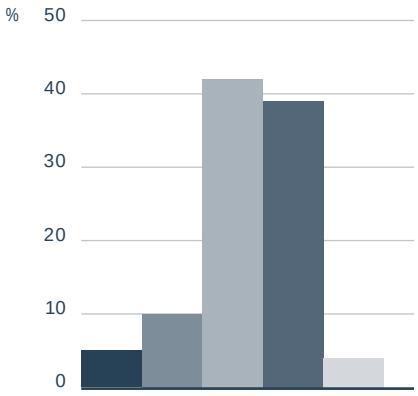


Figure 7
Percentage distribution of five types of thinking within each key skill level

	Level 1	Level 2	Level 3	Level 4
Strategic management of thinking	0%	1%	2%	14%
Reflective thinking	4%	8%	6%	23%
Productive thinking	16%	35%	56%	55%
Building understanding	69%	51%	34%	8%
Information gathering	11%	5%	2%	0%

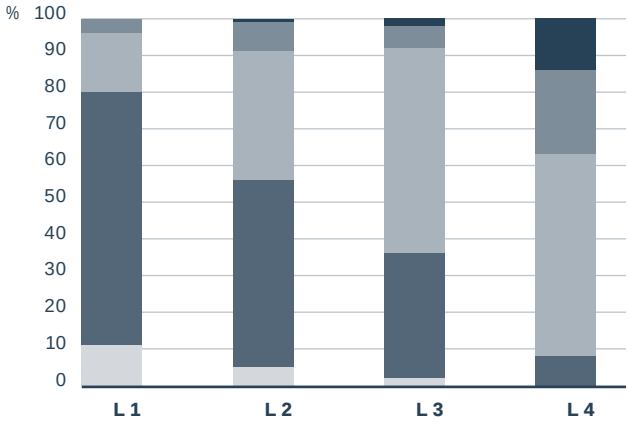
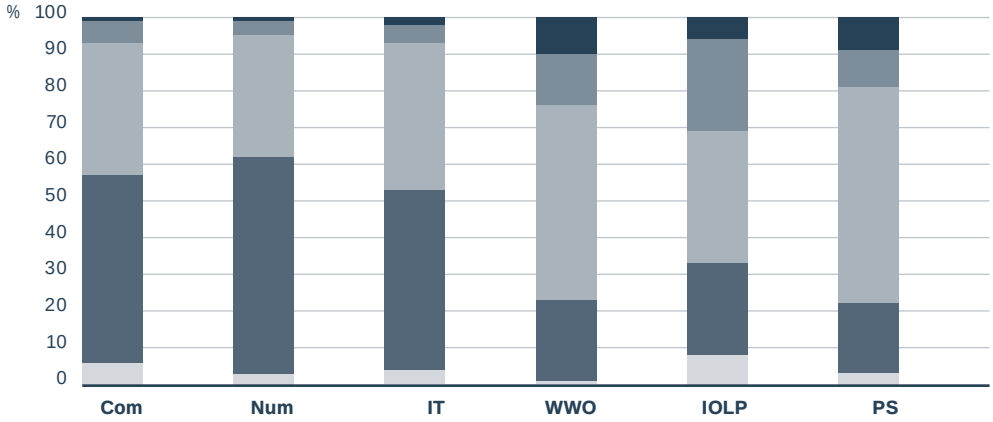


Figure 8
Percentage distribution of five types of thinking within each key skill

	Communication	Number	Information technology	Working with others	Improving own learning and performance	Problem solving
Strategic management of thinking	1%	1%	2%	10%	6%	9%
Reflective thinking	6%	4%	5%	14%	25%	10%
Productive thinking	36%	33%	40%	53%	36%	59%
Building understanding	51%	59%	49%	22%	25%	19%
Information gathering	6%	4%	4%	0%	8%	3%



5.2 Other ways of using thinking skill frameworks

Everyone who is involved in lifelong learning needs to have some understanding of its nature and purpose. A framework for understanding thinking and learning can be used at any level of generality; for example, as a guide to the formulation of a mission statement or in formulating specific learning objectives and assessment items. When a theoretical framework is used consistently and explicitly, it is likely that communication within an educational or training context will be enhanced, as well as communication with the outside world.

There are a number of subject disciplines which have as their focus the study of human beings. These include philosophy, psychology, sociology and anthropology, where almost every aspect of human behaviour is of potential interest. Geographers and historians are clearly interested in a broad spectrum of human behaviour and we could add other disciplines to the list. The point is that in the humanities, just as much as in the sciences, there are benefits to be obtained through collaboration and this too requires a shared language about how people think and learn. It is certainly possible for a thinking skills framework to be drawn up for each subject area, but if this were done, the differences would probably lie only in the detail. In our view, many benefits would flow from the interdisciplinary development of a common framework, especially if care were taken to avoid the use of the kind of esoteric language which tends to maintain artificial boundaries between traditional academic subjects.

Understanding thinking and learning is important not only in academic study, but also in professional and vocational courses. There is a strong case to be made for the development in the UK of post-16 qualifications which incorporate some of the positive features of the baccalaureate qualification, whether modelled on French, European or International exemplars. These have traditionally included the philosophical study of theories of knowledge, but have not included the study of theories of learning. However, it would make good sense for thinking and learning to form the core of such studies, associated with another subject of choice in which human behaviour is the focus. An understanding of thinking and learning frameworks should inform the planning of appropriate curricula.

There are many ways in which the use of thinking skills frameworks can be built into teacher training and professional development. Teachers need regular opportunities to reflect on their own learning and style of teaching. Without such opportunities, they are ill-prepared to engage learners in similar discussions. Thinking skills frameworks can help to provide the necessary lexicon of thinking and learning, to develop a common language applicable in every subject area.

Elsewhere in this report we have referred to the use of thinking skills frameworks in the planning of instruction, in teaching, in assessment, and in the alignment of all three. Planning can be done at several different levels, but it is the teacher who has, on the basis of formative and summative assessment, to make constant adjustments while teaching in order to facilitate learning. The skills required cannot be learned from textbooks alone, but are undoubtedly capable of development and fine-tuning. The teacher's job is to ensure that learning takes place, and as teachers develop expertise, their constructs about teaching and learning become more sophisticated. Being able to discuss those constructs within a community of practice and in relation to theory-based frameworks makes a teacher not only a learner, but a practitioner-researcher.

Thinking skills frameworks inform a number of reputable initiatives in educational and workplace settings. Among these are Feuerstein's (1980) Instrumental Enrichment (IE) programme, Thinking Skills at Work (Blagg, Lewis and Ballinger 1993), Teaching Thinking Skills in Vocational Education and Training (Soden 1993) and approaches based on Lipman's community of enquiry (Lipman, Sharp and Oscanyon 1980). There are many other initiatives which would benefit from being explicitly grounded in a theory-based framework of thinking skills; for example, de Bono's (1976) strategies for teaching thinking and Lake and Needham's Top Ten Thinking Tactics (1993).

It is not just teachers, but learners who need to develop a mature understanding of thinking and learning, especially in contexts where learners have to take a large share of the responsibility for their own progress. They need to consider not only their immediate needs, but the possible value of 'transferable skills' (the thinking that underlies key skills initiatives). Good Communication, effective Working with Others and a commitment to Improving One's Own Learning and Performance are clearly valuable qualities. They can be developed in many ways, not just through formal education and training. As Lipman (1991) argues, it is far from clear that the best way to develop an intrinsic interest in thinking and learning is through prescribed activities. Lipman advocates the *community of enquiry* approach to thinking and learning, through philosophical discussion of issues of concern to a group. Yet even here, participants need to understand the theoretical framework within which the community operates.

Another use of a framework for understanding thinking and learning is as a research and evaluation tool. For example, Vermunt and Verloop (1999) write persuasively about congruence and friction between learning and teaching. They suggest that 'congruence' exists when (a) teacher direction is high and student self-regulation is low; and (b) student self-regulation is high and teacher direction is low. A theory-based framework of approaches to learning like the one produced by Vermunt (1996) can lead to new ways of assessing psychological and pedagogical aspects of learning environments. It then becomes possible to relate what are presumed to be indicators of quality to outcome measures. There is a serious lack of evidence-based information of this kind, without which inspection regimes lack credibility.

5.3 Which frameworks are best suited to specific applications?

In Section 4.4, we gave reasons for recommending three frameworks for **general use**. Two of these (Halpern; Anderson and Krathwohl 2001) are written in an accessible style, although only Halpern writes explicitly with post-16 applications in mind. There is continuity between Bloom (1956) and Anderson and Krathwohl (2001) in that David Krathwohl was a member of Bloom's original team. In fact, teachers can still learn a lot from Bloom's famous book, which was written with college students in mind and shows few signs of its age. It has the advantage of being very concise and very well written. Pintrich's framework of self-regulated learning can be understood in tabular form, but does need a more accessible exposition.

These three frameworks are, however, not the only ones that can help teachers acquire what in Section 5.2 we called a 'lexicon of thinking and learning'. An outstanding resource is the latest edition of Costa's *Developing minds* (2001), which contains chapters by Baron, Ennis, Marzano, McTighe, Paul, Perkins, Presseisen and Tishman, among others.

We believe also that the following frameworks summarised in Appendix 2 can help the reader to understand the general subject of thinking and learning (which is not to say that all the original sources are accessible): Baron, Carroll, Gardner, Guilford, Hannah and Michaelis, Jewell, Koplowitz, Lipman, Quellmalz, Presseisen, Romiszowski, Sternberg, Vermunt and Verloop, and Williams. The work of Gardner, Presseisen, Sternberg and Vermunt is readily available and particularly relevant for teacher educators.

If the subject of thinking skills, especially critical thinking, is approached from a **philosophical perspective**, the frameworks of Ennis, Lipman and Paul can be usefully compared and contrasted. An in-depth **psychological perspective** on critical thinking is provided by Halpern. As Sternberg's earlier work on critical thinking is available only on microfiche (1986), we recommend the latest edition of his general textbook on cognitive psychology (2003). For understanding **developmental perspectives** on critical thinking, King and Kitchener's (1994) book is the best source, with Perry and Belenky (1986) providing both historical and theoretical context.

For **instructional design purposes**, we have highlighted Anderson and Krathwohl's revision (2001) of Bloom's taxonomy (1956). Readers who want a comprehensive treatment of instructional design should consult Jonassen, Tessmer and Hannum (1999). In addition, we suggest that consideration be given to the frameworks developed by Romiszowski (1981), Hannah and Michaelis (1977) and Hauenstein (1998). These all deal with psychomotor and affective learning objective (as well as cognitive ones) and are concerned with stages in the development of understanding as well as with the end result. If the focus of instructional design is *creative thinking*, the most useful frameworks are those of Gouge and Yates (2002) and Williams (1970), while the work of Halpern and Lipman is also relevant.

Of all the authors we have reviewed, Marzano is noteworthy for translating research findings into teaching recommendations, framing these within the structure of his new taxonomy (Marzano 1998, 2001a). His is a pragmatic **approach to pedagogy**. In contrast with Lipman and Paul, neither Marzano nor Anderson and Krathwohl seem desirous of radically transforming educational practice.

A wide spectrum of views about what constitutes effective pedagogy is represented in the work we have evaluated. It would be unwise to assume that thinking skills can only be developed in particular kinds of learning environment that are advocated by certain theorists or fashionable at the time. However, it does seem clear that if *strategic and reflective thinking* are to be developed, learners need to be in situations where they have opportunities to use that kind of thinking. Theorists usually have preferences about ways of encouraging good thinking, meaningful learning and deep or strategic approaches to study. All agree that learning and thinking are active processes in which new connections are made.

Vermunt and Verloop (1999) place approaches to learning and instruction on a continuum between teacher-regulated and student-regulated, and point out that there may be differences between pedagogic practice and beliefs and student conceptions of learning and ability to regulate it. The continuum of theoretical positions in the work we have reviewed ranges from Gagné (1965, 1985) and Ausubel at the teacher-regulated end to those like Feuerstein, Hannah and Michaelis (1977) and Romiszowski (1981), who favour forms of 'guided discovery', to those like Lipman and Paul who advocate learner-centred approaches. Learner empowerment through the social construction of knowledge is strongly valued by Belenky *et al*. (1986), King and Kitchener (1994), and Jonassen and Tessmer (1996/97). Gardner and Vermunt believe in the importance of tailoring instruction to meet group and individual needs.

Vermunt, in common with very many other theorists, emphasises process over content in much of his writing, arguing that self-regulation is the key to lifelong learning rather than the accumulation of knowledge. The only theorist to deal adequately with what teachers and learners can do to improve the *acquisition and retention of knowledge and skills* is Halpern. We believe this to be a neglected but still very important area. In our Gateshead College study (Moseley 2003), we found that teachers rated the internalisation of knowledge and skills as being a major aim, next in importance to the most important of all, the development of value-grounded thinking.

In the actual **practice of teaching**, it is possible for a teacher to keep a simple framework in mind, as a means of monitoring the kind of thinking expected of students. This is especially important in the process of questioning and when discussing a topic with a class, group or individual. The simple four-category system developed in this project (see Figure 5; Section 4.3) is very suitable for this purpose. Anderson and Krathwohl's (2001) six process categories (*remember*, *understand*, *apply*, *analyse*, *evaluate*, *create*) can also be used in this way. Many teachers find they can readily internalise Gardner's seven (now nine) kinds of intelligence (see Appendix 2) in order to monitor learning activities in those terms. The '3Cs' of *critical*, *creative*, *caring* thinking, which are derived from Lipman and used by Jewell (1996) are also easily memorised and applied.

Our brief description and evaluative summary of Altshuller's theory of inventive problem solving (TRIZ) (1996, 1999, 2000) does not do it justice. It is now taught in a number of universities in the UK and has been widely taken up in many countries where technological innovation is valued. It has the unique quality of organising creative thinking. Although coming up with inventive solutions to practical problems still depends on analogical thinking and looking for patterns, the task is much simplified by applying Altshuller's 'algorithmic' procedures. These are the result of many years of systematic data gathering and his analysis of existing patented solutions.

Consultancy (whether in educational or business contexts) is another area in which frameworks of thinking and learning are widely used. We have not attempted to identify all the frameworks that inform practice in this field, many of which are models of learning styles rather than thinking skills. Others (eg Senge 1990) are simply sets of problem-solving heuristics. We mention here three particular frameworks. One of the early rational problem-solving approaches was the Kepner-Tregoe (Kepner and Tregoe 1965) tenets of effective decision making – rational thinking. Koplowitz (1987) has applied his theory of stages in adult cognitive development in business settings and argues that better decisions are made when people move beyond logical analysis to more systemic and holistic ways of thinking. Although it was not devised with consultancy applications in mind, Vermunt and Verloop's categorisation of learning activities (1999) appears to us to be highly applicable as a way of understanding how learning develops (or not) in any organisation.

Assessment is another major area in which thinking skill frameworks, especially those dealing with educational objectives, are extremely relevant. As Ennis recognises, the assessment of critical thinking is a problematic area, despite being one in which he is personally involved as an author (Ennis and Millman 1985; Ennis and Weir 1985). We believe, however, that the most useful framework for assessing extended written assignments at post-16 level is the SOLO taxonomy of Biggs and Collis (1982). This has the merit of being easily communicable to students. Examples of relevant work in the appropriate subject area can be presented to students to illustrate each of the five SOLO levels. Students can also assess such pieces of work (including their own).

When it comes to the assessment of personal qualities and dispositions, especially as displayed in group situations, further problems arise. However, these are not necessarily insuperable, as experience with the wider key skills portfolios suggests (LSDA 2002). The lists of dispositions produced by the following authors may be helpful in this context: Baron (1985), Ennis, Halpern, Jewell (1996) and Paul. Costa and Kallick's (2000a, 2000b) 16 'habits of mind'[7] and the seven dispositions put forward by Perkins, Jay and Tishman (1993) as the basis of their dispositional theory of thinking are also worth considering. Costa, Kallick and Perkins (2000) address the topic of assessing and reporting on 'habits of mind'.[8]

Thinking skill frameworks are also valuable in **research and evaluation**. Pintrich is a good example of a researcher who has developed ways of assessing learning, aided by his theoretical framework of self-regulated learning. Sternberg is another, with his triarchic theory of successful intelligence and his claim that 'triarchic teaching' is more effective than traditional approaches (2002). Vermunt and Verloop's (1999) categorisation of learning activities and Vermunt's broader framework for understanding approaches to learning (1996) have led them and other researchers to find ways of assessing psychological and pedagogical aspects of learning environments. Feuerstein's Instrumental Enrichment (IE) intervention programme (1980) is typically evaluated using closely related cognitive measures from the Learning Potential Assessment Device (Hattie, Biggs and Purdie 1996; Romney and Samuels 2001). In fact, all thinking skill frameworks can be used to generate research questions.

Finally, meta-analysis can be structured by using categories from thinking skill frameworks. This makes it possible to compare the effect sizes produced by different types of educational intervention. It was in this way that Hattie, Biggs and Purdie (1996) were able to evaluate the effects of learning skills interventions on student learning (including 14 studies with adult students). They did so by using the SOLO taxonomy (Biggs and Collis 1982) to categorise interventions as being *uni-structural*, *multi-structural*, *relational* or *extended abstract*. They also compared 'near transfer' with 'far transfer' effects. Further information and a summary of the results are provided in Section 6.2. We believe that future meta-analyses should build on this kind of approach.

Marzano's (1998) meta-analysis was broader in scope and larger in scale than any other we have found. Marzano categorised all studies, including 147 studies at college level, using the categories and sub-categories from his new taxonomy of educational objectives. For further information, see Section 6.2. Marzano's overall conclusion (1998, 135) was as follows:

The effective teacher is one who has clear instructional goals. These goals are communicated both to students and to parents. Ideally, the instructional goals address elements of the knowledge domains as well as the cognitive, metacognitive, and self-system. Even if the instructional goals focus on the knowledge domains only (as is frequently the case in public education), the teacher still uses instructional techniques that employ the cognitive system, the metacognitive system, and the self-system. Perhaps, above all, the teacher understands the interrelationships among the knowledge domains, the cognitive system, the metacognitive system, and the self-system, and uses that understanding to make the myriad of instructional decisions that occur in a single lesson.

7
A phrase used by Dewey (1930).

8
For a categorisation of Costa and Kallick's 'habits of mind' using our integrated framework, see Appendix 4.

Section 6

Summary of what is known and the need for further research

6.1 Introductory outline

In this section, we summarise evidence from over 4000 empirical studies to show that thinking skills approaches can be very effective, especially those targeted at the skills of metacognition and self-regulation. We also present a list of research findings about thinking and learning which we believe to be based on extensive and sound empirical research.

Turning to matters of theory, we note a degree of rapprochement between cognitive, constructivist and some recent behaviourist formulations. However, we do not believe that it has been established that meaningful learning can take place only when there is a low level of teacher direction.

We point out that a great deal of educational practice is based on sets of widely accepted but usually untested beliefs, values and assumptions. Empirical evidence leads us to question one of these assumptions: the idea that to be effective, teachers need to base their practice on coherent theory.

After listing a large number of areas where it cannot be claimed that either beliefs or practice have strong research support, we prioritise certain areas where further research is needed in the post-16 sector.

We conclude by offering suggestions for policy-makers based on our understanding of the literature.

6.2 In which areas is there extensive or widely accepted knowledge?

Theorists and taxonomists who categorise thinking skills do so on the assumption that the terms they use have meaning: in other words, that there are at least some skills, abilities or dispositions which are recognisable in different contexts. The question as to how far people are able to make use of those skills, abilities and dispositions in new situations, especially when learning is required in addition to preparedness and recall, is one requiring an answer based on experience, not theory. In our view, empirical research has amply confirmed that thinking and learning skills can be taught in such a way that the skills can successfully be applied in different (albeit usually closely related) areas.

While it was not in our remit to evaluate the evidence as to the benefits of teaching thinking skills, we refer here to two relevant meta-analyses. In each of these, a thinking skill framework was used to categorise the results; and in both cases, it was found that interventions directed at metacognitive thinking skills were highly effective.

Hattie, Biggs and Purdie (1996) confined their interest to 271 effect sizes in 51 'learning skills interventions'. They found that 'unistructural' approaches (interventions directed at single-skill outcomes) were the most effective, with a large mean effect size of 0.83. Among the most effective unistructural interventions were those addressing memory and reproductive performance. However, 'relational interventions' with 'near transfer' were also highly effective, the mean effect size being 0.77. The authors say (1996, 105) that relational interventions 'are integrated to suit the individual's self-assessment, are orchestrated to the demands of the particular task and context, and are self-regulated with discretion.' Relational interventions frequently have a metacognitive emphasis and include attributional retraining studies (which had a mean effect size of 1.05). Using 'structural aids' (with a strategy emphasis) was also moderately effective, the mean effect size being 0.58. Overall, in line with the weight of previous research, transfer effects were larger with 'near' than with 'far transfer'. Hattie, Biggs and Purdie also found that the mean effect size for self-directed interventions (0.70) was higher than for teacher-directed interventions (mean effect size 0.44). The number of studies involving adults outside universities was too small to permit any breakdown, but the results were not encouraging, the mean effect size being small (only 0.22).

Marzano (1998), found that college students responded just as well as school pupils when data from more than 4000 studies were aggregated. He confirmed Hattie, Biggs and Purdie's finding (1996) that techniques designed to be used by students led to significantly better results than those designed to be used by teachers. Although there was enormous diversity in the intervention studies selected by Marzano, ranging from a focus on specific skills (such as memorisation) to the use of disposition-monitoring strategies, he made the following claim (1998, 127) about the importance of metacognition:

…instructional techniques that employed the metacognitive system had strong effects whether they were intended to enhance the knowledge domains, the mental process within the cognitive system, the beliefs and processes within the self-system, or the processes within the metacognitive system itself.

Overall, Marzano found that interventions which engage either the self system or the metacognitive system lead to better knowledge outcomes (by six and five percentile points respectively) than those which are directed only at the use of cognitive skills. Nevertheless, there are some types of very effective intervention at the cognitive skill level. These are interventions which address: *experimental enquiry*, *using analogies*, *comparing and contrasting*, *idea representation* and *the storage and retrieval of knowledge*.

We can summarise these meta-analyses by saying that there is powerful empirical evidence that thinking skill interventions can be very effective at all levels, but especially if they are directed at metacognition, self-regulation and what we have called 'value-grounded thinking'. Their effectiveness is likely to be greater if they are used for learner self-regulation rather than coming fully under teacher control. However, well-focused interventions at the cognitive level can also be very effective. These include interventions with a focus on experimental enquiry and idea representation, as well as approaches to study support such as using cues and questions to aid retrieval. Unfortunately, we cannot be confident that substantial learning gains are achievable with post-16 learners not in higher education, as there are so few published studies.

Apart from the evidence coming from the meta-analysis of high-quality empirical research, the following statements can be backed up by research findings (although, again, much of the evidence comes from younger age-groups).

- Learners have different preferences, needs, backgrounds and skills.
- Most learners think of teaching as the transmission of knowledge.
- Many learners have had negative experiences at school.
- Thinking and learning are active processes.
- Learning often involves a re-conceptualisation of information.
- Motivation is the key to active learning.
- Students need to have appropriate, specific and challenging goals.
- The quantity and quality of instruction make a big difference.
- Learners can benefit from thinking skills interventions irrespective of age.
- Learners can benefit from thinking skills interventions irrespective of ability.
- Teaching for critical, creative and caring thinking is rare in FE colleges.
- Many teachers and employers want compliant thinkers and learners.
- There are all-round benefits from learning in groups of 15 or less.
- Learning is affected by contextual factors.
- Progress is facilitated by constructive formative assessment.

Apart from the research evidence presented above, there are a number of areas in which there is a high level of consensus about how people think and learn. We have already drawn attention to structural similarities in many of the frameworks evaluated in this report, and shown how it is possible to construct an integrated framework within which several of them can be accommodated. This is a framework in which there is constant interplay between cognition, feelings and motivation. The assumption is made that there is a conscious self which sets goals and is motivated to achieve them; yet is, at the same time, strongly influenced by unconscious and interpersonal dynamics.

There is wide acceptance among psychologists and educators of the idea that thinking in individuals and groups is shaped through interpersonal interaction. Cognitive psychology is compatible with constructivist conceptions of learning and with the importance of person–situation interactions. As we have seen, theorists such as Pintrich and Vermunt see contextual factors as being highly important in relation to self-regulated learning. The socio-cultural contexts in which learning takes place are also generally considered to exert powerful influences, even within the behavioural tradition. For example, Strand, Barnes-Holmes and Barnes-Holmes (2003, 105) suggest 'that advances in our understanding of choice behavior and verbal behavior put us within reach of a comprehensive framework for making sense of the interconnectedness of social, self, and academic development.'

The widely held view that constructivist beliefs about thinking and learning are incompatible with teacher-directed or behavioural approaches to instruction is an exaggerated position which has only a modest level of support from the meta-analytic findings which favour self-regulation over teacher direction. The fact is that teacher-directed approaches can also be effective in teaching thinking. Strand, Barnes-Holmes and Barnes-Holmes (2003) refer to several examples of this within the behaviourist paradigm. As Ausubel argued, meaningful learning can occur with varying degrees of direction by teachers.

A great deal of educational policy and practice is based on sets of widely accepted but usually untested beliefs, values and assumptions. We now list some of these, without embarking on a radical critique of power relationships and political ideologies. Many people involved in post-16 education and training would agree with the following statements.

- Most people are potentially more competent than they think.
- Learners need to feel valued in personal, social and cultural terms.
- Learners need to see instruction as being personally relevant.
- Learners need to understand why their teachers do what they do.
- Thinking and learning are facilitated by social interaction and discussion.
- Good teaching helps learners to move from dependency to independence.
- Good thinking and learning help to develop valuable personal qualities.

It is important to acknowledge that while beliefs such as these have a commonsense appeal or can be justified on moral grounds, few are grounded in empirical research.

We now need to question a major assumption made at the start of the present project. Our initial brief was to evaluate thinking skill *taxonomies*, as it was thought that principled or theory-grounded classification systems are preferable as a basis for practice than simple lists or sets of heuristics. We subsequently decided to evaluate theory-grounded frameworks as well as taxonomies, but still made the assumption that thinking skills approaches derived from theoretically coherent frameworks, such as those based on the work of Feuerstein and Lipman, are more effective than those which we had to exclude, such as the subjects covered in de Bono's Cognitive Research Trust (CoRT) Thinking Lessons (1988).

Hattie, Biggs and Purdie (1996) have shown that this rather fundamental assumption may be ill founded. In their meta-analysis of learning skills interventions, they found a slightly higher mean effect size for 'atheoretical' interventions (n = 36 effects) than for theory-based interventions (n = 234 effects). Although the difference was not statistically significant, it appears that it makes no difference to practitioners whether a change in their normal practice has, or does not have, an academically respectable theory or well-structured taxonomy to support it.

To understand and explain this state of affairs, researchers and teachers will need to consider the following possibilities.

1
Many theories about thinking and learning are unimportant.

2
It is often difficult to work out how theories can be effectively applied.

3
The communication of relevant theory to practitioners is often poor.

4
Theories are often too complex or too abstract for classroom application.

5
Teachers rarely modify their 'theories in use'.

6
Many teachers are not interested in theory or do not understand it.

Although the lack of evidence in favour of theory-based educational interventions is not widely appreciated, we have mentioned it here as being based on extensive research and being consistent with our own observations that policy-makers and teachers are more often influenced by pragmatic than by theory-based concerns.

6.3 In which areas is knowledge very limited or highly contested?

In our evaluations we have commented on the explicit and implicit value systems communicated by each theorist. There is considerable diversity among these and many philosophically and morally contested areas. Here we will not enter into debates which cannot be settled by research evidence, but will simply note the main areas of contention.

First, there are diverse views about the nature of knowledge and about how to access and use it. The power which people can exercise through thinking and communication also occupies many writers, who take positions ranging from various forms of elitism (intellectual, socio-cultural or spiritual) to an egalitarian concern for human rights. There are also distinct moral and ethical belief systems – with some writers taking a pragmatic, technological view about the possible social and economic benefits of improved thinking; some espousing the values of a liberal-humanistic tradition; and others having a strong belief in rationalism.

We have also commented on a spectrum of views about nature and nurture and about individual freedoms and state control. Finally, opinions differ widely about which aspects of thinking should be taught and how they should be taught.

Of the contested issues listed above, those in the last paragraph are, to varying degrees, open to systematic enquiry and research. The first of these (the nature and nurture debate) has been researched in relation to adults more than the others. For example, Pederson, Plomin and McClearn (1994) found substantial and broadly similar genetic influences on both general and specific cognitive abilities. Several studies have shown that genetic influences on personality traits are somewhat lower than on cognitive abilities (Loehlin 1992). What is not known about thinking and learning in adults is how far genetic influences impose limits on achievement when motivation is high and good-quality personal and environmental support are provided.

Most teachers accept that it is a core part of their role to take account of individual differences in learners, whether in terms of goals, preferences, ability, aptitude, or style of thinking and learning. However, there is a paucity of research in the post-16 sector to indicate whether there is much room for improvement in this area, which is why the LSDA has also commissioned research reviews about learning styles (Coffield *et al*. 2003a, 2003b). There is no doubt that teachers are attracted by the idea that better results may be achievable if they capitalise on individual strengths, such as Gardner's multiple intelligences. However, in researching this area, there is a serious methodological difficulty in trying to control for the catalytic effects of enthusiasm on the part of those who take up novel approaches.

Just as the evidence base on the best ways to meet the individual needs of post-16 learners is weak, little is known about how to optimise performance in teachers in ways which respect individual differences and build on personal strengths. Apart from differences in the nature and extent of teacher direction and the facilitation of independent learning, teachers differ in other ways; for example, in creativity, in how they respond to a prescriptive curriculum, in their interest in abstract thinking, and in 'emotional intelligence'.

There seems to be very little public debate about which aspects of thinking people believe to be important in adult life and how they can best be developed. Yet if the present decline in participation in adult education is to be reversed, the views and motivation of actual and potential participants need to be studied in depth. There is at present very little evidence on which to base policy in terms of the emphasis to be given to different kinds of thinking (eg procedural, critical, creative or caring) in educational, vocational and recreational contexts.

6.4
What questions arise for further research?

As we have seen, very little research into thinking skills in post-16 learners has been carried out in the UK. We therefore need to identify: (a) the contexts in which knowledge, understanding and productive thinking are most lacking; and (b) which current pedagogic approaches seem to be most effective in problematic areas.

In Section 6.2, we identified a fundamental problem about the contribution of theory in education and training. The finding that theory-based interventions are typically no more effective than others makes it essential to evaluate theories and the ways in which they are used. In this respect, we believe that the present study has served a useful purpose, but it has not addressed the six issues raised towards the end of that section. This should be done by involving teachers in the development, application and evaluation of theory, rather than by a 'top down' approach.

We have not found any studies in which the communicability and practical utility of a thinking skill framework in post-16 education and training has been formally assessed. Research on how readily teachers can learn to use thinking skill frameworks, on how they may need to modify them for classroom use and about the impact of their use on teaching and learning should therefore be given high priority.

We are not aware of any published UK studies in which syllabuses, course planning, assessment tools or learning-related discourse have been analysed using a framework or taxonomy of thinking skills. If an analysis of this kind led to significant changes in classroom practice, these could be evaluated, initially through pilot studies and then more widely.

The positive message from international research findings about the value of self-regulation and self-directed interventions reported in Section 6.1 suggests that the communicability and utility for *learners* of the language of learning, thinking and instruction are even more important topics for research in post-16 education. Here, as in other areas, there appears to be great potential for collaborative work between practitioners and research-trained professionals, first to agree appropriate content and then to find effective ways of communicating it, perhaps taking forward and extending the work of Mason (1999).

In view of the importance of beliefs and motivation in thinking and learning, this is an area where a major research programme is required. 'One fits all' policies are likely to be counterproductive if they do not accommodate a range of approaches to teaching and learning, allowing for differences between contexts as well as for stylistic differences between teachers and learners.

There is clearly an urgent need to carry out further research into the effectiveness of pedagogical interventions intended to improve teacher and student thinking in the post-16 sector. Particular attention should be paid to interventions where there is already research evidence of generalisability. There is a pressing need to develop this work in contexts where increased social inclusion is one of the benefits sought, particularly in relation to contemporary initiatives in adult and community education (ACE) in relation to the development of adult numeracy and literacy, English for Speakers of Other Languages (ESOL) and key skills.

A very promising area for continuing research and development is the introduction of thinking skills approaches into a range of courses in FE colleges, building on exemplars such as the work of Gregson (2003) and Duffy (2003). Should the early results prove encouraging, research will then be needed to study the benefits of more radical reforms, such as applying the principles of a thinking community of enquiry throughout the education and training system: in policy-making; in curriculum design; in the education, training and support of teachers; in assessment; and in inspection.

Thinking skills approaches are not necessarily labour-intensive, or limited to face-to-face forms of learning. Research is needed to establish what kinds of thinking and learning activity are best carried out in large groups and which in smaller ones. At the same time, it is important to find out (a) how distance-learning methods are best integrated with in-person class attendance; and (b) what difference information and communications technology (ICT) can make to the need for, and frequency of, personal interaction in different-sized groups.

Assessment is a powerful driver of educational change. If progress in thinking and learning and the benefits of thinking skills approaches are to be measured reliably and with some validity, authentic, dynamic and ecologically relevant forms of assessment and evaluation must be devised. These must be suitable for the assessment of group as well as individual activities and should be in electronic, paper and other forms. In the production and assessment of written work and argument, the value for learners and teachers of using the SOLO taxonomy (Biggs and Collis 1982; see Section 3.3.1) should be put to the test.

In our view, the first logical step is to work collaboratively with teachers in post-16 education, to explore the potential uses and further development of the new integrated framework presented in this report (Section 4.3). At the same time, teachers should be introduced to this and other frameworks and pedagogical approaches designed to develop thinking skills. It will then be possible to set up, through action research and large-scale studies, systematic evaluations of their application and potential for wider use with post-16 learners across the UK.

Our conclusions need to be considered alongside those from the University of Strathclyde about post-16 pedagogy and thinking skills (Livingston, Soden and Kirkwood 2003) and those from the Evidence for Policy and Practice Information and Coordinating Centre (EPPI) systematic review (Higgins *et al*. 2003), in order to generate and develop new research. This should take several forms, including case studies, collaborative action research, randomised controlled trials and longitudinal process and outcome studies.

6.5 What are the implications of our research for policy-makers?

In planning any changes to the national system of post-16 education and training, the aims and objectives should be explicitly informed by the values that are widely associated with good thinking and meaningful learning. A balanced approach should be taken, so that critical, creative and caring thinking each play a part. Consideration should be given to developing new programmes focused on the study of human thinking, learning and behaviour.

Courses and qualifications in which there is incomplete, unbalanced or fragmented coverage of relevant ways of developing (a) knowledge and (b) thinking should be modified. A theoretical framework of thinking and learning should inform any changes made, perhaps beginning with key skills.

Teacher-training courses should include a more solid grounding in theories of thinking and learning than they do at present. In view of the importance which many stakeholders give to the internalising of knowledge and skills by the learner, theories which deal thoroughly with this issue should be included.

In the initial training and post-experience development of teachers, theory should be integrated with experiential learning and professional practice in ways which strengthen critical, creative and caring dispositions. 'Community of enquiry' and 'problem-based learning' are examples of models which appear to meet these requirements and should therefore be fully evaluated in the context of teacher training.

Dialogue and group discussion about how people think and learn should be a planned feature of college provision, available to all students at the start of their studies and on a regular basis.

Because strategic thinking and reflection are of value in all kinds of learning and at all levels, they should form part of all education and training (including work in basic skills and programmes addressing the needs of all students who find learning difficult).

Assessment should be designed to measure much more than the ability to reproduce information and use it to demonstrate understanding. Productive, strategic and reflective thinking should also be assessed with some rigour and not only in learners preparing for higher-level qualifications.

Continuing practitioner enquiry through action research should be directed at finding ways of enabling people to build on previous learning and to make use of their skills and abilities in more areas of their lives. Research and evaluation should be seen as collaborative activities, involving all stakeholders, not least the learners themselves.

Glossary

accommodation
adapting actions to respond to new stimuli (in Piaget's theory)

acculturated
having taken on the ways of thinking and behaving typical of a social group

affective
characterised by emotion

algorithm
a precise rule (or set of rules) specifying how to solve a problem

ampliative
enlarging a conception by adding to what is already known

analogical reasoning
thinking that if things agree in some respects, they probably agree in others

analytic
focusing on the parts of a whole or on underlying basic principles

assimilation
absorbing new information and fitting it into existing knowledge (in Piaget's theory)

attributional training
training which encourages the learner to attribute success or failure to processes within their control (such as effort rather than innate ability)

behaviourist
focusing only on observable stimuli and responses and the relations between them, discounting mental processes

cognitive
concerned with the psychological processes of perception, memory, thinking and learning

conative
expressive of effort and the will to achieve

construct
abstract or general idea inferred from specific instances

constructivist
(educational sense) believing that knowledge or understanding is created when the learner integrates new information with prior knowledge; (philosophical sense) believing that reality does not exist outside our conceptions, and that by conceptualising we 'construct' it

convergent thinking
thinking directed at finding a single correct solution to a well-structured problem

correlated
mutually related

correlation
a measure indicating how far two variables are totally unconnected (zero correlation), or are negatively (eg –0.5) or positively related, as determined by underlying or outside influences

declarative knowledge
knowledge of facts – knowing 'that'

deductive
reasoning from a general statement or definition to a particular instance

diagnosis
identifying the nature or causation of a problem

dialectic
involving a contradiction of ideas which acts as the determining factor in their interaction

dichotomous
dividing into two sharply distinguished parts or classifications

disposition
habit of mind or attitude

divergent thinking
exploratory thinking, seeking different possible ways of coping with ill-structured problems

dynamic assessment
finding out how far performance improves in response to teaching

effect size
a measure of difference or gain in average scores, whereby effect sizes of less than 0.2 (equivalent to a difference of 8 percentile points) are usually considered trivial, between 0.2 and 0.5 small, between 0.5 and 0.8 moderate, and 0.8 or more large (equivalent to a difference of 28 percentile points)

epistemology
the philosophical study of theories of knowledge

extrinsic motivation
the desire to do something in order to obtain an external reward

factor
an underlying dimension or influence

factor analysis
a statistical technique which identifies underlying dimensions in a set of measures by finding groups of items which vary between individuals in similar ways

far transfer
successfully making use of knowledge or skills where the context and performance required are substantially different from those experienced in the learning situation

field independence
being able to see parts of a structure distinctly and objectively

formative assessment
evaluation carried out in the course of an activity in such a way that the information obtained is used to improve learning and/or instruction

g (general intelligence)
a general cognitive ability factor which, in addition to specific abilities and skills, contributes to performance on a wide range of tasks

genetic epistemology
Piaget's theory about how children and young people move through a series of developmental stages, in which their understanding of objects, relationships and concepts is limited by their powers of thought

global
not interested in detail: holistic

heuristic
rule-of-thumb strategy intended to increase the chances of solving a problem

holistic
perceiving a whole object or focusing on the organic nature of a system

inductive
reasoning from particular facts to a general conclusion

intrinsic motivation
the desire to do something for the sake of the experience alone

key skills
government (England and Wales) guidelines on six areas of skill deemed necessary for contemporary living – Communication, Application of Number, Information Technology, Working with Others, Problem Solving and Improving One's Own Learning and Performance

meta-analysis
the process of synthesising a range of experimental results into a single estimate of effect size

metacognition
awareness and conscious use of the psychological processes involved in perception, memory, thinking and learning

metaphysical
dealing with highly abstract ideas about being and knowing which are not derived from the material world

near transfer
successfully applying knowledge or skills when the context and performance required are similar to those experienced in the learning situation

pedagogy
theoretical and procedural knowledge about teaching

percentile
a point on a scale below which a given percentage of a population will score

phenomenological
concerned with the recording and classification of subjective experience

perception
interpreting and understanding information received through the senses

procedural knowledge
knowledge of carrying out processes – knowing 'how'

psychometric
concerned with psychological measurement

psychomotor
relating to movements of the body associated with mental activity

psychosocial
relating to processes or factors that are both social and psychological

rationalist-constructivist tradition
reliance on reason alone to construct one's own understanding

schema (plural: schemata)
a structured mental representation consisting of related concepts

self-efficacy
having confidence in one's ability to succeed

self-regulation
the process of setting goals for oneself and then monitoring and evaluating progress

Socratic questioning
a deeply probing technique to uncover meaning, truth, understanding or beliefs

summative assessment
evaluation of performance carried out at the end of a piece of work

syllogistic reasoning
a deductive inference consisting of two premises which are assumed to be true and a conclusion. *Some women are mortal; some women are angelic; so some mortals are angelic* is invalid

taxonomy
a principled classification of the elements of a domain

transduction
literal copying or mapping

validity
the quality of being well grounded in reality

working memory
the system which temporarily holds the information needed for a particular task

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Appendix 1

Theoretical frameworks for thinking about thinking

	All-embracing family
1950s	
1960s	
1970s	
1980s	**Romiszowski's analysis of knowledge and skills** Romiszowski distinguishes between reproductive and productive learning in four skill domains: cognitive, psychomotor, reactive and interactive. He identifies 12 abilities which may be used in perception, recall, planning and performance. A Cg Cn M E / **ED**

1990s	**Hauenstein's conceptual framework for educational objectives** Acquisition, assimilation, adaptation, performance and aspiration are successive levels of learning in the cognitive, affective and psychomotor domains. At each level and in each domain, Hauenstein identifies processes which help to build understanding, skills and dispositions. A Cg Cn E / **ED**	**Jonassen and Tessmer's taxonomy of learning outcomes** The major categories in this taxonomy are: declarative knowledge, structural knowledge, cognitive component skills, situated problem solving, knowledge complexes, ampliative skills, self-knowledge, reflective self-knowledge, executive control, motivation (disposition) and attitude. A Cg Cn M E / **PS**	**Vermunt and Verloop's categorisation of learning activities** The cognitive categories are: relating / structuring; analysing; concretising / applying; memorising / rehearsing; critical processing; selecting. The affective categories cover motivation and the management of feelings. The regulative categories are an elaboration of 'plan–do–review'. A Cg Cn M E / **PS**
2000s	**Demetriou's model of mind, personality and self** For Demetriou, mind and personality interact at all levels of self-oriented and environment-oriented systems. There are long-term and working self systems, representational and regulatory. Progress through Piaget's stages can be seen in categorical, quantitative, causal, spatial, verbal, social and drawing 'modules'. A Cg M / **PS**	**Marzano's new taxonomy of educational objectives** The *self system* examines the importance of new knowledge, ability to learn and emotions linked with knowledge and motivation. The *metacognitive system* specifies learning goals and monitors execution, clarity and accuracy. The cognitive system deals with retrieval, comprehension, analysis and knowledge utilisation. A Cg Cn M E / **ED**	**Sternberg's model of abilities as developing expertise** This model includes the analytical, creative and practical aspects of 'successful intelligence': metacognition, learning skills, knowledge, motivation and the influence of context. A Cg Cn M E / **PS**

Key

ED Educationalist
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Cn Deals with conation
M Deals with metacognition
E Aimed at educators

	Instructional design family			
1950s	**Bloom's taxonomy of educational objectives (cognitive domain)** This framework is a way of classifying educational goals in terms of complexity. The intellectual abilities and skills of comprehension, application, analysis, synthesis and evaluation are applied to and help build knowledge. Cg E / **PS**	**Feuerstein's theory of mediated learning through instrumental enrichment** Building on his belief in cognitive modifiability, Feuerstein developed the concept of a mediated learning experience in which the mediator uses prescribed tasks to promote thinking rather than rote learning. A Cg M E / **PS**		
1960s	**Ausubel and Robinson's six hierarchically ordered categories** These are: representational learning, concept learning, propositional learning, application, problem solving and creativity. Cg E / **PS**	**Barrett's taxonomy of cognitive and affective dimensions of reading comprehension** The main categories used are: literal comprehension, reorganisation, inferential comprehension, evaluation and appreciation. A Cg E / **ED**	**Gagné's eight types of learning and five types of learned capability** Gagné set out an eight-level hierarchy of learning types, with problem solving at the top. He also identified five domains of learning: motor skills, verbal information, intellectual skills, cognitive strategies and attitudes. A Cg M E / **PS**	**Gerlach and Sullivan's taxonomy of commonly taught behaviours** This is a framework with six categories of student behaviour: name, order, identify (classify), describe, demonstrate and construct. Cg E / **PS**
1970s	**De Block's three-dimensional framework** This framework is focused on learning Latin. The first dimension has four categories: knowledge, comprehension, application and integration. The second dimension is content-based, and the third deals with the development of personal qualities. A Cg Cn E / **ED**	**Hannah and Michaelis's comprehensive framework for instructional objectives** The cognitive, psychomotor and affective domains are covered. Interpreting, comparing, classifying, generalising, inferring, analysing, synthesising, hypothesising, predicting and evaluating are listed as intellectual processes. A Cg E / **ED**	**F Williams' model for developing thinking and feeling processes** This three-dimensional cross-curricular model seeks to encourage creativity. Teachers can use 18 teaching modes to promote fluency, flexibility, originality, elaboration, curiosity, risk taking, complexity and imagination. A Cg Cn E / **ED**	**R Williams' behavioural typology of educational objectives (cognitive domain)** Williams lists types of content (facts, concepts, principles and procedures) and ways of testing the learning involved in: memorisation, summarisation, instantiation, prediction, application and evaluation. Cg E / **ED**
1980s	**Beyer's taxonomy** This is a three-level framework in which eight fundamental skills (based on Bloom) are used in at least ten critical-thinking operations in order to conceptualise, make decisions, and solve problems. Metacognition (thinking about thinking) is emphasised. Cg Cn / **PS**	**Biggs and Collis's SOLO taxonomy** This is an assessment tool looking at the structure of the observed learning outcome. Pre-structural responses betray limited understanding compared with uni-structural and multi-structural responses. Relational and extended abstract responses are qualitatively superior. Cg E / **ED**	**Bruce's modification of Bloom's taxonomy** Instead of having a separate knowledge category, Bruce inserts the sub-categories of knowledge into Bloom's original categories of application, analysis, synthesis and evaluation. Cg E / **ED**	**Marzano's dimensions of thinking** This framework has five interrelated dimensions: metacognition, critical and creative thinking, thinking processes, core thinking skills, and the relationship of content-area knowledge to thinking. A Cg Cn M E / **ED**
1990s	**Presseisen's models of basic, complex and metacognitive thinking skills** Presseisen lists five 'basic processes' which are used in problem solving, decision making, critical thinking and creative thinking. She also lists six metacognitive thinking skills involved in strategy selection, understanding and monitoring. Cg M E / **ED**	**Wiggins and McTighe's six facets of understanding** These authors list three performance facets (explain, interpret and apply) and three qualitative indicators of understanding (perspective, empathy and self-knowledge). A Cg M E / **ED**	**Wong and Williams' integrated thinking model** Knowledge is used in basic thinking, reorganised in critical thinking and generated in creative thinking. Critical thinking consists of three sub-categories: analysing, connecting and evaluating. Cg M E / **ED**	
2000s	**Anderson and Krathwohl's revision of Bloom's taxonomy** Bloom's taxonomy has been refined and developed into a two-dimensional framework using six cognitive processes and four knowledge categories. There is an emphasis on aligning learning objectives with learning activities and assessment. Cg M E / **PS**	**Gouge and Yates' ARTS project taxonomies of arts reasoning and thinking skills** A matrix of Piaget's levels (concrete, concrete transitional and formal operational thinking) and reasoning skills is used to create educational objectives for the visual arts, music and drama. Cg M E / **ED**	**Passig's taxonomy of IT-mediated future thinking skills** This is an extension of Bloom's taxonomy, with the additional category melioration – combining, adapting and using information to solve problems in accordance with cultural and personal meanings. Cg E / **ED**	

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Instructional design family

1950s

1960s

1970s

1980s

Merrill's component display theory
Merrill classifies learning along two dimensions: performance (remember instance, remember generality, use, find) and content (facts, concepts, procedures, and principles).
Cg E / **PS**

Quellmalz's framework of thinking skills
This framework lists five cognitive processes (recall, analysis, comparison, inference/interpretation and evaluation) and three metacognitive processes (planning, monitoring and reviewing/revising).
Cg M E / **ED**

Stahl and Murphy's domain of cognition
These authors set out a multi-stage model of information processing from preparation to generation. They also identify 21 cognitive processes (eg classifying, organising, selecting, utilising, verifying) which may be used singly or in combinations at different levels.
A Cg Cn E / **PS**

Williams and Haladyna's typology for higher-level test items
This framework is three-dimensional, with content, task, and response mode dimensions. The task categories are: reiteration, summarisation, illustration, prediction, application and evaluation (cf Williams 1977).
Cg E / **PS**

1990s

2000s

	Critical/productive thinking family			
1950s	**Altshuller's TRIZ theory of inventive problem solving** There are four main steps: problem definition; problem-solving tool selection; generating solutions; evaluating solutions. A specific problem is an instance of a generic problem which is solved when the appropriate generic solution is returned to a specific solution. Cg M E / **ED**			
1960s	**Allen, Feezel and Kauffie's taxonomy of concepts and critical abilities related to the evaluation of verbal arguments** Twelve abilities are involved in the recognition, analysis and evaluation of arguments. Truth claims depend on testimony and reasons. People should not be misled by rhetoric or the misuse of language. Cg E / **PH**	**Kepner-Tregoe tenets of effective decision making – rational thinking** Rational processes and practical steps are listed in simple language under the following headings: situation appraisal, problem analysis, decision analysis and potential problem (opportunity) analysis. Cg E / **PS**		
1970s	**Lipman's three modes of thinking and four main varieties of cognitive skill** Judgement and reasoning can be strengthened through critical, creative and caring thinking. In education, the four major varieties of higher-order thinking relate to: enquiry, reasoning, information organising and translation. A Cg M E / **PH**			
1980s	**Baron's model of the good thinker** The most important components of the model are the three conscious search processes – for goals, for possibilities and for evidence. Good thinking and the dispositions underlying it are to some extent teachable. A Cg M E / **PS**	**Ennis's taxonomy of critical thinking dispositions and abilities** 'Critical thinking is reasonable reflective thinking that is focused on what to believe or do.' For Ennis, the basic areas of critical thinking are clarity, basis, inference and interaction. He lists 12 relevant dispositions and 15 abilities. Cg M E / **PH**	**Gubbins' matrix of thinking skills** This is a composite list of 'core' critical thinking skills, based on other published lists. The skills are grouped under the following headings: problem solving, decision making, inferences, divergent thinking, evaluating, philosophy and reasoning. Cg M E / **ED**	**Halpern's reviews of critical thinking skills and dispositions** Halpern's skill categories are: memory, thought and language, deductive reasoning, argument analysis, hypothesis testing, likelihood and uncertainty, decision making, problem solving, and creative thinking. She also lists six relevant dispositions. Cg Cn M E / **PS**
1990s	**Jewell's reasoning taxonomy for gifted children** Jewell's taxonomy has three fields: objectives of reasoning, reasoning strategies and reasoning dispositions. The disposition to adopt thinking about thinking (metacognition) as a habit is very important. A Cg M E / **PH**	**Perkins, Jay and Tishman's dispositional theory of thinking** Seven dispositions are listed: to be broad and adventurous; to sustain intellectual curiosity; to clarify and seek understanding: to be 'planful' and strategic; to be intellectually careful; to seek and evaluate reasons; to be metacognitive. A Cg Cn M E / **PS**		
2000s				

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Critical/productive thinking family

1950s

1960s

1970s

1980s

Paul's model of critical thinking
The model has four parts: elements of reasoning, standards of critical thinking, intellectual abilities and intellectual traits. The first three parts focus on what is essential to critical thinking and the fourth on what it is to be a critical thinker.
A Cg Cn M E / **PH**

1990s

2000s

Cognitive structure and/or development family

1950s

Guilford's structure of intellect model
This is a three-dimensional model in which five cognitive operations work with four types of content to produce six types of product. The operations are: cognition, memory, divergent thinking, convergent thinking and evaluation.
Cg / **PS**

Piaget's theory of genetic epistemology
There are three main stages in intellectual development: sensorimotor, representational and formal. In middle childhood, thinking becomes logical rather than intuitive. Not all adults reach the formal operations stage and think in terms of abstract rules and systems.
A Cg M / **PS**

1960s

Perry's developmental scheme
The scheme consists of nine positions which liberal arts college students take up as they progress in intellectual and ethical development. They move from the modifying of 'either or' dualism to the realising of relativism and then to the evolving of commitments.
A Cg Cn M E / **PS**

1970s

Case's theory of intellectual functioning at different stages of development
This Piaget-based theory sets out four stages: sensorimotor, relational, dimensional and vectorial. Within each stage there is progress from unifocal to bifocal to elaborated coordination, each demanding more of working memory.
Cg E / **PS**

De Corte's modification of Guilford's structure of intellect model
This is a three-dimensional model in which five cognitive operations work with four types of content to produce six types of product. The operations are recall, interpretative, convergent and divergent production and evaluation.
Cg / **PS**

1980s

Belenky's 'women's ways of knowing' developmental model
Women in adult education tended to progress from: silence (a reaction to authority) to received knowledge to subjective knowledge to procedural knowledge (including separate and connected knowing), and finally to constructed knowledge.
A Cg E / **ED**

Gardner's theory of multiple intelligences
Gardner identifies nine kinds of intellectual ability: verbal/linguistic, mathematical/logical, musical, visual/spatial, bodily/kinaesthetic, interpersonal, intrapersonal, naturalist and existential.
A Cg M E / **PS**

Johnson-Laird's taxonomy of thinking
This model includes a decision tree for identifying four kinds of problem- solving process: calculation, deduction, induction and creativity.
Cg / **PS**

King and Kitchener's model of reflective judgement
This is a seven-stage model of progression in adolescent and adult reasoning. Assumptions about knowledge and strategies for solving ill-structured problems can move from pre-reflective through quasi-reflective to reflective stages.
Cg E / **ED**

1990s

Boekaerts and Simons' taxonomy of metacognition
These authors list seven metacognitive conceptions and seven metacognitive skills: orienting, planning, monitoring, testing, restoring, evaluating and reflecting. These skills are applied in the fields of memory, attention, cognition, reading and studying.
Cg M / **PS**

Carroll's three-stratum theory of cognitive abilities
This theory has a well-founded empirical basis for thinking of cognitive tasks as making demands on narrow and/or broad abilities as well as on general intelligence.
Cg / **PS**

2000s

Pintrich's general framework for self-regulated learning
Pintrich identifies four phases of self-regulation. Cognition, motivation/affect, behaviour and context can be regulated by:

1. forethought, planning and activation
2. monitoring
3. control
4. reaction and reflection.

A Cg Cn M / **PS**

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Cognitive structure and/or development family

1950s

1960s

1970s

1980s

Koplowitz's stages in adult cognitive development
Koplowitz builds on Piaget's stage theory, but adds two post-modern stages beyond the formal operations stage – post-logical and unitary thinking. The stages reflect changes in how people understand causation, logic, relationships, problems, abstractions and boundaries.
A Cg / **PS**

1990s

2000s

Appendix 2

Descriptions and evaluative summaries of 26 frameworks

These are arranged alphabetically.

Allen, Feezel and Kauffie's taxonomy of concepts and critical abilities related to the evaluation of verbal arguments

Description

This taxonomy (1967) was created by a team of educators at the University of Wisconsin with the intention of promoting critical thinking. It builds on Toulmin's analysis (1958) of the field-invariant nature of the structure of argument (ie truth claim), supported by warrants of various kinds which relate to relevant data. The authors claim that the taxonomy is systematic, coherent and empirically adequate. It is meant to encompass all arguments to be found in everyday discourse and to have mutually exclusive categories. It is a taxonomy of the thinking skills (or critical abilities) involved in constructing and analysing arguments. Critical abilities are defined as the application of principles and standards to newly encountered situations. There are 12 critical abilities and these are listed below, with details of the concepts involved added in (material in brackets).

1
Distinguishing between sentences functioning as statements and sentences functioning as performatives (ie not calling for affirmation or denial).

2
Distinguishing arguments (which include a claim and a justification for it) from other forms of verbal discourse (such as narration and exposition).

3
Recognising the components which are related in statements (classes, individuals and attributes).

4
Recognising types of claim in arguments (attributive, membership, indicative, responsibility and comparative).

5
Recognising testimony (source statement) offered in justification.

6
Appraising testimony in terms of internal and external criteria.

7
Recognising reasons offered as justification; classifying reasons by argumentative function (data or warrant); detecting arguments in which relational statements are suppressed.

8
Recognising various patterns of reasoning; supplying appropriate warrants to relate data to claim; appraising reasons according to relevant rules of inference. (The patterns listed are: sign reasoning, individual to member, member to individual, alternate, parallel case, cause–effect, effect–cause and comparative.)

9
Recognising the degree of acceptability of a claim as determined by the various elements in an argument.

10
Analysing the functions of statements in complexes of interrelated arguments.

11
Detecting irrelevance in argument (in the form of dissuasions and diversions. Dissuasions are: persuasive prefaces, glittering generalisations, name calling, technical terms and circularity. Diversions are: attacking the person or appealing to the populace, to pity, to authority, to force, to ignorance, to large numbers, to humour and ridicule or to speculation.)

12
Detecting misuses of language in argument (ambiguity and equivocation).

The taxonomy is also presented in flowchart form, to show that apart from the overall sequential process of argument recognition, analysis and evaluation, some critical processes can take place in parallel or not at all, depending on the nature of the argument, as well as individual interest or preference (eg identifying patterns of reasoning and evaluating the authority of an external source).

Evaluative summary

Purpose and structure	Indicators of quality	Relevance for teachers and learning	Evaluation of presentation and other features (PMI)
Main purpose(s) To promote critical thinking	**Terminology** Clear Necessarily uses some technical terms	**Contexts of application** Education Work Citizenship Recreation	**Presentation** Available only on microfiche Original has text plus flowchart
Domains addressed Cognitive	**Theory base** Toulmin's work on informal argument	**Pedagogical stance** None	**Plus points** Clarifies in some detail the concepts and vocabulary needed to build and analyse arguments Could be useful as a basis for teaching and assessment
Levels addressed Reflective thinking Productive thinking Basic thinking skills Knowledge recall	**Compatibility** Ennis King and Kitchener Paul	**Practical illustrations for teachers** Enough to explain core concepts	**Minus points** More examples of application in specific domains are needed
Classification by Broadly sequential processes leading to judgement	**Values** Belief in reason	**Relevance for key skills** Low	**Interesting** Deals with argument structure and argument (mis)use

Table 9
Evaluative summary of *Allen, Feezel and Kauffie's taxonomy of concepts and critical abilities related to the evaluation of verbal arguments*

Altshuller's TRIZ (teoriya resheniya izibreatatelskikh zadach) theory of inventive problem solving

Description

TRIZ (Altshuller 1999, based on Russian material written in 1974) is a systematic creativity and innovation process devised as an aid to practical problem solving, especially in engineering. It owes much to the work of Genrich Altshuller whose study of patents led him in 1946 to devise an algorithm for inventive problem solving in the Soviet Union. This 'algorithm', known as ARIZ, from the Russian, is a part of TRIZ. The first published paper about TRIZ appeared in Russian (Altshuller and Shapiro 1956). It is estimated that by 2002, some 1500 person-years have gone into the development of TRIZ. The aim is to encapsulate principles of good inventive practice and set them in a generic problem-solving framework (for more details, see Altshuller 1996, 1999, 2000; Salamatov 1999; Mann 2002). TRIZ may now be described as a philosophy, a process and a series of tools to aid thinking to solve practical problems. TRIZ is intended to complement and add structure to our natural creativity rather than replace it. It is claimed to be the most exhaustive creativity aid ever assembled. More recently, it has been adapted to suit non-material problems, such as those that arise in management.

TRIZ helps the would-be problem solver define a specific problem, see it as a particular kind of problem, identify a potential solution in general terms and translate this into a specific solution. This sequence is illustrated in Figure 9. It should be noted that TRIZ aims to point thinking in directions that are likely to be productive. It does not guarantee solutions: for example, the solver still has to cross the space S in Figure 9. In effect, TRIZ is a collection of tools to aid thinking. Although TRIZ has major unique features, development seems to be eclectic, and thinking aids from a variety of sources are incorporated.

In TRIZ there are four main steps in thinking: problem definition, problem-solving tool selection, generating solutions, evaluating solutions.

Problem definition: in which the would-be solver comes to an understanding of the problem

1
The Problem Explorer provides ways of understanding the problem. These include: a benefits analysis, a problem hierarchy explorer (the original problem, the broader problem, the narrower problem), a '9-windows' tool for exploring resources and constraints (in terms of past, present and future; both within and around the system), and an identification of 'sore' points.

2
The Function and Attribute Analysis (FAA) identifies in detail what the solution is expected to do and what its attributes will be. For example, these can be set out in noun-verb-noun diagrams, rather like concept maps.

3
S-curve Analysis locates the problem on a general development curve (S-shaped). For instance, if the current situation lies near the beginning of the curve, solutions are likely to involve improvements to the system. If it lies at the mature (top) end of the S-curve, an entirely new system may be needed as opportunities for further improvements may be few.

4
The Ideal Final Result (IFR) describes the characteristics of the ideal solution to the problem.

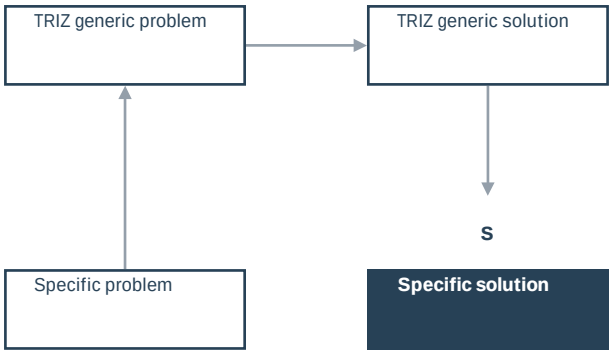

Figure 9
Classifying a specific problem as an instance of a TRIZ generic problem, using TRIZ tools to identify a generic solution, then translating it into a specific solution

Selecting a problem-solving tool

Advice is given on the order in which to try the thinking tools. The order is not intended to be rigid, and different authors may suggest different ways of working. It is also possible to construct short versions so that courses lasting from 2 days to 6 months are offered. It is recognised that short courses are not adequate to do justice to TRIZ and should be seen as taster courses.

Generating solutions: using the tools

1
Technical Contradictions deals with the technical problems identified (eg high strength, but low weight). The solver uses a matrix to identify which of 40 Inventive Principles (strategies) seems to have the potential to suggest a resolution of the contradiction. The use of these 40 generic strategies is said to account for the success of hundreds of thousands of patents. For example, Principle 1: *segmentation* suggests: a) divide a system into separate parts or sections; b) make a system easy to put together or take apart; c) increase the amount of segmentation. All 40 principles are possible ways of improving the functionality of a product by solving relevant problems.

2
Physical Contradictions are the physical problems identified (eg the object must be both hot and cold). Again, a grid provides Inventive Principles that may suggest solutions.

3
S-field Analysis involves codifying the problem into a general form. This general form is used to identify those Inventive Principles that may be useful (as these are also expressed in a general form). In addition, extra charts suggest solutions to difficulties raised by the analysis, such as insufficient or excessive relationships.

4
Evolutionary Trends are patterns of development that have been found to be more or less general among solutions to practical problems. These may suggest ways in which a product might be changed (eg many boundaries to few boundaries to no boundaries; commodity to product to service to experience to transformation).

5
Resources are what is in or around the system. In identifying these, it draws attention to their existence and directs thought to their potential.

6
Knowledge/Effects amount to the know-what and know-how that have the potential to solve the problem. There are three resources for identifying these: a) a database of functional effects; b) a database of ways of altering attributes; and c) knowledge resources to be found online, through a search of patent databases.

7
ARIZ is a problem-solving 'algorithm' originally devised by Altshuller. It involves: defining the specific problem, technical and physical contradictions, the IFR, the x-component (some magical product that eliminates the contradictions); analysing resources; and selecting and applying the Inventive Principles. ARIZ preceded TRIZ, but could be used as a compact or reduced version of it.

8
Trimming is the process of reducing the parts of a solution. Once an existing solution has been given or a new one devised, trimming is used to reduce its elements and to make those left work to maximum effect.

9
IFR refers to the Ideal Final Result, described above. Once it has been identified using the Problem Explorer, the IFR may point the way to solutions that are better than at present. It also serves to narrow the search space to what is manageable and potentially productive.

10
Psychological Inertia (PI) may impede changes in thought. Four ways of breaking out of PI are offered: the 9-windows tool; Smart Little People; a Size-Time-Interface-Cost tool; and the Why-What's Stopping analysis. The first of these draws thinking away from the present and the system to the past, future, sub-system and super-system. The second reconstructs the problem in terms of Little People and uses their behaviour as an analogy to suggest other ways of doing things. The third takes the size and time both to infinity and to zero and asks what happens. The last asks: 'Why do I want to solve this problem?' and 'What's stopping me solving this problem?'

11
Subversion Analysis considers matters of reliability.

Solution evaluation

Ways of analysing various qualitative and quantitative aspects of the solution are described.

TRIZ is an ongoing project, though mature enough to be useful. There is a *TRIZ Journal*, a range of books (eg published by CREAX), plus websites and software. TRIZ offers a structured way of working in the practical problem-solving field and elsewhere. In 1974, Altshuller prepared TRIZ courses for high-school students (the material subsequently translated in Altshuller 1999). Salamatov (1999) claims that TRIZ can be readily mastered by anyone; but in our judgement, it takes time and perseverance, and in its original form requires a foundation in science and technology.

TRIZ is distinctive because it uses the study of historical information to indicate evolutionary trends and to predict the likely nature of solutions. It is also especially noteworthy because it is a generic problem-solving framework that seeks to draw on, relate and apply knowledge from different disciplines (eg biology, chemistry, engineering and physics). It is not unusual for important inventions to draw on knowledge from outside the particular industry within which they are applied, and sometimes from several sciences.

Evaluative summary

Purpose and structure	Indicators of quality	Relevance for teachers and learning	Evaluation of presentation and other features (PMI)
Main purpose(s) To provide a systematic approach to practical problem solving Has some application in management	**Terminology** Few specially defined terms Uses vocabulary of main application area: technology	**Contexts of application** Education Work	**Presentation** Instruction manuals and websites for enthusiasts
Domains addressed Cognitive	**Theory base** Evolutionary biology Natural science Systemic theory Psychology of problem solving	**Pedagogical stance** Prescriptive: teacher/text-directed Intended for creative application when understood	**Plus points** Skills can be acquired and used at several levels TRIZ structures and guides thinking in complex technological situations Practical relevance is apparent
Levels addressed Reflective thinking Productive thinking Basic thinking skills Knowledge recall	**Compatibility** Ennis Halpern Jonassen and Tessmer Marzano	**Practical illustrations for teachers** Many examples provided	**Minus points** Needs time to acquire and expertise in use At higher learning levels, application can be demanding
Classification by Temporal order of use of skills	**Values** Skills widely accessible with training	**Relevance for key skills** High	**Interesting** Supports the idea that both generic thinking skills and knowledge from different fields are needed in practical problem solving Software is available to aid users

Table 10
Evaluative summary of *Altshuller's TRIZ (teoriya resheniya izibreatatelskikh zadach) theory of inventive problem solving*

Ausubel and Robinson's six hierarchically ordered categories

Description

Ausubel is best known for his theory of meaningful learning, developed in the 1960s (Ausubel 1968). He proposed (1968, 10) that 'rotely and meaningfully learned materials are represented and organized quite differently in the student's psychological structure of knowledge.' He claimed that rote as opposed to meaningful learning is more likely to take place when:

- the material to be learned lacks logical meaning
- the learner lacks the relevant ideas in his/her cognitive structure
- the individual lacks a meaningful learning set (a disposition to link new concepts, propositions, and examples to prior knowledge and experience).

Although he is not opposed to rote-learning techniques in, for example, the teaching of phonics, Ausubel sees the development of conceptual understanding as the goal of education. However, he asserts (1978, 530) that much of what is termed conceptual understanding is actually the assimilation (rather than the formation) of concepts: 'Most of what anyone really knows consists of insights discovered by others that has been communicated to him or her in a meaningful fashion'.

It is therefore important, in Ausubel's view, for teachers to present new learning in such a way that students can relate it to their existing knowledge, taking into account the complexity of the new learning and the cognitive development of the learners. Ausubel and Robinson (1969) use the following six hierarchically ordered categories in their analysis of learning:

- representational learning
- concept learning
- propositional learning
- application
- problem solving
- creativity.

As in Bloom's taxonomy (1956), here there is an emphasis on the need to build up a store of meaningful knowledge before operating with it at a more advanced level. Representational learning is equivalent to Bloom's *knowledge category*, while concept and propositional learning are equivalent to *comprehension*.

However, while Ausubel sees some value (especially at the secondary stage of education) in using problem-solving approaches within subject areas, he does not believe that the main purpose of education should be to develop generic thinking, enquiry and problem-solving skills. In his view (1978, 583), this idea is: 'little more than an illusory goal and a recurrently fashionable slogan in education. On theoretical and practical grounds it can never amount to more than a critical approach to the teaching of particular subject matter disciplines.'

Creativity and creative thinking fare no better under Ausubel's analysis. He regards genuine creativity as so rare that it is not worth pursuing in most educational contexts, where it is more democratic to use available resources to cater for the needs of the many rather than the few. He goes so far as to say (1978, 546):

Would it not be more realistic to strive first to have each pupil respond meaningfully, actively and critically to good expository teaching before we endeavour to make him or her a creative thinker or even a good critical thinker and problem solver?

Ausubel believes that teacher-directed learning is more effective than learning by discovery, arguing that pupil enquiry can result in uncorrected errors and misconceptions and indeed, meaningless rote learning. Instead, teachers should 'provide ideational scaffolding', especially in the form of *advance organisers* (1967, 26). An advance organiser is '…material that is presented in advance of and at a higher level of generality, inclusiveness, and abstraction than the learning task itself' (Ausubel and Robinson 1969, 606). This provides a framework so that new learning material can be discriminated and integrated with previously learned, related ideas. To be most effective, the organisers should be formulated in terms of language and concepts already familiar to the learner and use appropriate illustrations and analogies.

Ausubel (1978, 352) also proposes that big concepts should be presented first, as the adequacy of prior learning of key superordinate concepts is more important than age or IQ as a predictor of success:

Since subsumption of new information is generally much easier than acquisition of new superordinate concepts, curricula should be planned to introduce the major concepts or propositions early in the course to serve as a cognitive anchorage for subsequent learning.

He also urges teachers (1967, 23) to order the sequence of subject matter by 'constructing its internal logic and organisation and arranging practice trials and feedback'. The aim is to facilitate 'integrative reconciliation'.

Evaluative summary

Purpose and structure	Indicators of quality	Relevance for teachers and learning	Evaluation of presentation and other features (PMI)
Main purpose(s) To ensure that education is informed by psychology To promote meaningful learning	**Terminology** Clear with a comprehensive survey of approaches to teaching and learning Simple explanations of theories such as creativity and discovery learning	**Contexts of application** Education	**Presentation** Clear description of theory, but academic in style and with few practical examples
Domains addressed Cognitive	**Theory base** New learning is assimilated after robust superordinate concepts are established Learning as a process of subsumption, differentiation and integrative reconciliation Draws upon Piaget and Vygotsky	**Pedagogical stance** Teacher structures learning Use of advance organisers to scaffold understanding Start with the big concepts Meaningful learning is an active process, even if it is 'reception learning'	**Plus points** Emphasis on the responsibility of teachers to promote meaningful learning Building on prior learning Using language to support learning, particularly through advance organisers and analogies
Levels addressed Productive thinking Basic thinking skills Knowledge recall	**Compatibility** Anderson and Krathwohl Halpern Jonassen and Tessmer Marzano	**Practical illustrations for teachers** Few examples of how to apply the theory in practice, but some accessible illustrations of the theory	**Minus points** Main emphasis on basic knowledge and skills Belief that few learners will become independent problem solvers Confuses promoting discovery learning and creative thinking with being a creative genius
Classification by Rote or meaningful learning Cognitive complexity Superordinate and subordinate concepts	**Values** Learning should be meaningful All students can learn, within genetically imposed limits, if taught well Opposes sentimentality regarding the critical/creative skills of young learners	**Relevance for key skills** Moderate – a useful reminder of the need to provide a conceptual framework for learning that can render it meaningful	**Interesting** Points out that it is often the case that in schooling we are concerned with the assimilation of existing concepts rather than in the formation of new concepts

Table 11
Evaluative summary of *Ausubel and Robinson's six hierarchically ordered categories*

Baron's model of the good thinker: a typology of attitudes and dispositions related to acquiring and using thinking skills

Description

Baron's key interest lies in how psychology can be used to improve thinking through education. He takes the view (1985, 108) that a major problem with our thinking and decision making is that much of it suffers from 'intellectual laziness' brought on by a lack of actively open-minded thinking. His work explores the origins and processes of irrationality and poor thinking, and aims to find ways of correcting both.

Baron argues that intelligence and rational thinking are closely related in that rationality is a function of the dispositional components of intelligence. He presents rational decision making as being dependent upon the rational formation of beliefs about consequences. He believes that the skills involved in rational thinking are teachable, although not without reference to the thinker's beliefs and goals.

Baron uses the idea of a search–inference framework to argue that thinking begins with doubt and involves a search directed at removing the doubt. In the course of this search, which involves the consideration of *goals, possibilities* and *evidence*, inferences are made, in which each possibility is strengthened or weakened on the basis of evidence. Glatthorn and Baron (1991, 63) outline the model as follows.

1
Thinking begins with a state of doubt about what to do or believe.

2
We usually have a goal in mind when the doubt arises, but we may search for new goals, sub-goals, or a reformulation of the original goal.

3
We search for possibilities.

4
We search for evidence relative to the possibilities.

5
We use the evidence to revise the strengths of the possibilities.

6
We decide that the goal is reached and conclude the search.

Glatthorn and Baron go on to identify the traits of the 'good thinker' in contrast to those of the 'poor thinker'. A good thinker:

- welcomes problematic situations and is tolerant of ambiguity
- is self-critical, searches for alternate possibilities and goals; seeks evidence on both sides
- is reflective and deliberative; searches extensively when appropriate
- believes in the value of rationality and that thinking can be effective
- is deliberative in discovering goals
- revises goals when necessary
- is open to multiple possibilities and considers alternatives
- is deliberative in analysing possibilities
- uses evidence that challenges favoured possibilities
- consciously searches for evidence against possibilities that are initially strong, or in favour of those that are weak.

Baron concentrates on *how* information is processed in thinking, in terms of a search for goals, possibilities and evidence to evaluate possibilities. It is important to note that these processes do not go on in any fixed or hierarchical order, but occur in a flow of dynamic interaction. The search processes are relevant in all types of thinking, which we summarise below, using Baron's terminology as far as possible:

- *diagnosis* – trying to find the source of a problem
- *hypothesis testing* – forming and testing theories
- *reflection* – controlled searching for general principles
- *insight* – where only the search for possibilities is controlled
- *artistic creation* – searching for and evaluating possibilities and goals
- *prediction* – searching for principles and analogies to explain imagined consequences
- *decision making* – choosing between plans on the basis of imagined consequences
- *behavioural learning* – learning about the effects of one's conduct in certain situations
- *learning from observation* – passive acquisition of knowledge.

Evaluative summary

Purpose and structure	Indicators of quality	Relevance for teachers and learning	Evaluation of presentation and other features (PMI)
Main purpose(s) Understanding and correcting irrationality and poor thinking	**Terminology** Clear Non-technical	**Contexts of application** Education Psychology Work Citizenship	**Presentation** Logical Concrete examples given
Domains addressed Cognitive (Affective) Psychomotor Conative	**Theory base** Dewey Simon's concept of bounded rationality Role of strategies in intelligent behaviour Psychological research on bias in judgement	**Pedagogical stance** Teach thinking in each subject, using teacher explanation and enquiry-based learning with an emphasis on problem finding Provide time for and value reflection	**Plus points** Baron's model is easy for learners to understand and use The model can be applied in all types of thinking, including personal decision making Emphasis on the role of dispositions
Levels addressed Self-engagement Reflective thinking Productive thinking Basic thinking skills Knowledge recall	**Compatibility** Anderson and Krathwohl Ennis Jonassen and Tessmer Marzano Paul Pintrich	**Practical illustrations for teachers** Some examples provided of how the model might be used	**Minus points** Does not describe the components of thinking in any detail Not comprehensive
Classification by Type of search Quality of thought and behaviour	**Values** Rationalistic Humanistic	**Relevance for key skills** High	**Interesting** Integrative potential of the model Rationality is a function of intelligence

Table 12
Evaluative summary of *Baron's model of the good thinker: a typology of attitudes and dispositions related to acquiring and using thinking skills*

Belenky's 'women's ways of knowing' developmental model

Description

In *Women's ways of knowing*, Belenky *et al*. (1986) presented a qualitative study of epistemological development in women. They set out to explore women's experiences and problems as learners and knowers through in-depth interviews with 135 female participants. Their informants were rural and urban American women of different ages, class, ethnic backgrounds, and educational histories.

The study is an attempt to identify aspects of intelligence and thinking that may be more common and highly developed in women. Belenky *et al*. contrast their approach with those in previous studies of women's intellectual competencies that sought to minimise intellectual differences between the sexes. The team acknowledges the importance of Perry's scheme (1968) in stimulating their interest in modes of knowing and share his phenomenological approach, based on open and leisurely interviews that establish rapport with the interviewees.

When Belenky *et al*. mapped their data onto Perry's scheme they found that women's thinking did not fit neatly into his categories. Building on his scheme, they grouped women's ways of knowing into the five categories outlined below.

- *Silence*: a position in which women experience themselves as mindless and voiceless and subject to whims of external authority.
- *Received knowledge*: a perspective from which women conceive of themselves as capable of receiving, even reproducing, knowledge from the all-knowing external authorities, but not capable of creating knowledge on their own.
- *Subjective knowledge*: a perspective from which truth and knowledge are conceived of as personal, private, and subjectively known or intuited.
- *Procedural knowledge*: a position in which women are invested in learning and applying objective procedures for obtaining and communicating knowledge.
- *Constructed knowledge*: a position in which women view all knowledge as contextual, experience themselves as creators of knowledge, and value both subjective and objective strategies for knowing.

Belenky *et al*. 'suspected that in women one mode often predominates', namely that women tend to be:

- process-oriented, rather than goal-oriented
- intuitive, rather than rational
- personal, rather than impersonal.

Likewise, women tend to value:

- discovery, rather than didacticism
- related, rather than discrete approaches to life/learning
- being with others, rather than being on their own
- breadth, rather than concentration
- support, rather than challenge
- responsibility and caring for others, rather than self-concern
- inner, rather than outer control and validation
- listening, rather than speaking.

The authors believe that male-dominated conventional educational practice often treats women's ways of knowing as deficient, so that some 'women come to believe that they cannot think and learn as well as men' (1986, 16). The metaphor for women's intellectual development that Belenky *et al*. most emphasise is that of 'gaining a voice'.

Evaluative summary

Purpose and structure	Indicators of quality	Relevance for teachers and learning	Evaluation of presentation and other features (PMI)
Main purpose(s) To make teaching less adversarial and authoritarian To contrast female with male approaches and values	**Terminology** Non-technical	**Contexts of application** Education Work Citizenship Recreation	**Presentation** Uses illustrative case studies
Domains addressed Cognitive	**Theory base** Perry's developmental scheme Feminism	**Pedagogical stance** Learner empowerment through cooperative learning learners construct knowledge	**Plus points** Encourages reflection on ways of knowing Interviewing is a good way of talking about conceptions of thinking and learning
Levels addressed Reflective thinking Productive thinking Basic thinking skills Knowledge recall	**Compatibility** Anderson and Krathwohl Ennis Jonassen and Tessmer Marzano	**Practical illustrations for teachers** Indirect evidence from interviews	**Minus points** The stages also apply to men As the study was cross-sectional, it is not clear when or why changes occurred
Classification by Hypothesised developmental progression	**Values** 'Gaining a voice' Anti-authoritarian Humanistic	**Relevance for key skills** Low	**Interesting** The model applies to non-traditional learners as well as to those in universities

Table 13
Evaluative summary of *Belenky's 'women's ways of knowing' developmental model*

Bloom's taxonomy of educational objectives: cognitive domain

Description

This well-known taxonomy was produced in 1956 by a group of college and university examiners with the initial aims of promoting 'the exchange of test materials and ideas about testing' and of 'stimulating research on examining and on the relations between examining and education' (Bloom 1956, 4). Broader aims of improving communication and practice among educators were also identified. The authors claimed that the taxonomy was a means of classifying intended behaviours 'related to mental acts or thinking' occurring 'as a result of educational experiences' (1956, 12). They intended it to be a useful tool for educators – readily communicable, comprehensive, capable of stimulating thought about educational problems, and widely accepted by curriculum designers, teachers, administrators and researchers.

Bloom's taxonomy consists of six major categories and has a varying amount of detail in the form of sub-categories. The basic structure is shown in Table 14. Bloom's group provided many illustrative examples of actual test items within each category and sub-category, but these are not included here.

The starting point for the group's work was educational practice rather than educational or psychological theory. The group found that no single theory of learning 'accounted for the varieties of behaviors represented in the educational objectives we attempted to classify' (1956, 17). Nevertheless, they tried to order the major categories in terms of complexity and noted a possible association between levels of consciousness and complexity: 'it appears that as the behaviors become more complex, the individual is more aware of their existence' (1956, 19).

According to Bloom, the principle of ordering categories by complexity created a hierarchy in the sense that 'each classification within it demands the skills and abilities which are lower in the classification order'. For example, *application* is above *comprehension* in the hierarchy and 'to apply something requires "comprehension" of the method, theory, principle, or abstraction applied' (1956, 120). More fundamentally, the exercise of any intellectual ability or skill, whether it involves *comprehension*, *application*, *analysis*, *synthesis* or *evaluation*, logically depends on the availability of content in the form of knowledge.

Bloom's group worked according to the following guiding principles (1956, 13–14).

- The major distinctions between classes should reflect … the distinctions teachers make among student behaviours.
- The taxonomy should be logically developed and internally consistent.
- The taxonomy should be consistent with our present understanding of psychological phenomena.
- The classification should be a purely descriptive scheme in which every type of educational goal can be represented in a relatively neutral fashion.

The group had initially planned to create 'a complete taxonomy in three major parts – the cognitive, the affective, and the psychomotor domains'. Their decision to limit their first published taxonomy to the cognitive domain was taken on largely pragmatic grounds. When the affective domain taxonomy was published in 1964, the authors acknowledged considerable overlap between the two taxonomies: 'The fact that we attempt to analyze the affective area separately from the cognitive is not intended to suggest that there is a fundamental separation. There is none.' (Krathwohl, Bloom and Masia 1964, 45) Nevertheless, there is (understandably) a strong emphasis on verbally expressed ideas throughout the cognitive taxonomy and an explicit exclusion of *synthesis* activities which 'emphasize expression of emotional impulses and physical movements, rather than organization of ideas' (Bloom 1956, 165).

As can be seen in Table 14, as well as by the number of pages devoted to it in Bloom (1956), the taxonomic category where least detail is provided is *application*. Bloom says that *application* is 'the use of abstractions in particular and concrete situations and may include general ideas, rules or procedures, generalised methods, technical principles, ideas, and theories which must be remembered and applied' (1956, 205). Bloom stresses that it cannot be assessed unless new and meaningful situations are provided in which the student has to restructure a problem, work out how best to respond and thereby demonstrate transfer.

It is worth asking whether metacognitive processes are included within the taxonomy, especially as the word 'metacognition' did not exist in 1956. This turns out not to be a problem. When the Bloom taxonomic categories are applied to self-knowledge and self-monitoring, the components of metacognition (such as analysing and evaluating one's own thinking) can be identified. Bloom does explicitly value self-regulation.

Table 14
Levels of detail in Bloom's taxonomy (cognitive domain)

Intellectual abilities and skills		
Evaluation:	judgements in terms of	■ internal evidence ■ external criteria
Synthesis:	production of	■ a unique communication ■ a plan ■ a set of abstract notions
Analysis:	of	■ elements ■ organisational principles
Application		
Comprehension:	■ translation from	■ one level of abstraction to another ■ one symbolic form to another form or vice versa ■ one verbal form to another
	■ interpretation	
	■ extrapolation	
Knowledge		
of:	■ specifics	■ terminology ■ specific facts
	■ ways and means of dealing with specifics	■ conventions ■ trends and sequences ■ classification and categories ■ criteria ■ methodology
	■ the universals and abstracts in a field	■ principles and generalisations ■ theories and structures

Evaluative summary

Bloom's cognitive domain taxonomy (1956) has been more influential than any other. Its influence can be seen in many other taxonomic frameworks, including those which focus on critical thinking. As its authors hoped, it has often been adapted or extended, most recently and convincingly by Hauenstein (1998) and by Anderson and Krathwohl (2001).

Purpose and structure	Indicators of quality	Relevance for teachers and learning	Evaluation of presentation and other features (PMI)
Main purpose(s) To stimulate discussion and research about examining To improve communication and practice among educators	**Terminology** Clearly defined Some overlap between categories Easily understood	**Contexts of application** Education	**Presentation** Logical and well structured Accessible summary Although some test items are dated, Bloom's writing is highly relevant today
Domains addressed Cognitive	**Theory base** Not based on a single psychological theory, but compatible with many The importance of history and context are acknowledged Individuals creatively construct knowledge	**Pedagogical stance** Emphasis on transferable learning Enquiry-based learning and self-regulation are favoured Teachers should make much greater use of learning objectives involving *analysis*, *synthesis* and *evaluation*	**Plus points** Deals with both mental activity and observed behaviour Provides a comprehensive means of classifying verbs used in stating educational goals Understandable by learners Useful in curriculum design, teaching and assessment
Levels addressed Reflective thinking (but not explicitly) Productive thinking Basic thinking skills Knowledge recall	**Compatibility** Anderson and Krathwohl Ennis Jonassen and Tessmer Marzano	**Practical illustrations for teachers** Many examples of assessment items, varied in format but mainly in multiple-choice form	**Minus points** The hierarchical principle is weak and contested Sub-categories are not established by applying a principle in a consistent way Broad educational aims are not covered
Classification by Complexity Level in a hierarchy of prerequisites for the use of a particular ability or skill (Possibly) level of consciousness Type of knowledge	**Values** Either neutral or explicit in terms of educational values Values intellectual honesty, creativity, independent thought and decision making, and personal integrity; all of which support a democratic way of life	**Relevance for key skills** High	**Interesting** This taxonomy is the first part of a scheme intended to cover the cognitive, affective and psychomotor domains Bloom raises important questions about the assessment of cooperative learning

Table 15
Evaluative summary of *Bloom's taxonomy of educational objectives: cognitive domain*

Carroll's three-stratum theory of cognitive abilities

Description

This theory is the outcome of factor analyses of some 460 data sets. Carroll (1993, 712) found evidence for a 'substantial number of different cognitive abilities' that differ in generality. The purpose of the study was to order the field of cognitive abilities and guide psychological research and thinking in that domain. Carroll's analyses allowed him to identify three strata of abilities: *general* (applying to all cognitive tasks), *broad* (relating to a range of moderately specialised abilities) and *narrow* (numerous abilities, specialised in specific ways). The stratum is an indication of the degree of generality. This hierarchical model does not, however, imply a tree structure in which higher factors branch individually into clusters of subordinates. A narrow ability may have loadings on more than one factor at a higher level.

The relevance of the theory for the systematic classification and teaching of thinking skills rests on the extent to which a cognitive ability can be seen as an identifiable, purposive facility in thinking that is also open to instruction. As Carroll defines cognitive ability as the conscious processing of mental information that enables a more or less successful performance of a defined task (paraphrasing Carroll 1993, 8–10), he admits a purposive facility in thinking which is identifiable on the basis of task performance. Elsewhere, he writes: 'No simple answer can be given to the question of whether cognitive abilities are malleable or improvable through specific types of experiences and interventions. Undoubtedly, some abilities are more malleable than others' (1993, 686). He sees general and broad abilities as relatively long-lasting and persistent attributes, but allows that narrow abilities may be open to instruction. This stratum of abilities, then, is likely to be the most relevant for the classification and teaching of thinking skills.

Insofar as his data sets allowed, Carroll also looked for differences in factor structures across cultural, ethnic and racial groups and across gender, but found little evidence of systematic variation.

The following list indicates what is in each level (but is highly selective at stratum 3, where the focus is productive thinking).

Stratum 1
General intelligence
(likely to be correlated with speed of information processing and capacity of working memory)

Stratum 2
Broad abilities

- fluid intelligence (concerned with the basic processes of reasoning that have a minimal dependency on learning)
- crystallised intelligence (mental processes which depend heavily on developed abilities, especially those involving language)
- indeterminate combinations of fluid and crystallised intelligence
- broad visual perception (involved in tasks requiring the perception and visualisation of shapes and spatial relationships)
- broad auditory perception (involved in tasks requiring the perception of sounds, including speech sounds and music)
- broad cognitive speediness (involved in tasks that require rapid transmission and processing of information)
- general memory ability (involved in tasks where new content or responses are learned and remembered)
- broad retrieval ability (involved in the ready retrieval of information from long-term memory).

Stratum 3
Narrow abilities
(approximately 170 of these)

- sequential reasoning (starting from stated premises, rules or conditions and engaging in one or more steps of reasoning to reach a conclusion that follows from the premises)
- induction (discovering the rules that govern the materials or the similarities or contrasts on which rules can be based)
- quantitative reasoning (reasoning with concepts involving mathematical relations in order to arrive at a correct conclusion: the reasoning can be either inductive or deductive or both)
- Piagetian reasoning (at different levels of complexity and abstraction)
- visualisation (ability to manipulate visual patterns)
- originality/creativity (success in thinking of original verbal/ideational responses to specified tasks).

The examples above of narrow abilities which are relevant to productive thinking are drawn from what Carroll calls 'level factors'. These factors can exist at more than one level of ability. There are also speed factors, but these have not been illustrated here. In education, the prime concern is generally to establish a certain level of functioning before speed of functioning is addressed, if it is addressed at all.

Evaluative summary

Purpose and structure	Indicators of quality	Relevance for teachers and learning	Evaluation of presentation and other features (PMI)
Main purpose(s) To determine the structure of mental abilities	**Terminology** Technical and psychological	**Contexts of application** Education Work Citizenship Recreation	**Presentation** Detailed statistical analyses Not for the general reader
Domains addressed Cognitive	**Theory base** Psychometrics Theories and models of human abilities	**Pedagogical stance** None	**Plus points** Comprehensive and authoritative Provides empirical support for ways of assessing thinking
Levels addressed Productive thinking Basic thinking skills Knowledge recall Perception	**Compatibility** Anderson and Krathwohl Jonassen and Tessmer Marzano	**Practical illustrations for teachers** None	**Minus points** Many narrow abilities have been studied only in the laboratory It is hard to decide which skills are worth teaching
Classification by Level of generality Factor structure	**Values** Rational-empirical	**Relevance for key skills** Moderate	**Interesting** Can memory and fluency be improved?

Table 16
Evaluative summary of *Carroll's three-stratum theory of cognitive abilities*

Feuerstein's theory of mediated learning through Instrumental Enrichment

Description

Instrumental Enrichment (IE) is an intervention programme developed from Feuerstein's early theory and research on cognitive modifiability (Richelle and Feuerstein 1957). It was originally designed to be used with underachieving adolescents, but has since been implemented in a wide range of settings; for example, with gifted students, dyslexic students, adult learners.

'Instrumental Enrichment is most simply described as a strategy for learning to learn. It uses abstract, content free, organisational, spatial, temporal and perceptual exercises that involve a wide range of mental operations and thought processes.' (Begab 1980, xv). According to Feuerstein, human beings are capable of altering the way they think, through the radical restructuring of the cognitive system. In his work with individuals facing genetic, developmental or socio-cultural challenges, Feuerstein has translated this belief into a number of educational strategies.

Mediated learning experience (MLE) depends on the quality of one-to-one interaction between the learner and the stimuli in the learner's environment, where this interaction is mediated by the presence of a more advanced individual who selects, emphasises, changes and interprets the stimuli for the learner. Feuerstein (1980) argues that an insufficient amount or inadequate type of parental or school-based teaching is responsible for the reduced learning potential of some individuals, and that the infusion of MLE into educational intervention is capable of significantly enhancing learning potential. Instrumental Enrichment emphasises the transfer ('bridging') of the principles discovered through MLE into other areas of learning and mediation of meaning.

Feuerstein's IE cognitive intervention programme targets those cognitive prerequisites of effective learning which, for whatever reason, have remained underdeveloped in an individual. These are addressed through a range of materials including 14 booklets of paper-and-pencil tasks with the following titles.

- *Organisation of dots*
- *Analytic perception*
- *Categorisation*
- *Temporal relations*
- *Transitive relations*
- *Illustrations*
- *Comparisons*
- *Instructions*
- *Numerical progressions*
- *Representational stencil design*
- *Orientation in space 1*
- *Family relationships*
- *Orientation in space 2*
- *Syllogisms*

A list of the cognitive functions said to be tapped and developed through mediated learning with each instrument is provided by Feuerstein, Falik and Feuerstein (1998). There are more than 60 of these (including much duplication) and it is possible to classify them under the following eight headings:

- control of perception and attention
- comparison
- categorisation
- understanding relationships
- defining problems
- thinking hypothetically
- planning
- solving problems.

Feuerstein's theory of learning, instruction and cognitive modifiability has five interlinked aspects, but here we focus on the areas of thinking and problem solving addressed in the Learning Propensity Assessment Device (LPAD) (Feuerstein, Falik and Feuerstein 1998).

The LPAD (first produced by Feuerstein, Rand and Hoffmann in 1979) is designed to assess an individual's capacity to learn through 'dynamic assessment'. Individuals are not only given tasks, but also receive instruction based on the principles of MLE. The assessment takes into account the individual's response to mediation as well as the nature of the help provided.

Table 17
Map of cognitive strengths and weaknesses (adapted from Skuy *et al*. 1991)

Input	
Clear perception/data gathering	Blurred and sweeping perception/data gathering
Systematic exploration of a learning situation	Impulsive exploration of a learning situation
Precise and accurate receptive verbal tools	Impaired receptive verbal tools
Well-developed understanding of spatial concepts	Impaired understanding of spatial concepts
Well-developed understanding of temporal concepts	Impaired understanding of temporal concepts
Well-developed ability to conserve constancies	Impaired ability to conserve constancies
Precise and accurate data gathering	Impaired data gathering
Well-developed capacity to consider more than one source of information	Impaired capacity to consider more than one source of information
Elaboration	
Accurate definition of the problem	Inaccurate definition of the problem
Ability to select relevant cues	Inability to select relevant cues
Ability to engage in spontaneous comparative behaviour	Inability to engage in spontaneous comparative behaviour
Broad mental field	Narrow and limited mental field
Can engage in spontaneous summative behaviour	Does not see need for spontaneous summative behaviour
Ability to project virtual relationships	Inability to project virtual relationships
Perceives need for logical evidence	Lack of need for logical evidence
Ability to internalise events	Inability to internalise events
Ability to use inferential/hypothetical thinking	Inability to use inferential/hypothetical thinking
Ability to use strategies for hypothesis testing	Inability to use strategies for hypothesis testing
Perceives need for planning behaviour	Lack of planning behaviour
Meaningful grasp of time and place	Episodic grasp of reality
Output	
Mature communication	Immature communication
Participatory	Poor participation in discussion, etc
Worked-through responses	Trial-and-error responses
Adequate verbal tools	Inadequate verbal tools
Precise and accurate data output	Impaired data output
Accurate visual transport	Impaired visual transport
Appropriate behaviour	Inappropriate behaviour

There are 13 instruments in the LPAD: four of these are said to assess perceptual-motor functions organised by cognitive components; four assess memory, with a learning component; and five assess higher-order cognitive processes and mental operations. What is striking is the heavy reliance on visual presentation, with only one orally presented test making explicit demands on verbal reasoning. The types of task in the LPAD correspond very closely with those used in the IE teaching programme.

Feuerstein provides a cognitive map to guide the teacher to assess where difficulties in effective thinking may lie. The teacher can then plan the right combination of mediated learning experiences and interactions at the *input*, *elaboration* or *output* phases of the learning process.

Evaluative summary

Purpose and structure	Indicators of quality	Relevance for teachers and learning	Evaluation of presentation and other features (PMI)
Main purpose(s) Promoting a 'learning to learn' approach in assessment and teaching To raise expectations concerning the learning potential of low-attaining groups	**Terminology** Some psychological vocabulary and specially defined terms are used Some theoretical concepts are ill defined	**Contexts of application** Education Work (in a modified form)	**Presentation** Abstract in register Prescriptive
Domains addressed Cognitive	**Theory base** Established models of intellectual and perceptual abilities Vygotsky's theory of socially mediated learning	**Pedagogical stance** Belief in the special quality of one-to-one mediated learning Emphasis on process rather than subject-specific content Skilled 'bridging' is needed to ensure transfer	**Plus points** Belief in cognitive modifiability Many find the materials and procedures helpful
Levels addressed Reflective thinking Productive thinking Basic thinking skills Knowledge recall Perception	**Compatibility** Anderson and Krathwohl Jonassen and Tessmer Marzano	**Practical illustrations for teachers** Special materials and training are offered	**Minus points** Insufficient emphasis on practical, critical and creative thinking Incomplete coverage of cognitive domain makes 'bridging' very difficult Feuerstein has little interest in the use of psychometric methods
Classification by Phase of learning process (input, elaboration, output)	**Values** Socio-cultural elitism Humanism	**Relevance for key skills** Moderate (at lower levels)	**Interesting** Use of 'dynamic assessment' Uses many visually presented problems

Table 18
Evaluative summary of *Feuerstein's theory of mediated learning through Instrumental Enrichment*

Gagné's eight types of learning and five types of learned capability

Description

Gagné (1985, xv) seeks to enable those with an interest in education to: 'acquire an organised schema of human learning as it occurs in situations of instruction … such a schema will be valuable as a referential model against which the complex events of teaching and learning can be compared and evaluated.'

He is concerned with the translation of psychological theory into the effective design of instruction. He believes that a better understanding of how learning operates will facilitate planning for learning, managing learning and instructing. For Gagné, learning ability consists partly of trainable intellectual skills and partly of a strategic thinking capability that can only evolve as a function of experience and intelligence. He analyses learning in terms of the conditions of learning and learning outcomes. The conditions of learning are concerned with the external events that support different types of learned capability, as well as with internal processes.

According to Gagné, we first need to identify and classify learning outcomes. We then analyse the procedural components of learning to reveal prerequisites and to facilitate retrieval of previously learned material from long-term memory. Finally, we provide detailed task descriptions.

For Gagné, the factors that influence learning are chiefly determined by the environment, and many external conditions can be altered and controlled. It is, therefore, possible to study learning in a scientific manner. When analysing a learning task, it should be broken down into steps and a line drawn to indicate what the learner can already do (what is below the line), and what will be learned through the task (above the line). Essentially, Gagné subscribes to an information-processing model of learning, emphasising the mastery that can be achieved through learning and applying rules. His work has its roots in a behaviourist model, which he subsequently revised to address cognitive aspects of problem solving.

Gagné considers prior learning to be extremely important, and this applies to the development of thinking skills. He argues that, as we cannot think in a vacuum, we always draw on acquired basic skills and knowledge. For Gagné, the time spent in formal school acquiring knowledge and intellectual skills does not mean that problem solving and cognitive strategies are being neglected.

In his earlier work, Gagné (1965) identifies eight distinct types of learning, ordered here from simple to complex:

1
signal learning
(classical Pavlovian conditioning)

2
stimulus/response learning
(Skinner's operant conditioning)

3
chaining
(learning sequences of actions through practice)

4
verbal chaining
(learning sequences of words through practice)

5
discrimination learning
(distinguishing similar items by their various features)

6
concept learning
(the identity of classes)

7
rule learning
(organising information using 'if, then' statements about concepts)

8
problem solving
(learning new rules or applying them to new situations).

Categories 2–8 are organised in what is claimed to be a hierarchy of prerequisite skills and abilities. For example, it is impossible to solve a problem without applying a rule. However, motor and verbal chaining provide an exception to the linear hierarchy, as they are at the same level and both have stimulus-response learning as prerequisite skills.

In his later work (Gagné 1985), the eight categories are replaced by five varieties of learned capability (which can be presented in any order).

- *Intellectual skills*. Intellectual skills (which are forms of procedural knowledge) are oriented towards aspects of the learner's environment and are used to solve problems. It is possible to identify organised sets of intellectual skills relevant to learning at the level of rules in specific domains, and these are 'learning hierarchies'. The skills of which the hierarchies are composed are: making discriminations, learning concepts, using rules, using higher-order rules and using procedures.

- *Cognitive strategies*. These are defined as metacognitive and novel problem-solving processes – that is, processes of executive control. Thinking skills are included under cognitive strategies and Gagné talks about the possible existence of a 'master thinking skill' – a form of executive control that governs the management of other skills and strategies. He is of the opinion that this capability, which is essentially the ability to formulate situationally relevant learning strategies, is a form of strategic problem solving that cannot be taught effectively using traditional methods. It is generalised thinking ability – that is, processing ability not tied to a particular intellectual skill, and can only be inductively derived by students through incidental learning over years of practice. Consequently, metacognitive training can only be effective if it is accompanied by opportunities for frequent practice on a long-term basis within a curriculum that supplies an appropriate context for the development of executive control skills.
- *Verbal information*. This is declarative knowledge and is dependent on the recall of internally stored complexes of ideas which constitute 'meaningfully organised' structures. Gagné contributed to the debate regarding the status of declarative and procedural knowledge by claiming that it is possible to be told how to do something (and then be able to do it well) without understanding the process. In fact, focusing too much on unpacking the processes can interfere with learning.
- *Motor skills*. These are psychomotor chains.
- *Attitudes*. Most attitudes are learned incidentally through modelling by key figures, rather than as a result of pre-planned instruction. Attitudes are influential in determining to what and how we pay attention.

Evaluative summary

Purpose and structure	Indicators of quality	Relevance for teachers and learning	Evaluation of presentation and other features (PMI)
Main purpose(s) To help teachers understand learning and instruction To identify the conditions of learning, particularly in terms of prerequisites and the sequencing of learning	**Terminology** Clear Some psychological terms used	**Contexts of application** Education	**Presentation** Detailed breakdown of conditions for learning Clear outline of practical issues
Domains addressed Affective Cognitive Psychomotor	**Theory base** Behaviourist Cognitive Information processing	**Pedagogical stance** Teach according to the identification of the necessary steps for successful learning Practise frequently Establish appropriate conditions for learning according to individual needs	**Plus points** Clear guidelines on instructional design
Levels addressed Reflective thinking Productive thinking Basic thinking skills Knowledge recall Perception	**Compatibility** Anderson and Krathwohl Jonassen and Tessmer Marzano	**Practical illustrations for teachers** Breakdown of steps in learning	**Minus points** Emphasis on efficiency tends to undermine the importance of problem solving in uncertain situations He is not convinced of the value of discovery learning Rooted in behaviourism and so less interested in ideas about the construction of understanding
Classification by Degree of complexity in terms of required stages before learning can take place Type of knowledge	**Values** Concerned with the efficiency of learning in terms of time spent and desired outcomes It is possible to control the learning environment to achieve maximum efficiency	**Relevance for key skills** High for learning some basic skills, but less clear on problem solving	**Interesting** Learning is configured differently in different contexts

Table 19
Evaluative summary of *Gagné's eight types of learning and five types of learned capability*

Gardner's theory of multiple intelligences

Description

Gardner first proposed his theory of multiple intelligences in *Frames of mind* (1983). The theory was a challenge to the 'classical view of intelligence' (Gardner 1993, 5). According to Gardner (1993), the classical view holds that intelligence is a unitary capacity, is genetically determined and can be measured simply by an IQ test. Instead, he began to think of the mind 'as a series of relatively separate faculties, with only loose and non-predictable relations with one another' (1993, 32).

Early in his career Gardner made the following observations while working with children and with brain-damaged adults.

- People have a wide range of capabilities.
- A person's strength in one area of performance does not predict any comparable strengths in other areas.
- Likewise, weakness in one area does not predict either success at or failure in most other cognitive tasks.
- Some children seem to be good at many things, others at very few.
- In most cases, strengths are distributed in a skewed fashion.

Then, with funding for a 5-year project, he systematically read studies in the biological, social and cultural sciences about the nature and realisation of human potential. This resulted in the first edition of *Frames of mind* (1983), in which he first proposed seven intelligences (see below). These represent different ways of thinking and are connected with different areas of experience. As the concept of an intelligence is built around the idea of a core operation or set of operations, it is reasonable to consider it as a set of thinking skills.

Gardner (1999) applied eight inclusion and exclusion criteria to determine what should count as an intelligence. These were:

1
the potential of isolation by brain damage

2
an evolutionary history and evolutionary plausibility

3
an identifiable core operation or set of operations

4
susceptibility to encoding in a symbol system

5
a distinct development history, along with a definable set of expert 'end-state' performances

6
the existence of idiots savants, prodigies, and other exceptional people

7
support from experimental psychological tasks

8
support from psychometric findings.

Gardner thinks of an intelligence as 'a biopsychological potential to process information that can be activated in a cultural setting to solve problems or create products that are of value in a culture' (1999, 33). Whether or not an intelligence is activated depends on 'the values of a particular culture, the opportunities available in that culture, and the personal decision made by individuals and/or their families, schoolteachers, and others' (1999, 34). There is not a leader or an executive among the multiple intelligences to enable people to function effectively. However, each intelligence comprises constituent units or 'sub-intelligences' which are useful for certain educational or training purposes. In practice, these often work together.

Since the publication of *Frames of mind*, other possible intelligences have been discussed for inclusion in the list, such as naturalist intelligence, existential intelligence, spiritual intelligence, and moral intelligence. Gardner (1999) added naturalist and existential intelligences to the original list of seven, but expressed strong views against the inclusion of moral intelligence. The list now reads as follows.

1
Linguistic intelligence – involves sensitivity to spoken and written language, the ability to learn language, and the capacity to use language to accomplish certain goals.

2
Logical–mathematical intelligence – involves the capacity to analyse problems logically, carry out mathematical operations and investigate issues scientifically.

3
Musical intelligence – entails skills in the performance, composition and appreciation of musical patterns.

4
Bodily–kinaesthetic intelligence – entails the potential of using one's whole body or parts of the body to solve problems or to fashion products.

5
Spatial intelligence – features the potential to recognise and manipulate the patterns of wide space as well as the patterns of more confined areas.

6
Interpersonal intelligence – denotes a person's capacity to understand the intentions, motivations and desires of other people; and consequently, to work effectively with others.

7
Intrapersonal intelligence – involves the capacity to understand oneself, to have an effective working model of oneself (including one's own desires, fears, and capacities) and to use such information effectively in regulating one's own life.

8
Naturalist intelligence – demonstrates core capacities to recognise and classify living creatures; to distinguish among members of a species; to recognise the existence of other, neighbouring species; and to chart out the relations, formally or informally, among the several species.

9
Existential intelligence – to have the capacity to be aroused and engaged in circumstances which are essential to human life, and to ask profound questions about the meaning of life and death.

Gardner (1999, 45) makes two essential claims about multiple intelligences.

- The theory is an account of human cognition in its fullness.
- People have a unique blend of intelligences which 'arise from the combination of a person's genetic heritage and life conditions in a given culture and era'.

As human beings, we can mobilise and connect these intelligences according to our own inclinations and cultural preferences, and we can also choose to ignore our uniqueness, strive to minimise it or revel in it. Gardner stresses that all intelligences can be used in constructive or destructive ways.

Evaluative summary

Purpose and structure	Indicators of quality	Relevance for teachers and learning	Evaluation of presentation and other features (PMI)
Main purpose(s) To provide a full account of human cognition To broaden educational experience, enabling more people to succeed	**Terminology** Clear definitions Technical terms explained in simpler language	**Contexts of application** Education Work Citizenship Recreation	**Presentation** Both academic and popularised
Domains addressed Cognitive Affective Psychomotor	**Theory base** Psychometrics Neuropsychology Evolutionary psychology	**Pedagogical stance** Provide for multiple ways of learning Learner-centred, recognising individual strengths and weaknesses Seeks to raise teacher expectations	**Plus points** Gardner applies clear criteria, including evidence from psychometry It has worldwide appeal to educators and learners High value placed on artistic and practical abilities High value placed on emotional and social learning Teachers have to decide how to use it
Levels addressed Self-engagement Reflective thinking Productive thinking Basic thinking skills Knowledge recall Perception	**Compatibility** Anderson and Krathwohl Pintrich	**Practical illustrations for teachers** Enough to encourage teachers to generate many more	**Minus points** Unreasonable denial that there is such a thing as general intelligence (g), as the nine intelligences are less independent than Gardner claims
Classification by Areas of experience	**Values** Equal opportunities Cultural sensitivity	**Relevance for key skills** High	**Interesting** Implications for 'intelligence-fair' assessment

Table 20
Evaluative summary of *Gardner's theory of multiple intelligences*

Gouge and Yates' ARTS Project taxonomies of arts reasoning and thinking skills

Description

These taxonomies were devised by a cognitive acceleration project team seeking to develop a new approach to the teaching of thinking through the creative arts (visual arts, music and drama). The theories informing this approach are those of Piaget (1952) and Vygotsky (1978) [which also underpin the well-known CASE and CAME cognitive acceleration programmes in science (Adey, Shayer and Yates 1995) and mathematics (Adhami, Johnson and Shayer 1998)]. Gouge and Yates (2002, 137) describe how three taxonomies were devised, using basically the same framework 'in order to provide a consistent structure for designing a programme of intervention lessons' for pupils aged 11–14.

In essence, Gouge and Yates have produced a framework for classifying the reasoning skills involved in creative thinking. They state (2002, 137) that creativity 'requires mental discipline, previous experience and a firm grounding in knowledge', and see dangers in the notion that the arts are all about 'fun' and free expression.

Three Piagetian levels of cognitive demand are used: *concrete*, *concrete transitional* and *formal operational thinking*. These are said to correspond with Peel's (1971) *restricted*, *circumstantial*, and *imaginative comprehensive* stages of adolescent judgement. Although 'formal operation thought can begin to develop at about the age of 12', Gouge and Yates claim (2002, 137) that even by the age of 16, few adolescents are 'deductive, rational and systematic' in their thinking, able to 'reason about hypothetical events that are not necessarily in accord with their direct experience'. Their aim is to accelerate adolescent cognitive development beyond the level where pupils can only 'make simple assumptions and deductions to offer imaginative explanations'.

Five reasoning patterns are common to all three taxonomies, but a sixth pattern (narrative seriation) is used in the taxonomy for drama. The common 3x5 matrix, within which sets of educational objectives are located, is illustrated in Table 21.

The six reasoning patterns are based on unpublished work by Fusco (1983). They are not ordered by any principle and no claim is made as to their comprehensiveness. A summary is provided below:

- *classification* – the ability to group or order attributes or objects by one attribute or criterion
- *frames of reference* – dealing with relativity of thought by attempting to reconcile conflicting information and reach closure
- *symbolic reasoning* – the use of a wide range of visual and auditory symbols to create imagery and perspective and to communicate ideas
- *critical reflection* – the development of judgement, from restricted to imaginative and comprehensive forms
- *intention, causality and experimentation* – the act of making, including hypothesising and trialling
- *narrative seriation* – the ability to sequence and re-sequence actions to create a narrative and to manipulate components to give multiple meanings and layers of complexity.

Each cell in the taxonomy framework contains between two and four educational objectives. The distinctions between the Piagetian stage levels are expressed in several ways, including the number of variables or viewpoints involved, the level of abstraction and the use of argument to support diverse interpretations. Here is an illustrative example for the reasoning pattern *classification*, taken from the taxonomy for music:

- *Concrete*: identify similarities and differences in music; for example, mood and pace.
- *Concrete transitional*: compare and contrast pieces of music using more than two variables simultaneously.
- *Formal operational*: make rich comparisons of two or more pieces of music, identifying multiple variables such as context, style and instrumentation.

Gouge and Yates do not move beyond a Piagetian framework into a conception of 'post-formal' or 'post-logical' thought, although they do acknowledge that it is not always possible to arrive at firm conclusions on artistic matters. The overall impression is that they have tried to bring an analytic scientific perspective to bear on the creative arts in 'an attempt to deconstruct the neglected aspects of critical thinking which practising artists use intuitively, and which they usually have difficulty in articulating' (2002, 138).

Table 21
The common framework used in the ARTS reasoning taxonomies

	Classification	Frames of reference	Symbolic reasoning	Critical reflection	Intention, causality and experimentation
Concrete					
Concrete transitional					
Formal operational thinking					

Cognitive acceleration is based on the five pedagogical principles, with reasoning patterns being the focus of each lesson. These principles are as follows:

1
cognitive conflict within Vygotsky's 'zone of proximal development'

2
social construction of knowledge with teacher and peer mediation

3
preparation (including establishing a shared language) and 'bridging' (creating links to facilitate transfer to other domains of experience)

4
metacognition (thinking about one's own thinking)

5
reasoning patterns (in this case, the six patterns listed above).

It remains to be seen how teachers will respond to cognitive acceleration in the arts. It is intended to be a challenge to teachers 'to restructure their attitudes and behaviour as mediators of cognitive development' (2002, 138). Some may see it as being inimical to creativity, while it may stimulate others to achieve a new synthesis between the affective, motivational and cognitive aspects of their practice.

Evaluative summary

Purpose and structure	Indicators of quality	Relevance for teachers and learning	Evaluation of presentation and other features (PMI)
Main purpose(s) To use the arts as a vehicle for cognitive acceleration To promote creative and critical thinking	**Terminology** Clear Technical terms are explained	**Contexts of application** Education	**Presentation** One-page tabular format Well structured and not too complex
Domains addressed Cognitive	**Theory base** Piaget Vygotsky Fusco Peel	**Pedagogical stance** Directive, but also facilitatory in enabling the mediation and construction of meaning Learning through peer coaching and collaboration	**Plus points** Gives equal weight to creative and critical thinking in education Provides a structured framework for the sequencing of learning objectives All learners are expected to be creative
Levels addressed Reflective thinking Productive thinking Basic thinking skills Knowledge recall	**Compatibility** Anderson and Krathwohl Ennis Jonassen and Tessmer Marzano	**Practical illustrations for teachers** Curricula for the visual arts, music and drama have been developed	**Minus points** Equates value with complexity of analysis Seemingly arbitrary choice of reasoning patterns Little attention is paid to the part played by the emotions in the creative arts
Classification by Piagetian cognitive level Subject area	**Values** Rationalist Social constructivist	**Relevance for key skills** High	**Interesting** Similarities and differences between problem solving in science and the arts How to accommodate relativism within formal operational thinking

Table 22
Evaluative summary of *Gouge and Yates' ARTS Project taxonomies of arts reasoning and thinking skills*

Gubbins' matrix of thinking skills

Description

This account is based on a description by Sternberg (1986) and material which can be downloaded from the social studies section of the curriculum of the North Shore School District 112 (Gubbins 1999). Gubbins (1986) surveyed a large number of critical thinking skill taxonomies and compiled a list of 'core' skills common to the majority of them. Gubbins (2002) has confirmed that the term 'matrix' is inappropriate and is not hers. She sees the core skills as a list, organised under six main headings. There is no overall organising principle, but there is an implied time sequence within the first two.

1 Problem solving

- identifying general problem
- clarifying problem
- formulating hypothesis
- formulating appropriate questions
- generating related ideas
- formulating alternative solutions
- choosing best solution
- applying the solution
- monitoring acceptance of the solution
- drawing conclusions

2 Decision making

- stating desired goal/condition
- stating obstacles to goal/condition
- identifying alternatives
- examining alternatives
- ranking alternatives
- choosing best alternative
- evaluating actions

3 Inferences

- inductive thinking skills
- determining cause and effect
- analysing open-ended problems
- reasoning by analogy
- making inferences
- determining relevant information
- recognising relationships
- solving insight problems
- deductive thinking skills
- using logic
- spotting contradictory statements
- analysing syllogisms
- solving spatial problems

4 Divergent thinking skills

- listing attributes of objects/situation
- generating multiple ideas (fluency)
- generating different ideas (flexibility)
- generating unique ideas (originality)
- generating detailed ideas (elaboration)
- synthesising information

5 Evaluating thinking skills

- distinguishing between facts and opinions
- judging credibility of a source
- observing and judging observation reports
- identifying central issues and problems
- recognising underlying assumptions
- detecting bias, stereotypes, clichés
- recognising loaded language
- valuating hypotheses
- classifying data
- predicting consequences
- demonstrating sequential synthesis of information
- planning alternative strategies
- recognising inconsistencies in information
- identifying stated and unstated reasons
- comparing similarities and differences
- evaluating arguments

6 Philosophy and reasoning

- using dialogical/dialectical approaches.

Gubbins aimed to provide comprehensive coverage of critical and creative thinking (and combinations of the two). What she does not deal with is Lipman's 'caring thinking' (1995), in which feelings and dispositions are strongly involved. Her *philosophy and reasoning* category is potentially useful and does not often appear elsewhere. However, Gubbins does not include in it ways of thinking about systemic or epistemological issues.

Evaluative summary

Purpose and structure	Indicators of quality	Relevance for teachers and learning	Evaluation of presentation and other features (PMI)
Main purpose(s) To bring order to a complex field	**Terminology** Clear	**Contexts of application** Education Citizenship	**Presentation** Presented as a list, without definitions or rationale
Domains addressed Cognitive	**Theory base** All major authorities on critical thinking	**Pedagogical stance** None	**Plus points** Not too complex Includes creativity
Levels addressed (Reflective thinking) Productive thinking	**Compatibility** Anderson and Krathwohl Biggs and Collis Ennis Jonassen and Tessmer Marzan Paul Pintrich	**Practical illustrations for teachers** None	**Minus points** Metacognition is not explicitly covered 'Caring thinking' is not covered
Classification by Time sequence in problem solving and decision making	**Values** Not known	**Relevance for key skills** High	**Interesting** Includes non-verbal thinking Wide coverage of productive thinking

Table 23
Evaluative summary of *Gubbins' matrix of thinking skills*

Guilford's structure of intellect model

Description

Guilford's structure of intellect model (1958) is a theory which aims to explain the nature of intelligence (Guilford 1958, 1967, 1977, 1982; Guilford and Hoepfner 1971). It is a way of describing thinking in terms of three dimensions: *operations*, *content* and the complexity of the *products* of thought. The resulting 5x4x6 model is illustrated in Figure 10 and its sub-categories are explained in Table 24.

Guilford's three dimensions of *content*, *operations* (functions) and *products* (classified in terms of structure) are based on distinctions made by Piaget, while the operations dimension uses categories which resemble those used in Bloom's taxonomy (Guilford 1967). Apart from the fact that Guilford does not include a category like Bloom's *apply*, the two sets of categories correspond quite closely (for example, Guilford's *convergent production* resembles Bloom's *analysis* and *divergent production* resembles Bloom's *synthesis*). Each cell of the model is defined in terms of the three dimensions, so 'DSU' refers to divergent semantic units or word fluency. Identifying the meaningfulness of the other 149 cells is quite a task!

Guilford researched and developed a wide variety of psychometric tests to measure the specific abilities proposed by his structure of intellect theory. These tests provide an operational definition of many of the abilities. Factor analysis was used to determine which tests appeared to measure the same or different abilities. Correlations between the psychometric tests designed to assess different abilities (Guilford 1982) indicate that the proposed mental abilities are not completely independent.

An important aspect of Guilford's theory is that intelligence is modifiable and that through accurate diagnosis and remediation, an individual's performance in any aspect of thinking can be improved. Another important feature of Guilford's approach is his interest in creativity (1950). The *divergent production* operation identifies a number of different types of creative ability. Many researchers have been influenced as a result (eg Torrance 1966; McCrae, Arenberg and Costa 1987; Runco 1992).

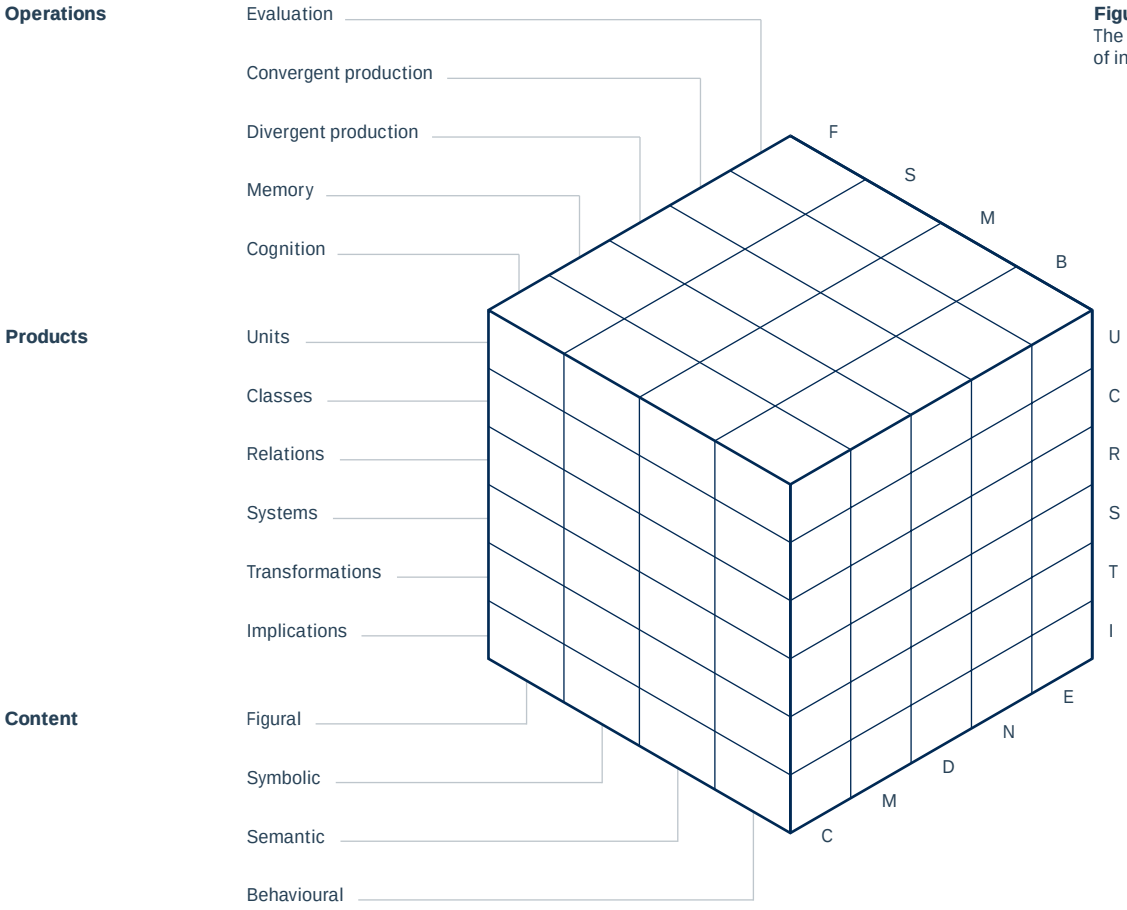

Figure 10
The structure of intellect model

Table 2.4
Guilford's model, with sub-category descriptors

Operations	
Cognition	Recognising, understanding or comprehending information
Memory	Stored information
Divergent production	Generating a variety or a quantity of alternative information
Convergent production	Generating information through analysis and reason
Evaluation	Comparing the information generated with established criteria
Content	
Figural	Concrete information in images, using the senses of sight, touch, and hearing
Symbolic	Information represented by signs, letters, numbers or words that have no intrinsic meaning in and of themselves
Semantic	Meaning contained in words (eg talking and thinking), or pictures
Behavioural	Non-verbal information about people's attitudes, needs, moods, wishes and perceptions
Products	
Units	Separated items of information
Classes	Items grouped by common characteristics
Relations	Connections between items based on changeable characteristics
Systems	Interrelated parts and/or structured items of information
Transformations	Changes in the existing information or its function
Implications	Predictions, expected outcomes, or consequences of information

The distinction between convergent and divergent production is just one of the features of the structure of intellect model which led Guilford (1980) to propose that it provides a unifying theoretical basis for explaining individual differences in cognitive style as well as intelligence. He suggested that Witkin's (1962) concept of *field independence* may correspond with a broad set of 'transformation' abilities and that many existing cognitive-style models are based on preferences for different types of content, process or product (eg visual content, the process of evaluation, products which are abstract).

The structure of intellect model illustrates how diverse abilities, as defined by various combinations of operations, content and products, can work together in the course of thinking. It has been widely used in programmes aiming to develop thinking skills, such as the Structure of Intellect (SOI) programme (Meeker 1969).

Evaluative summary

Purpose and structure	Indicators of quality	Relevance for teachers and learning	Evaluation of presentation and other features (PMI)
Main purpose(s) To provide a comprehensive model of intelligence as a basis for developing psychological tests	**Terminology** Terminology is clear, but the combinations of terms in the model are harder to understand	**Contexts of application** Education Work	**Presentation** The cuboid model brings logical structure to a highly complex field
Domains addressed Cognitive Affective (some aspects through 'behavioural' content)	**Theory base** Psychometrics and psychology Relates ideas to Piaget Makes links with Bloom explicit	**Pedagogical stance** Practice and feedback are important, to overcome confusion and help develop transposable skills	**Plus points** Extensive empirical base Inclusion of creativity Helps to explain learning preferences
Levels addressed Productive thinking Basic thinking skills Knowledge recall Perception	**Compatibility** Anderson and Krathwohl Biggs and Collis	**Practical illustrations for teachers** None	**Minus points** The model is not analysed in terms of different contexts of knowledge Some aspects of thinking are omitted (eg kinaesthetic, affective)
Classification by Three key dimensions: content, product and operations	**Values** Modifiability of intelligence	**Relevance for key skills** Moderate	**Interesting** The content dimension draws attention to mode of presentation and form of mental representation Persuasive analysis of intelligence, thinking and cognitive style

Table 25
Evaluative summary of *Guilford's structure of intellect model*

Hannah and Michaelis's comprehensive framework for instructional objectives

Description

Acknowledging their debt to Bloom (1956) and Krathwohl, Bloom and Masia (1964) and drawing on relevant literature about perceptual and motor skills, Hannah and Michaelis (1977) were the first to realise Bloom's original aim of producing a comprehensive framework for the design and classification of educational objectives. They sought (1977, iii) to 'bring objectives back into teaching' by encouraging teachers to write lesson and course objectives 'so that students move from knowledge to operations on knowledge that involve increasingly more complex processes, to greater independence in the development of skills, and to higher levels of commitment insofar as attitudes and values are concerned'.

According to Hannah and Michaelis, the perceptual and knowledge base for learning is built up by data gathering (observing and/or remembering). As shown in Figure 11, the availability of data is a prerequisite for all development. The authors illustrate (1977, 173) the interrelatedness of their categories in the following way:

…a student with prior experience participating in an experiment may observe certain elements, recall prior learnings including a generalization, and quickly state an inference related to the experiment. … Moreover, the student's feeling that she or he is a capable learner … influences both the receptivity to participation in experiment and the willingness to offer ideas. Mastered skills may have been involved in data collection during the experiment.

The categories of *intellectual processes*, *skills* and *attitudes and values* are independent but interacting dimensions, each of which is ordered by a different principle (complexity, degree of learner independence and level of commitment, respectively). All the level headings used are clearly defined, as shown in the examples below.

Generalising – the student expresses a conclusion drawn from the consideration of a number of specific instances.

Inferring – the student uses appropriate generalisations to reach and express conclusions that go beyond the data studied.

Patterning – the student practises a skill with assistance while progressing towards unassisted performance.

Integrating – the student consistently demonstrates a pattern of value-based behaviour.

The scope of Hannah and Michaelis's framework is unrestricted, but it seems not to have been used outside the school age range. The authors did not attempt a thorough academic justification for their framework, but instead put their energies into making it effective over a 5-year period, working with teachers and administrators in the Elk Grove School District in California. It certainly has considerable potential for further development as an instructional design tool and for a range of other uses in the post-16 sector, ranging from teacher education to programme evaluation.

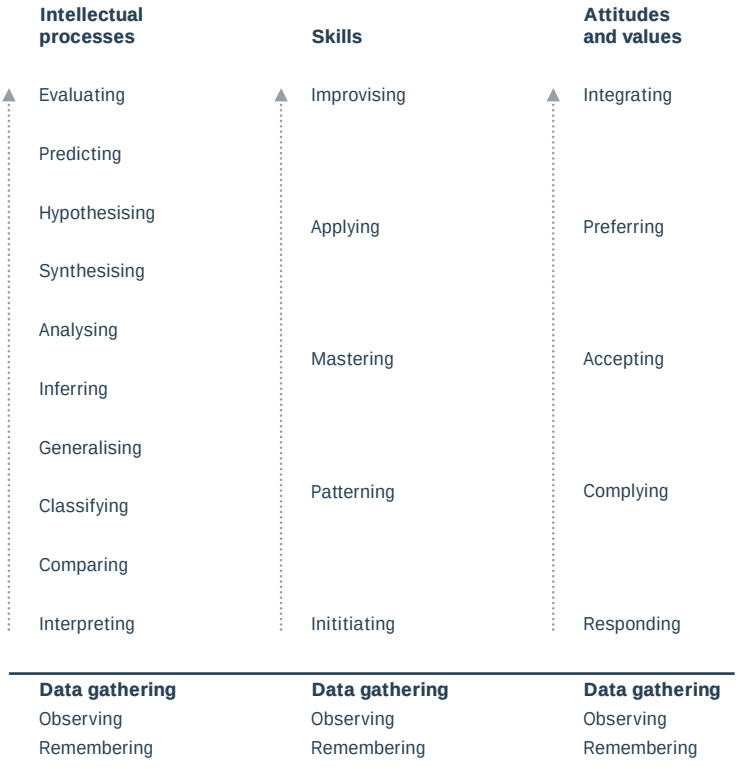

Figure 11 The complete framework for instructional objectives

Evaluative summary

Purpose and structure	Indicators of quality	Relevance for teachers and learning	Evaluation of presentation and other features (PMI)
Main purpose(s) To guide teachers in writing and evaluating objectives To provide a model of how students learn in order to align and improve planning, teaching and assessment	**Terminology** Clear Simple	**Contexts of application** Education Work Citizenship Recreation	**Presentation** Includes definitions, focusing questions and directions, illustrative objectives and assessment tools Teacher-friendly and not too complex
Domains addressed Cognitive Affective Conative Psychomotor	**Theory base** Bloom and other taxonomists of cognitive, affective, and psychomotor domains Compatible with behaviourist and cognitive theories	**Pedagogical stance** Teacher as guide Holistic in that most teaching addresses more than one category and level Promotes skill development for mastery learning Supports learner enquiry, critical thinking and creativity	**Plus points** Deals with long-range and short-term planning Developed with and field-tested by teachers The skill category includes intellectual and motor skills Distinction between covert and overt behaviours Developmental structure
Levels addressed Self-engagement (Reflective thinking) Productive thinking Basic thinking skills Knowledge recall Perception	**Compatibility** Anderson and Krathwohl Ennis Jonassen and Tessmer Marzano	**Practical illustrations for teachers** Many rich and detailed examples at primary and secondary level	**Minus points** Could lead to fragmented instruction No explicit treatment of metacognition
Classification by Complexity Degree of learner independence Level of commitment	**Values** Either neutral or explicit in terms of educational values Democratic human rights	**Relevance for key skills** Very high	**Interesting** Importance given to speed and accuracy Risk of 'death by assessment'?

Table 26
Evaluative summary of *Hannah and Michaelis's comprehensive framework for instructional objectives*

Hauenstein's conceptual framework for educational objectives

Description

It was in 1972 that Hauenstein first published an integrated taxonomical framework in which he accommodated the cognitive, affective and psychomotor domains. His 1998 book sets out a revised version of the original, based on the idea that teachers should not lose sight of the whole person as a learner, since (1998, 125) 'We are what we believe, what we think, and most of all, what we do.' He identifies the long-term aims of education as being to produce *knowledgeable*, *acculturated* and *competent* individuals.

Arguing that the development of feelings, values and beliefs is just as important as gaining knowledge, and critical of the devaluing of practical skills in favour of the academic, Hauenstein points out that all learning involves feeling and doing as well as thinking. He advocates experiential learning and hopes that the use of his framework by teachers will enable students 'to develop their critical, reflective and problem-solving abilities and skills' in all three domains (1998, 29). More specifically, his objectives (1998, xii) are that 'teachers and curriculum planners will have a better understanding of the learning process, be able to classify their objectives accurately, be more cognizant of student learning levels, and be better equipped to provide appropriate interconnected subject matter, objectives and lessons for their students.'

Hauenstein offers three hierarchical taxonomies as well as one in which all three are integrated. The main organising principle is that of a learning hierarchy in which lower-order processes are prerequisites for higher-order processes. He claims that his taxonomies are comprehensive, with mutually exclusive categories, and he seeks to use terms which communicate the meaning of the objectives to teachers. All categories include sub-categories, ordered according to the same principle that applies between levels in the hierarchy.

The composite *behavioural domain* taxonomy has five levels, defined (in brief) as follows.

1
Acquisition – ability to receive, perceive and conceptualise a concept, idea or phenomenon in a specific context.

2
Assimilation – ability to comprehend and make appropriate responses in a situation. Ability to transfer and transform concepts, ideas and perceptions to a similar situation.

3
Adaptation – ability to modify knowledge, skills and dispositions which conform to ascribed qualities, criteria and standards. Ability to demonstrate intellectual and physical abilities and skills with desired qualities and characteristics to do a task or solve a problem in practical or simulated contexts and exhibit a preference for certain values.

4
Performance – ability to evaluate situations and be productive. Includes the acts of analysing, qualifying, evaluating and integrating knowledge, values and beliefs to act in accord with the situation.

5
Aspiration – ability to synthesise knowledge and seek to master skills and demonstrate these in behaviour. Students can synthesise, hypothesise and resolve complex problems, and seek to originate and perfect their abilities and skills.

In Table 27, the complete framework is set out in abbreviated form, with a distinction being made in all cases between short-term (achievable within a single lesson) and longer-term objectives. It is important to note that the behavioural domain is not an additional domain, but a simplified combination of the cognitive, affective and psychomotor domains.

Hauenstein's treatment of both the affective domain and the behavioural composite closely resembles Krathwohl, Bloom and Masia's (1964) classification of educational goals in the affective domain. There is also a family resemblance between Hauenstein's cognitive domain taxonomy and the pioneering work of Bloom and his team (1956). We shall now compare and contrast these two cognitive domain taxonomies.

Table 27
Hauenstein's abbreviated taxonomy of educational objectives

	Behavioural domain	Cognitive domain	Affective domain	Psychomotor domain
Short-term objectives	1 Acquisition	Conceptualisation	Receiving	Perception
	■ receiving	■ identification	■ awareness	■ sensation
	■ perception	■ definition	■ willingness	■ recognition
	■ conceptualisation	■ generalisation	■ attentiveness	■ observation
				■ predisposition
	2 Assimilation	Comprehension	Responding	Simulation
	■ responding	■ translation	■ acquiescing	■ activation
	■ comprehension	■ interpretation	■ complying	■ imitation
	■ simulation	■ extrapolation	■ assessing	■ coordination
	3 Adaptation	Application	Valuing	Conformation
	■ valuing	■ clarification	■ accepting	■ integration
	■ application	■ solution	■ preferring	■ standardisation
	■ conformation		■ confirming	
Long-term objectives	4 Performance	Evaluation	Believing	Production
	■ believing	■ analysis	■ trusting	■ maintenance
	■ evaluation	■ qualification	■ committing	■ accommodation
	■ production			
	5 Aspiration	Synthesis	Behaving	Mastery
	■ behaving	■ hypothesis	■ demonstrating	■ origination
	■ synthesis	■ resolution	■ modifying	■ perfection
	■ mastery			

At Level 1, Bloom and Hauenstein both include the process of remembering (recall and recognition). Hauenstein calls Level 1 *conceptualisation*, which has the sub-categories of *identification*, *definition* and *generalisation* (by which he means the ability to explain a term or outline a process). At Level 2 (*comprehension*), the sub-categories in the two taxonomies are identical; and at Level 3 (*application*), the only difference is that Hauenstein has two sub-categories, *clarification* and *solution* of problems. Despite the fact that *conceptualisation* includes some processes (such as explaining) which Bloom may have seen as demonstrating comprehension, the two taxonomies are very similar at this level of 'short-term objectives'.

Hauenstein claims that his treatment of 'long-term objectives' provides a better account of critical thinking, reflective thinking, problem solving and decision making than Bloom's higher-order categories of *analysis*, *synthesis* and *evaluation*. Hauenstein uses only two categories, *evaluation* and *synthesis*, each with two sub-categories. He sees analysis as a necessary part of *evaluation*, preceding measurement against a criterion or standard (which he calls *qualification*). *Synthesis* follows *evaluation* and is defined as the 'ability to hypothesise and resolve complex problems which yield new arrangements and answers' (Hauenstein 1998, 49). *Synthesis* is seen as the highest level of thought, as it can include creative, innovative thinking. Hauenstein differs from Bloom in placing *evaluation* below *synthesis* and in treating *analysis* as only a sub-category.

Evaluative summary

Purpose and structure	Indicators of quality	Relevance for teachers and learning	Evaluation of presentation and other features (PMI)
Main purpose(s) To improve instructional design To help teachers be more aware of learning levels	**Terminology** Clearly defined Not always transparent	**Contexts of application** Education	**Presentation** Logical and well structured Rather abstract, with few concrete examples
Domains addressed Affective Cognitive Conative Psychomoto Social	**Theory base** Draws heavily on taxonomies by Bloom and others Uses Piagetian ideas of assimilation and adaptation Knowledge is constructed	**Pedagogical stance** Objectives-driven Emphasises cross-curricular links Student-centred and holistic Experiential learning	**Plus points** Deals with short-and long-term objectives Can be used in curriculum design and implementation Categories and sub-categories are consistently ordered
Levels addressed Self-engagement Reflective thinking Productive thinking Basic thinking skills Knowledge recall Perception	**Compatibility** Anderson and Krathwohl Jonassen and Tessmer Marzano	**Practical illustrations for teachers** Few	**Minus points** Rather weak on metacognition Processes are not analysed in relation to different types of knowledge
Classification by Short-term versus long-term objectives Level in hierarchy of prerequisites for learning Domain of experience Internalisation of knowledge, skills and dispositions	**Values** Tension between habitual conformity and open-mindedness Emphasis placed on individual rather than on social development	**Relevance for key skills** High	**Interesting** Attempt to integrate cognitive, affective and psychomotor domains into a behavioural composite Evaluation seen as a prerequisite for (creative) synthesis

Table 2 8
Evaluative summary of *Hauenstein's conceptual framework for educational objectives*

Jewell's reasoning taxonomy for gifted children

Description

In a conference paper posted on the worldwide web, Jewell (1996) outlines a reasoning taxonomy for gifted education. This is presented, largely from a philosophical perspective, in response to a perceived need to understand how gifted students think and reason. He focuses on classroom text-based activities (in terms of what the activities are trying to achieve and how best to match them to student needs), to provide a foundation for the understanding of advanced reasoning.

Jewell considers the nature versus nurture debate and argues that giftedness manifests as learned behaviour. Following Lipman, he identifies the types of behaviour that may be characteristic of giftedness as:

- creative thinking
- logical / rational / critical thinking
- caring thinking (interpersonal skills and moral behaviour).

The paper focuses on critical thinking, but Jewell argues that creative, critical and caring thinking are not mutually exclusive and should be regarded as complementary aspects of human behaviour. He accepts Ennis's definition (1987) of critical thinking as 'reasonable and reflective thinking focused on deciding what to believe or do'. It has the characteristics of being purposeful, ordering information in order to produce a result and providing reasons for adopting a belief or course of action.

Jewell's taxonomy or 'overview of reasoning objectives, strategies and habits available to the advanced thinker' (1996) is summarised in Table 29.

The exceptionally competent reasoner is seen as a self-directed, self-disciplined, self-monitoring and self-corrective thinker. Jewell identifies the components of thinking as: reasoning, purposeful thinking, ordering information, producing results, and adopting a belief or course of action. He claims that such a list helps teachers to foster reasoning strategies.

Jewell argues that to enable gifted students to develop a disposition for reasoning and mental self-management, a qualitatively different curriculum is required. A school-wide environment should value open-mindedness, objective thinking, impartiality, intellectual integrity and independent judgement.

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Table 29
Jewell's reasoning taxonomy for gifted children

Section A – the objectives of reasoning

To discover how things work in order:

1 to plan
2 to problem solve
3 to decide
4 to recommend
5 to communicate

Section B – reasoning strategies

1 community of enquiry (presented as a five-point code)
2 model construction
3 argument construction
4 considering the evidence
5 moral reasoning

Section C – reasoning dispositions/attitudes/habits

Adopting metacognition as a habit, which involves:

1 questioning own position
2 seeking and offering justification for views
3 constructing or adopting alternative models
4 monitoring own assumptions and thinking habits
5 changing one's mind for good reasons
6 empathising with the beliefs, values and thinking processes of other people.

Evaluative summary

Purpose and structure	Indicators of quality	Relevance for teachers and learning	Evaluation of presentation and other features (PMI)
Main purpose(s) To help teachers understand ■ how gifted students think and reason ■ claims made for	**Terminology** Clear Simple Not fully consistent	**Contexts of application** Education Citizenship	**Presentation** Understandable by teachers and learners Economical
Domains addressed Cognitive Affective Conative	**Theory base** Ennis Lipman	**Pedagogical stance** Lipman's community of enquiry	**Plus points** Purposes of reasoning included Critical, creative and caring thinking seen as interdependent Need to develop metacognition (reflection) as a habit Reasoning treated as an individual and social activity
Levels addressed Reflective thinking Productive thinking Basic thinking skills	**Compatibility** Ennis Jonassen and Tessmer Marzano Paul	**Practical illustrations for teachers** Very few	**Minus points** Does not describe patterns of reasoning and argument Some important dispositions omitted No organising principles within sections
Classification by Phase of reasoning cycle (objectives / strategy / developing habits)	**Values** Rationalism Humanism Independence of thought	**Relevance for key skills** High	**Interesting** Practical approach from a philosopher Wider relevance of the taxonomy

Table 30
Evaluative summary of *Jewell's reasoning taxonomy for gifted children*

Koplowitz's theory of adult cognitive development

Description

The theoretical foundations of Koplowitz's theory (1987) are Piagetian. The first two stages of his theory correspond to Piaget's *concrete operations* and *formal operations*. The remaining stages are two post-formal stages that go beyond Piaget's stage theory. At the third stage, *post-logical* or *system thinking*, the individual understands that there are often simultaneous causes that cannot be separated. Koplowitz then offers a fourth stage, *unitary operational thought*, where the way we perceive the external world is only one of many possible constructs, and causality which had been thought of as linear is now seen as pervading all the universe, connecting all events with each other. This connectivity of all things is holistic, going beyond rational linear thinking, and can best be conveyed through context, metaphors, paradoxes, experience and even mysticism. Koplowitz believes that, although very few people are capable of sustaining a unitary consciousness, many can achieve momentary unitary perspectives of situations.

As implicitly shown in Table 31, Koplowitz (1987) sees his theory as applying to problem solving in personal and social contexts. He illustrates the potential use of the theory by describing a troubled organisation and explaining how individuals at different developmental stages analyse a problem. He maintains that the theory has three main uses.

1
It helps to determine the cognitive development level at which an adult is operating and whether an intervention strategy is required.

2
It provides an insight into where and how it is appropriate to teach critical thinking and the limitations of critical thinking.

3
It is inspirational, in that it encourages us to be passionate about thinking and improving thinking. Logic is not seen as an abstract standard by which thinking can be measured, but rather as a characteristic of one stage of human development.

Koplowitz suggests that there is a need to teach not only logical thinking, but also post-logical thinking. In such teaching, three balances must be maintained. First, there needs to be a balance between thought and action. While it is important to search for evidence and not be impulsive, it is also important to know when to stop thinking and take action. Second, while it is important to be unbiased in the use of evidence, it is also important to trust in one's own hunches and intuitive processes. Third, although adults need to think abstractly, they also need to think concretely and emotionally, although Koplowitz (1987, 231) does acknowledge that 'it might take years of Gestalt therapy to arrive at the ability to move from "confrontation is rude" to "I get embarrassed when confronted"'.

	Pre-logical	Logical	Post-logical	Unitary
Cause	One-step	Linear	Cyclical	All-pervading; cause and effect as manifestations of one dynamic
Logic	Emotion over logic; process not separated from content	Logical	Logic in context	One communication tool out of many
Relation among variables	Unrelated	Independent	Interdependent	Constructed
Blame/problem location	Others	Where problem starts	In the system	Problems as opportunities / boundary constructed
Intervention site	Others	Where the problem is	Where there is leverage	Where appropriate
Ability to deal with the abstract	Concrete	Abstract	Relationships	Spiritual; non-material
Boundaries	Closed	Closed	Open	Constructed

Table 31
Koplowitz's stages in adult cognitive development

Evaluative summary

Purpose and structure	Indicators of quality	Relevance for teachers and learning	Evaluation of presentation and other features (PMI)
Main purpose(s) To promote an inspirational concept of post-logical thinking To provide a tool for consultants to use in assessment and intervention	**Terminology** Clear, with unfamiliar terms well defined	**Contexts of application** Education Work Citizenship Recreation	**Presentation** Enthusiastic writing, with persuasive use of 'Aunt Maud' parable
Domains addressed Cognitive	**Theory base** Piagetian Systems theory Constructivist theories of knowledge Buddhist	**Pedagogical stance** Guru	**Plus points** Compatibility with SOLO taxonomy and related theories Systemic emphasis Has personal and social relevance
Levels addressed Self-engagement Reflective thinking Productive thinking Basic thinking skills	**Compatibility** Biggs and Collis King and Kitchener Perry	**Practical illustrations for teachers** Few	**Minus points** Few practical suggestions provided Some deny the possibility of 'post-logical' thinking Lack of empirical evidence
Classification by Stages of development	**Values** Pragmatism Spiritual elitism	**Relevance for key skills** Moderate	**Interesting** The idea that Aunt Maud is a skilled management consultant

Table 3 2
Evaluative summary of *Koplowitz's theory of adult cognitive development*

Lipman's three modes of thinking and four main varieties of cognitive skill

Description

Although Lipman takes enormous care to qualify all statements which might suggest structural rigidity rather than organic dynamism in his thinking, he clearly offers a theoretical framework and, in several places, ways of classifying thinking (albeit illustrative rather than comprehensive). Here we describe a major change in the structure of his theoretical framework, from a bipartite model in 1991 (describing *critical* and *creative* thinking) to a tripartite one (1995) in which *critical*, *creative* and *caring* thinking are equally important and interdependent. We then focus on his account (1991) of four varieties of cognitive skill: *enquiry*, *reasoning*, *concept formation* and *translation*. This account is very similar in the 1991 and 2003 editions of his book *Thinking in education*.

In the first edition of *Thinking in educatio*n, Lipman defines cognitive skills as 'the ability to make cognitive moves and performances *well*' (1991, 76). Building on Bloom's approach (1956), he distinguishes between *lower-order* and *higher-order* cognitive skills in terms of complexity, scope, the intelligible organisation of a complex field, the 'recognition of causal or logical compulsions' and 'qualitative intensity' (1991, 94). He sees value in a curricular sequence whereby an initial emphasis on comparing, distinguishing and connecting leads to classification, seriation, analogical reasoning and immediate inference and finally to *higher-order thinking*, involving syllogistic reasoning and the use of criteria.

He portrays higher-order thinking as involving both *critical* and *creative* thinking, which are guided by the ideas of truth and meaning respectively. Critical and creative thinking are interdependent, as are criteria and values, reason and emotion. They both aim at judgement, but *critical thinking* is 'sensitive to context' and self-correcting while *creative thinking* is 'governed by context' and 'self-transcending' (1991, 25). *Critical thinking* resembles Bloom's *analysis*, *creative thinking* Bloom's *synthesis*, and *judgement* Bloom's *evaluation* (1991, 51).

A significant shift in Lipman's thinking is evident in his paper on 'Caring as thinking' (1995). Here he presents a tripartite account of higher-order thinking, tracing its lineage to the ancient Greek regulative ideals of the *true* (critical thinking), the *beautiful* (creative thinking) and the *good* (caring thinking). In this account, feelings and emotions play a much more important role than previously, since in matters of importance, caring thinking enacts values and is equated with judgement. The three dimensions or modes of thinking, with their corresponding emphases on technique, invention and commitment are said to be present in varying degrees in all higher-order thinking.

In the second (2003) edition of *Thinking in education*, Lipman consolidates and elaborates his tripartite model. He believes that an enquiry-driven society depends on the education that people experience in critical, creative and caring thinking. These help to build the character structure of *reasonableness* and the social structure of *democracy*. For each type of thinking, he identifies value principles (criteria), which are set out in Figure 12 below.

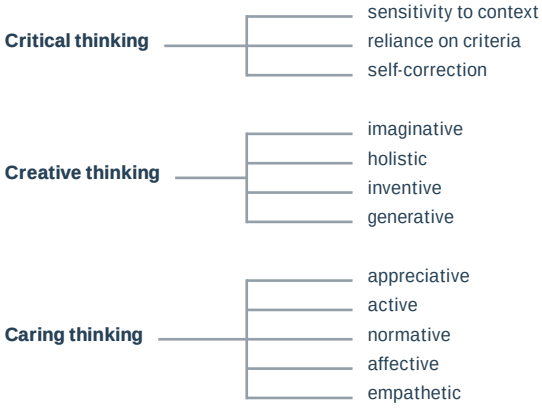
Lipman is inspired by the idea of 'converting the classroom into a community of enquiry' (1991, 15). He claims (1991, 45) that the most relevant skill areas for educational purposes are: *enquiry*, *reasoning*, *information organising* and *translation*. It is important to note that he identifies these four main varieties of cognitive skill as the most important within educational contexts, but makes no claim for comprehensiveness.

Enquiry *is a self-corrective practice in which a subject matter is investigated with the aim of discovering or inventing ways of dealing with what is problematic. The products of enquiry are judgements.*

Reasoning *is the process of ordering and coordinating what has been found out through the enquiry. It involves finding valid ways of extending and organising what has been discovered or invented while retaining its truth.*

Concept formation *involves organising information into relational clusters and then analysing and clarifying them so as to expedite their employment in understanding and judging. Conceptual thinking involves the relating of concepts to one another so as to form principles, criteria, arguments, explanations, and so on.*

Figure 12
Major modes of thinking (with criteria)



Translation *involves carrying meanings over from one language or symbolic scheme or sense modality to another and yet retaining them intact. Interpretation becomes necessary when the translated meanings fail to make adequate sense in the new context in which they have been placed.*

In the above summary, the term concept formation is used to represent what Lipman calls information-organising skills (which he equates with Bloom's *comprehension*). He describes three basic types of informational clustering: the sentence, the concept and the schema. He also stresses the skills of narration and description as being organisational processes which are 'global ways of formulating and expressing what we know'.

In the 2003 edition of *Thinking in education*, Lipman introduces a list of 13 dispositions which are fostered by the meaningfully orchestrated use of cognitive skills in a community-of-enquiry setting. These are:

- to wonder
- to be critical
- to respect others
- to be inventive
- to seek alternatives
- to be inquisitive
- to care for the tools of enquiry
- to cooperate intellectually
- to be committed to self-corrective method
- to feel a need for principles, ideals, reasons, and explanations
- to be imaginative
- to be appreciative
- to be consistent.

For Lipman, the goal and product of thinking is good judgement, and judgements represent meanings. If education fails to provide meaning, it is, according to him, an overall failure. He goes further: 'To compel children to memorise mere content is to deprive them of opportunities to discern relationships and form judgments; it is to make their school experience meaningless.' (1991, 62).

Lipman lists three kinds of relationship that a curriculum must incorporate. These are (1991, 61): 'symbolic relationships (eg linguistic, logical, and mathematical relationships), referential relationships (ie those between symbolic terms or systems and the world they refer to), and existential relationships (ie connections between things in the world)'.

Arguing that a taxonomy of judgement 'would be invaluable for curriculum development in the cognitive aspects of education' (1991, 61), Lipman offers us instead the following list of procedures in which he claims students need practice:

- prejudice reduction
- classification
- evaluation
- criterion identification
- sensitisation to context
- analogical reasoning
- self-correction
- sensitisation to consequences
- adjusting means and ends
- adjusting parts and wholes.

In the 2003 edition of his book, Lipman provides a 21-item table of validities which he wishes even young children to study. This is a sample list of the opposites of common fallacies in informal logic, such as 'attacking the argument, not the opponent' and 'non-circular reasoning'. Lipman states that the informal fallacies violate only five basic value principles: *precision*, *consistency*, *relevance*, *acceptability* and *sufficiency*.

Lipman's critique of educational practice and values is even stronger in 2003 than it was 12 years earlier. He blames 'the Piagetian empire in education' for promoting the widespread belief that young children are 'not capable of monitoring their own thought, of giving reasons for their opinions, or of putting logical operations into practice' (2003, 40). This belief led teachers to misinterpret Bloom's taxonomy as a theory of developmental stages, so that it might not be until late secondary school or even college that children would 'arrive at the adult level, the pinnacle of the entire process, the evaluational stage'. Instead of speaking about higher-order and lower-order thinking (as he did in 1991), Lipman now argues strongly for a non-hierarchical approach to excellence in thinking, claiming that even in the pre-school years, children are potentially young philosophers.

Evaluative summary

Purpose and structure	Indicators of quality	Relevance for teachers and learning	Evaluation of presentation and other features (PMI)
Main purpose(s) To bring meaning to education and democracy To encourage excellence in thinking	**Terminology** Clear Simple	**Contexts of application** Education Citizenship	**Presentation** Enthusiastic writing
Domains addressed Cognitive Affective Conative	**Theory base** Philosophically eclectic Bloom	**Pedagogical stance** Holistic and learner-centred Enquiry-based learning, using dialogue and discussion	**Plus points** High expectations placed on all learners Developing thinking by engaging learners in meaningful activities Integration of critical, creative and caring aspects of thinking
Levels addressed Reflective thinking Productive thinking Basic thinking skills	**Compatibility** Anderson and Krathwohl Ennis King and Kitchener Jonassen and Tessmer Marzano Paul	**Practical illustrations for teachers** Available in separate narrative-based packages	**Minus points** Unclear distinctions between categories Categories are often illustrative rather than comprehensive Practitioners need to have a good understanding of philosophical enquiry
Classification by Lower- or higher-order cognitive skills	**Values** Truth Beauty Goodness	**Relevance for key skills** High	**Interesting** The educational, social and political implications of adopting the 'community of enquiry' model

Table 33
Evaluative summary of *Lipman's three modes of thinking and four main varieties of cognitive skill*

Perry's developmental scheme

Description

As director of the Bureau of Study Counsel at Harvard College from 1947, Perry (1970, 4) decided to study 'the variety of ways in which the students responded to the relativism which permeates the intellectual and social atmosphere of a pluralistic university'. Accordingly, he devised in 1954 a measure called a 'checklist of educational views' (CLEV), which embodied the essential ideas of the scheme (dualism, multiple frames, relativism and commitment). The initial purpose was to enable undergraduate students to think about their own thinking and value systems and so to make progress.

All students participating in the study completed the CLEV and then volunteered to be interviewed towards the end of each year. The developmental scheme was fully worked out after analysis of 98 tape-recorded 1-hour interviews, including complete 4-year records for 17 students. The sample was later extended by another 366 interviews, including complete 4-year records for 67 students. Only two of the 84 complete records were for women students. Trained judges reached high levels of agreement in assigning the interview transcripts to one of nine positions on the chart of development.

The following outline of the chart of development is taken from Perry (1970, 10–11).

Position 1 (strict dualism): the student sees the world in polar terms of we-right-good versus other-wrong-bad. Right Answers for everything exist in the Absolute, known to Authority whose role is to mediate (teach) them. Knowledge and goodness are perceived as quantitative accretions of discrete rightnesses to be collected by hard work and obedience (paradigm: a spelling test).

Position 2 (dualism with multiplicity perceived): the student perceives diversity of opinion, and uncertainty, and accounts for them as unwarranted confusion in poorly qualified Authorities or as mere exercises set by Authority 'so we can learn to find The Answer for ourselves'.

Position 3 (early multiplicity): the student accepts diversity and uncertainty as legitimate but still temporary in areas where Authority 'hasn't found The Answer yet'. He/she supposes that Authority grades him/her in these areas on 'good expression' but remains puzzled as to standards.

Position 4 (late multiplicity): (a) the student perceives legitimate uncertainty (and therefore diversity of opinion) to be extensive and raises it to the status of an unstructured epistemological realm of its own in which 'anyone has a right to his own opinion', a realm which he/she sets over against Authority's realm where right-wrong still prevails; or (b) the student discovers qualitative contextual relativistic reasoning as a special case of 'what They want' within Authority's realm.

Position 5 (relational knowing): the student perceives all knowledge and values (including Authority's) as contextual and relativistic and subordinates dualistic right-wrong functions to the status of a special case, in context.

Position 6 (anticipation of commitment): the student apprehends the necessity of orienting him/herself in a relativistic world through some form of personal Commitment (as distinct from unquestioned or unconsidered commitment to simple belief in certainty).

Position 7 (initial commitment): the student makes an initial Commitment in some area.

Position 8 (multiple commitments): the student experiences the implications of Commitment, and explores the subjective and stylistic issues of responsibility.

Position 9 (resolve): the student experiences the affirmation of identity among multiple responsibilities and realises Commitment as an ongoing, unfolding activity through which he/she expresses his/her lifestyle.

Perry found that most students, although having different starting positions, went through the developmental stages in the same order. However, some got stuck for a year or more, some became alienated and escaped, and some retreated to positions 2 or 3, still believing in absolute, divine or Platonic truth.

The principles and values underlying the scheme are clearly stated, and Perry provides a glossary of key terms. The dimension along which students were expected to progress was a purposive move away from authoritarianism (Adorno *et al*. 1950) towards a synthesis of contextual pragmatism and existential commitment (Polanyi 1958). For some, this involved rejecting a literal interpretation of the Bible, but ending up with a renewed and more tolerant religious faith. The ideal is portrayed as the achievement of a courageous and creative balance between dialectically opposed intellectual and ethical influences, 20 of which are specified. Perry acknowledges a debt to Piaget and sees his scheme as in some ways going beyond Piaget's framework by adding a 'period of responsibility' in which there are 'structural changes in a person's assumptions about the origins of knowledge and value' (1970, 229). The process is seen as a cyclical one in which people are driven by an 'aesthetic yearning to apprehend a certain kind of truth: the truth of the limits of man's certainty' (1970, 63).

Evaluative summary

Purpose and structure	Indicators of quality	Relevance for teachers and learning	Evaluation of presentation and other features (PMI)
Main purpose(s) To understand and facilitate intellectual and moral growth in a pluralistic society	**Terminology** Clear definitions provided where needed	**Contexts of application** Education Citizenship	**Presentation** Accessible and persuasive Good use of case vignettes
Domains addressed Cognitive Affective Conative	**Theory base** Dewey (pragmatism) Existentialism Piaget	**Pedagogical stance** Open, participatory, constructive, holistic	**Plus points** Easily understood as three main stages Theory is grounded in student experience Reliable assessments are possible Encourages reflection Continuing impact on theory and practice
Levels addressed Self-engagement Reflective thinking Productive thinking Basic thinking skills Knowledge recall	**Compatibility** Biggs and Collis King and Kitchener	**Practical illustrations for teachers** Many examples of student views and perceptions	**Minus points** Learners may feel pressure to adopt a certain philosophical position Procedural and routinised learning may be devalued
Classification by Stages in coming to understand the nature of knowledge and belief	**Values** Humanistic Liberal, democratic Ultimately aesthetic	**Relevance for key skills** Moderate	**Interesting** Idea of adapting Perry's approach for use with all learners

Table 34
Evaluative summary of *Perry's developmental scheme*

Presseisen's models of essential, complex and metacognitive thinking skills

Description

Presseisen presents a taxonomy of essential thinking skills, a model of complex thinking skills and a model of metacognitive thinking skills in a chapter in Costa's (2001) book *Developing minds*. This is a revised version of similar material which she originally presented 10 years earlier (in Costa 1991). She seeks to provide a common understanding of 'thinking' which will help teachers in their planning, teaching and assessment. The overriding aim is to improve students' cognitive performance. Presseisen (2001, 52) believes that a shared understanding of thinking will also 'help educators examine the kinds of material available to them to enhance thinking in the classroom'.

According to Presseisen (2001), there are at least five categories of thinking skill that have to be included in a taxonomy of essential thinking skills: *qualifying*, *classifying*, *finding relationships*, *transforming* and *drawing conclusions*. These are ordered from simple to more complex, as shown in Table 35. The main use of such a taxonomy is in 'planning a curricular sequence' (2001, 49).

Essential skills are not enough, since they need to be orchestrated and used in different combinations for different purposes. Presseisen (2001, 58) stresses that it is important that 'educators develop and use a common design to link essential skills to higher-order, more complex operations'. She uses Cohen's (1971) macro-process strategies of *problem solving*, *decision making*, *critical thinking* and *creative thinking* to create a 4x3 matrix with *task*, *essential skills* and *yields*. This produces her model of complex thinking skills in which the elements of the taxonomy can be applied (see Table 36).

In her model of metacognitive thinking skills, Presseisen acknowledges the importance of self-regulation. This has two main dimensions: *monitoring task performance* and *selecting appropriate strategies* (see Table 37).

Presseisen ends her chapter with an overview called a 'Global view of thinking'. In addition to *cognition* and *metacognition*, this introduces two new components.

- *Epistemic cognition*: the skills associated with understanding the limits of knowing, as in particular subject matter and the nature of the problems that thinkers can address.
- *Conation*: the striving to think clearly, including personal disposition, and to develop and consistently use rational attitudes and practices.

No classificatory system is proposed for epistemic cognition and conation.

Table 35
Presseisen's taxonomy of essential thinking skills

Qualifying (finding unique characteristics)	■ recognising units of basic identity ■ defining ■ gathering facts ■ recognising tasks/problems
Classifying (determining common qualities)	■ recognising similarities and differences ■ grouping and sorting ■ comparing ■ making either/or distinctions
Finding relationships (detecting regular operations)	■ relating parts and wholes ■ seeing patterns ■ analysing ■ synthesising ■ recognising sequences and order ■ making deductions
Transforming (relating known to unknown)	■ making analogies ■ creating metaphors ■ making initial inductions
Drawing conclusions (assessing)	■ identifying cause and effect ■ making distinctions ■ inferring ■ evaluating predictions

Table 36
Presseisen's model of complex thinking skills

	Problem solving	Decision making	Critical thinking	Creative thinking
Task	Resolve a known difficulty	Choose the best alternative	Understand particular meanings	Create novel or aesthetic ideas or products
Essential skills emphasised	Transforming; conclusions	Classifying; relationships	Relationships; transforming; conclusions	Qualifying; relationships; transforming
Yields	Solution Generalisation (potentially)	Assessment	Sound reasons Proof Theory	New meanings Pleasing products

Table 37
Presseisen's model of metacognitive thinking skills

Monitoring task performance (leads to more accurate performance of task)	■ keeping place, sequence ■ detecting and correcting errors ■ pacing of work
Selecting and understanding appropriate strategy (leads to more powerful ability to complete thinking processes)	■ focusing attention on what is needed ■ relating what is known to material to be learned ■ testing the correctness of a strategy

Evaluative summary

Purpose and structure	Indicators of quality	Relevance for teachers and learning	Evaluation of presentation and other features (PMI)
Main purpose(s) To plan a curricular sequence To develop a common design for the effective teaching of thinking To outline a 'global view of thinking'	**Terminology** Uses clear definitions Generally accessible	**Contexts of application** Education	**Presentation** Understandable by teachers and learners
Domains addressed Cognitive	**Theory base** Guilford Bloom	**Pedagogical stance** Emphasises application and context of thinking	**Plus points** Sets essential thinking skills in a purposeful context Strong emphasis on the meaningful use of complex thinking and metacognition
Levels addressed Self-engagement Reflective thinking Productive thinking Basic thinking skills Knowledge recall Perception	**Compatibility** Anderson and Krathwohl Jonassen and Tessmer Marzano Pintrich	**Practical illustrations for teachers** Very few examples are given to explain abstract concepts	**Minus points** The relationships between the taxonomy, the two models of thinking and the 'global view' are not obvious Oversimplified account
Classification by Complexity (essential thinking skills) Purpose and control (implicit)	**Values** Rationalist Strong belief that teaching thinking will improve the quality of education	**Relevance for key skills** High	**Interesting** Synthesis of Guilford, Bloom and Marzano Integrates philosophical, psychological and educational approaches

Table 38
Evaluative summary of *Presseisen's model of essential, complex and metacognitive thinking skills*

Quellmalz's framework of thinking skills

Description

Edys Quellmalz is an educational psychologist who produced an integrated thinking skills framework to help teachers and learners understand the strategies and processes used in problem solving. She draws on work by philosophers such as Ennis, by psychologists such as Guilford and Sternberg, and on Bloom's taxonomy. Her framework (1987) is intended for use in the design of instructional and assessment tasks as well as in classroom practice. She wishes greater emphasis to be placed on higher-order skills, since these are needed in different subject areas as well in solving real-life problems. She provides illustrations of analysing, comparing, inferring and evaluating in the subject domains of science, social science and literature (1987). Within subject areas, Quellmalz urges teachers to 'emphasise the use of a full problem-solving process, rather than drill on isolated components' (1987, 95).

The proposed framework is hierarchical only in that a distinction is made between lower- and higher-order thinking skills (Stiggins, Rubel and Quellmalz 1988). It includes a lower-order category called recall, which is a combination of the Bloom categories of *knowledge* and *comprehension*. While *recall* is a means of gaining access to existing knowledge, *higher-order* thinking is about restructuring it. The higher-order thinking strategies and processes are all needed in problem solving and are not seen as hierarchical in terms of difficulty or progression. The higher-order framework as presented in 1987 (see Table 39) includes strategies in which demands are made on both cognitive and metacognitive processes (all of which are seen as teachable).

Stiggins, Rubel and Quellmalz (1988) provide definitions of the higher-order cognitive processes which are paraphrased as follows.

- *Analysis* involves restructuring knowledge by getting information from abstract visual representations, by classifying items, or in terms of whole-part or causal relationships.
- *Comparison* goes beyond whole-part relationships and involves explaining how things are similar and how they are different.
- *Inference* is deductive (moving from the general to the specific) or inductive (moving from details to a generalisation).
- *Evaluation* involves judging quality, credibility, worth or practicality using established criteria.

Table 39
Higher-order thinking strategies and processes

Strategies

Students engage in purposeful, extended lines of thought where they:

- identify the task (or type of problem)
- define and clarify essential elements and terms
- gather, judge and connect relevant information
- evaluate the adequacy of information and procedures for drawing conclusions and/or solving problems.

In addition, students will become self-conscious about their thinking and develop their self-monitoring problem-solving strategies.

Processes

Cognitive	Metacognitive
■ analysis	■ planning
■ comparison	■ monitoring
■ inference/interpretation	■ reviewing/revising
■ evaluation	

Evaluative summary

Purpose and structure	Indicators of quality	Relevance for teachers and learning	Evaluation of presentation and other features (PMI)
Main purpose(s) To encourage the teaching of problem solving across the curriculum	**Terminology** Clear definitions, but some do not accord with common usage	**Contexts of application** Education Citizenship	**Presentation** Teacher-friendly, easily understood Tabular format with trigger words and examples
Domains addressed Cognitive	**Theory base** Cognitive psychology Learners construct meaning Philosophical accounts of critical thinking	**Pedagogical stance** Model and teach metacognition Critical thinking can be infused across the curriculum through extended problem-solving activities	**Plus points** Thinking skills are set in the wider context of problem solving It can help to identify gaps in curriculum and lesson plans The 'plan-monitor-review' cycle is widely used and accepted
Levels addressed Reflective thinking Productive thinking Basic thinking skills Knowledge recall	**Compatibility** Anderson and Krathwohl Ennis Jonassen and Tessmer Marzano Paul Pintrich	**Practical illustrations for teachers** Many provided	**Minus points** It does not deal with motivation, beliefs or dispositions There is no clear organising principle Categories overlap
Classification by No hierarchic order is claimed, but the categories resemble those in Bloom's taxonomy	**Values** Learner autonomy There is an implicit emphasis on convergent rather than divergent and creative thinking	**Relevance for key skills** Very high	**Interesting** Quellmalz's (1987) McRAT Multicultural Reading and Thinking programme could be adapted for use in the post-16 sector There is a cost-effective model for teaching the framework

Table 40
Evaluative summary of *Quellmalz's framework of thinking skills*

Romiszowski's analysis of knowledge and skills

Description

Romiszowski's (1981) analysis of knowledge and skills forms part of his treatment of instructional design, which he places in the still wider context of human resources (HR) development. He aims to achieve a balanced approach to instructional design by taking into account information content, cognitive processing and behavioural responses.

He claims to provide a comprehensive means of classifying knowledge and skills (while recognising that knowledge of a particular topic is seldom of one type and that his categories are non-exclusive). Table 41 lists the types of knowledge which are described by Romiszowski (1981).

Romiszowski then outlines a four-stage skill cycle, applicable in the cognitive, psychomotor, reactive (self-management) and interactive (social interaction) skill domains. The four stages (*perceive*, *recall*, *plan*, and *perform*) are said to be usually, but not always, involved in skilled performance. For example, little or no conscious planning may be involved in repetitive or routine tasks.

The 'expanded' skill cycle is presented opposite (Table 42), in tabular rather than in cyclical form. Romiszowski (1981, 257) presents the skill cycle as 'a language for analysing skills', helpful in identifying gaps between performance requirements and trainee abilities. It is 'a taxonomy if you like', but 'no hierarchical dependencies are implied'.

The complete model of skill development therefore involves the operation of a skill cycle in which knowledge is selected for a particular purpose and used according to a plan. This produces results, which act as new information to be evaluated in relation to purpose and plan.

Skills which require little planning and show little variation in execution from one instance to another are described as *reproductive*, while those which require strategic planning and show substantial variations in execution are termed *productive*. *Reproductive skills* generally map onto Bloom's categories of *knowledge*, *comprehension* and *application*, while *productive skills* involve *analysis*, *synthesis* and *evaluation*. In Table 43, the reproductive–productive skill continuum is shown to apply to skilled performance in all four domains. This skills schema is intended as a means of analysing instructional objectives so as to determine sources of difficulty, before one looks for effective ways to overcome them.

Table 41
Romiszowski's knowledge categories

1.1	**Concrete facts**
1.1.1	concrete associations (things observed and remembered)
1.1.2	verbal (symbolic) information (including all knowledge of a factual naturethat has been gained by means of a symbolic language)
1.1.3	fact systems (structures or schemata)
1.2	**Procedures**
1.2.1	linear procedures (chains)
1.2.2	multiple discriminations (distinguishing similar information)
1.2.3	algorithms (procedures which may be complex, but which guarantee successful performance if followed correctly)
2.1	**Concepts**
2.1.1	concrete concepts (classes of real objects or situations)
2.1.2	defined concepts (concepts which are classes of other concepts and cannot be learned without the use of a suitable language)
2.1.3	concept systems (structures or schemata)
2.2	**Principles**
2.2.1	rules of nature (principles we can observe to be in operation in the world either by direct observation or by inference from their effects)
2.2.2	rules of action (general heuristics regarding the appropriate actions or reactions to specific situations)
2.2.3	rule systems (theories or strategies suitable for a given class of problems)

Table 42
Romiszowski's skill cycle in tabular form

Perceive

1 *attention*: ability to concentrate on the task
2 *perceptual acuity*: ability to recognise the stimuli
3 *perceptual discrimination*: ability to identify the stimuli in a 'noisy' environment

Recall

4 *interpretation*: 'knowing the language' of the stimuli
5 *recall procedures*: having a suitable algorithm 'in store'
6 *recall schemata*: having relevant concepts and principles 'in store'

Plan

7 *analysis*: ability to restructure the problem situation
8 *synthesis*: ability to generate alternative solutions
9 *evaluation*: ability to 'think through' alternatives and implications

Perform

10 *initiation*: ability to make and act on a decision
11 *continuation*: ability to 'see through' the action to the end
12 *control*: ability to 'self-correct' one's actions automatically

Table 43
Romiszowski's schema of skill categories

	Type of 'knowledge content' ⟷	
	Reproductive skills Applying procedures (algorithms)	**Productive skills** Applying principles and strategies
Cognitive skills Decision making, problem solving, logical thinking, etc	Applying a known procedure to a known category of 'problem', eg dividing numbers, writing a grammatically correct sentence	Solving 'new' problems; 'inventing' a new procedure, eg proving a theorem, writing creatively
Psychomotor skills Physical action, perceptual acuity, etc	Sensorimotor skills; repetitive or automated action, eg typewriting, changing gear, running fast	'Strategy' skills or 'planning' skills; arts and crafts, eg page-layout design, 'road sense', playing football
Reactive skills Dealing with oneself; attitudes, feelings, habits, self-control	Conditioned habits and attitudes, eg attending, responding and valuing and approach/avoid behaviours	'Personal control' skills, developing a 'mental set' or a value system; self-actualisation
Interactive skills Dealing with others	Social habits; conditioned responses, eg good manners, pleasant tone, verbal habits	'Interpersonal control' skills, eg leadership, supervision, persuasion, discussion, salesmanship

Evaluative summary

Purpose and structure	Indicators of quality	Relevance for teachers and learning	Evaluation of presentation and other features (PMI)
Main purpose(s) To improve instructional design To identify gaps between objectives and performance	**Terminology** Clear Simple	**Contexts of application** Education Work Citizenshi Recreation	**Presentation** Small print size: not an easy read
Domains addressed Affective Cognitive Conative Psychomotor Social	**Theory base** Eclectic and integrative	**Pedagogical stance** Guided discovery; use of a learning or skill cycle	**Plus points** Understandable by learners Deals with knowledge and learning 'plan–do–review' emphasis
Levels addressed Self-engagement Reflective thinking Productive thinking Basic thinking skills Knowledge recall Perception	**Compatibility** Anderson and Krathwohl Jonassen and Tessmer Marzano	**Practical illustrations for teachers** Examples are provided to help with planning, teaching and assessment	**Minus points** May be too simple for some purposes, as it lacks detailed sub-categories
Classification by Types of knowledge Phase in skill cycle Reproductive–productive skill dimension Skill domain	**Values** Rationalist Technological	**Relevance for key skills** Very high	**Interesting** This analysis is part of a wider approach to instructional design Analysis, synthesis and evaluation are seen as planning skills

Table 4.4
Evaluative summary of *Romiszowski's analysis of knowledge and skills*

Stahl and Murphy's domain of cognition taxonomic system

Description

Stahl and Murphy had the ambitious aim of producing a taxonomy based on the principle of a learning hierarchy of 'levels of cognitive-affect thinking and learning-related behaviours' (1981, 23). They were writing for teachers and teacher-educators and, as Marzano did 20 years later, based their taxonomy as far as possible on theory and research findings in cognitive psychology. They address memory, thinking and learning and are concerned with helping teachers to 'separate pre- and post-learning behaviours within classroom situations' (1981, 10). The taxonomy is intended to be used in instructional design and the authors assume that teachers can infer from pupil behaviour what mental processes are, or have been, taking place. It is located in a broad theoretical framework which includes a cognitive belief system (equivalent to Marzano's self system), but not a separate system dedicated to metacognition.

The levels and sub-levels of the domain of cognition taxonomic system are shown in Table 45, together with illustrative general instructional objectives. The same instructional objectives are repeated at different levels, as the levels represent no more than progress towards the internalisation and automatic use of new knowledge.

Stahl and Murphy identify 21 mental processes involved in thinking and learning, and claim that these may be used in different combinations at any of the following levels: *transformation*, *transfersion*, *incorporation*, *organisation* and *generation*. These processes are said to operate with all kinds of content, whether cognitive or affective. They are provided in list form, as follows:

1
associating: connecting items together

2
classifying: putting items into categories

3
combining: putting items into some single whole

4
comparing: identifying similarities and differences

5
condensing: producing a shortened version of information

6
converting: changing the features of an item or information

7
describing: reporting the features of an item or information

8
designating: assigning a name or exactness to an item

9
discriminating: treating some items or information differently

10
extending: providing information to fill a gap or gaps

11
extracting: focusing on parts, part-part and part-whole relationships

12
interpreting: making sense of information

13
organising: putting items in order or sequence to bring out their relationships

14
proposing: suggesting a probable way of dealing with a problem

15
reconciliating: putting opposing items together to make a consistent whole

16
selecting: making a preferred, imperative or needed choice

17
separating: taking things apart to identify distinct components

18
translating: putting information into a different form or version

19
utilising: demonstrating how things could be, are being or have been put to use

20
valuating: assigning value, a rating or priority to an item or information

21
verifying: specifying how information should be accepted as valid or true.

Table 45
The domain of cognition

Levels and sub-levels	Function	Illustrative instructional objective
Preparation	Readying oneself to receive and/or be capable of accepting information	
Observation	Taking in and becoming aware of information and stimuli	
Reception Literation Recognition Recollection	Noticing and remembering information that has just been presented (during a lesson)	Understands information and facts Recognises details and data Knows verbal information Understands steps of a method Knows a formula or principle Recognises laws or theories
Transformation Personalisation Adaptation (rehearsal and 'field-testing')	Giving meaning to information that has just been received (during a lesson) Applying principles, using steps of a method, solving problems	Understands laws or theories Comprehends information Understands facts Knows the meaning of Applies principles to a situation Uses steps of a method Solves problems Constructs examples of a graph
Information acquisition Encoding Storage Retrieval	Placing information and meanings into long-term storage	
Retention Recognition Recollection	Identifying information retrieved from long-term storage (from previous lessons)	Understands information and facts Recognises verbal information Knows laws, principles or rules Understands steps of a method
Transfersion Replication Variation	Using recalled information (guidelines and rules) to deal with new situations	Understands laws or theories Applies information Uses steps of a method Solves problems Applies principles or laws Understands how information is used
Incorporation	Automatically using fully internalised guidelines and rules	(Same as above)
Organisation	Interrelating and prioritising all previously understood information within one's cognitive belief system	Demonstrates consistent and predictable beliefs Provides consistent and defensible rationale Demonstrates commitment to a particular perspective Appreciates how a technique works Values a particular point of view or product
Generation	Synthesising previous information (guidelines and rules) to form new ideas and understandings	Formulates a new set of rules or principles Develops a new explanation Formulates a new way of solving a problem

Evaluative summary

Purpose and structure	Indicators of quality	Relevance for teachers and learning	Evaluation of presentation and other features (PMI)
Main purpose(s) To help teachers and teacher-educators understand thinking and learning A tool for use in instructional design and teaching	**Terminology** Not easy to grasp Uses specially defined technical terms	**Contexts of application** Education	**Presentation** The complexity of lists, tables and graphics is off-putting
Domains addressed Cognitive (Affective)	**Theory base** Psychological models of information processing	**Pedagogical stance** Transmission of knowledge	**Plus points** May help teachers to understand and monitor learning
Levels addressed Self-engagement Productive thinking Basic thinking skills Knowledge recall Perception	**Compatibility** Anderson and Krathwohl Marzano	**Practical illustrations for teachers** Not at the level of specific learning outcomes	**Minus points** Ignores social and cultural influences Does not deal with metacognition Treats feelings only as a source of additional information As it is content-free, it is of little use in curriculum planning and assessment Too complex for practical use with individual students
Classification by Levels of internalisation of information and rules	**Values** Academic detachment	**Relevance for key skills** Low	**Interesting** Potential use of internalisation in more than one domain Locating the taxonomy within a well-supported theoretical framework

Table 46
Evaluative summary of *Stahl and Murphy's domain of cognition taxonomic system*

Sternberg's model of abilities as developing expertise

Description

Well-known for his 'triarchic' theory of critical, creative and practical intelligence and to a lesser extent for his model of thinking styles (1997), Sternberg (2001) has also written about 'abilities as forms of developing expertise'. He claims that the development of expertise involves the interaction of at least the following six elements.

1
Metacognitive skills: these refer to people's understanding and control of their thought processes. For example, such skills would encompass what an individual knows about writing an essay or solving arithmetic problems, both with regard to the steps involved and how these steps can be executed effectively. Seven particularly important metacognitive skills are: problem recognition, problem definition, problem representation, strategy formulation, resource allocation, monitoring of problem solving and evaluation of problem solving. All of these skills are deemed to be modifiable, yet Sternberg (2001) notes that students are often resistant to metacognitive training.

2
Learning skills: these are seen as sometimes explicit, when we make an effort to learn; or implicit when we pick up information incidentally, without any systematic effort. Examples of learning skills are: selective encoding, which involves distinguishing relevant from irrelevant information; selective combination, which involves putting together the relevant information; and selective comparison, which involves relating new information to information already stored in memory.

3
Thinking skills: there are three main kinds of thinking skill that individuals need to master:

- *critical (analytical)* thinking skills, including: analysing, critiquing, judging, evaluating, comparing and contrasting, and assessing
- *creative* thinking skills, including: creating, discovering, inventing, imagining, supposing, and hypothesising
- *practical* thinking skills, including: applying, using, utilising and practising.

These three aspects are viewed as comprising 'successful intelligence'.

4
Knowledge: there are two kinds of knowledge relevant in academic situations. *Declarative* knowledge is knowledge of facts, concepts, principles, laws, etc ('knowing that'). *Procedural* knowledge is knowledge of procedures and strategies ('knowing how'). Sternberg does not devalue the process of teaching for knowledge outcomes, as without this foundation, students cannot think critically about what they know.

5
Motivation: while noting that it is indispensable for school success, Sternberg has tended not to consider motivation to the same extent as the cognitive elements. In setting out his model, he briefly refers to McClelland's (1961) theory of achievement motivation and Bandura's self-efficacy (1997), but makes no reference to more contemporary work. He gives (2002) the following examples of desirable attitudes: (a) combatting the tendency to procrastinate, (b) organising oneself to get work done, (c) figuring out how one learns best, (d) avoiding the tendency to use self-pity as an excuse for not working hard, and (e) avoiding blaming others for one's own failings.

6
Context: all the elements above are seen as characteristics of the learner, but Sternberg emphasises that all these processes are affected by, and can in turn affect, the context in which they operate.

Sternberg emphasises the interactive nature of these six elements.

At the centre, driving the elements, is motivation. Without it, the elements remain inert … Motivation drives metacognitive skills, which in turn activate learning and thinking skills, which then provide feedback to the metacognitive skills, enabling one's level of expertise to increase. The declarative and procedural knowledge acquired through the extension of the thinking and learning skills also results in these skills being used more effectively in the future.
(Sternberg and Grigorenko 2002, 8–9)

Evaluative summary

Purpose and structure	Indicators of quality	Relevance for teachers and learning	Evaluation of presentation and other features (PMI)
Main purpose(s) To improve teaching and learning	**Terminology** Clear Simple	**Contexts of application** Education	**Presentation** Accessible, broad-brush outline, but far from exhaustive
Domains addressed Affective Cognitive Conative	**Theory base** Largely Sternberg himself (eg triarchic theory of intelligence)	**Pedagogical stance** Provide an optimal degree of challenge Teach 'triarchically' for analytic, creative and practical learning	**Plus points** Sets thinking and learning in the wider context of individual development A balanced emphasis on analytic, creative and practical skills
Levels addressed Self-engagement Reflective thinking Productive thinking Basic thinking skills Knowledge recall Perception	**Compatibility** Anderson and Krathwohl Jonassen and Tessmer Marzano Pintrich	**Practical illustrations for teachers** Some examples are provided	**Minus points** Limited accounts of motivation and of learning as a social process A tendency to make arbitrary and incomplete lists Lack of empirical support for 'practical intelligence'
Classification by Steps in problem solving and in information processing Type of knowledge	**Values** Emphasis placed on individual rather than on social development	**Relevance for key skills** High	**Interesting** Evidence is beginning to emerge in support of triarchic teaching

Table 47
Evaluative summary of *Sternberg's model of abilities as developing expertise*

Vermunt and Verloop's categorisation of learning activities

Description

In his doctoral research project, Vermunt (1992) developed a theoretical framework for categorising approaches to learning, especially in higher education. He built the framework around cognitive, affective and metacognitive (regulative) dimensions. He drew on several lines of research dating back to the 1970s, including Flavell's ideas (1979) about metacognition. In 1999, Vermunt and Verloop use the same dimensions to present what they call a taxonomy or categorisation of learning activities. Their treatment of the affective and regulative dimensions is rather more developed than in Vermunt's earlier work (1996, 1998), while cognition is treated in very much the same way. Vermunt and Verloop (1999) hope that their formulation will be used to guide theory and research into learning and instruction and will not prove too simple or too complex for that purpose. The 'taxonomy' is not presented as an 'ultimate solution' and its authors do not claim that the categories are either exhaustive or mutually exclusive. For this reason, it is better described as a framework than a taxonomy. The various categories of learning activities are summarised in Table 48.

It should be noted that Vermunt and Verloop use the terms *metacognitive* and *regulative* interchangeably when referring to a type of learning activity (the other types being *cognitive* and *affective*). They define the metacognitive regulation of learning processes as 'exerting control over one's own cognitive and affective processing of subject matter' (1999, 262).

Vermunt and Verloop expand on the meaning of each category, but mostly at an abstract or general level. Some paraphrased examples are given below.

Relating means looking for connections, including part-whole relationships and those between new information and prior knowledge.

Analysing means breaking down a whole into its parts and studying those parts or aspects in a step-by-step fashion.

Selecting means finding and studying the most important parts.

Attributing means ascribing learning outcomes to causal factors.

Appraising means deciding whether a learning task is worth the time and effort.

Dealing with emotions means being positive and coping with negative feelings.

Evaluating means judging how far the learning proceeded as planned and was successful.

Reflecting means thinking over what has happened as well as thinking about learning experiences in general.

Although they clearly favour a high degree of student self-regulation, the authors develop further pedagogical implications of their framework by taking each learning function and giving examples of things teachers can do to activate learning where there is either *shared regulation of learning* or *strong teacher regulation*. Thus, for example, with *shared regulation*, a teacher might promote critical processing by 'having students present arguments, presenting conflicting views, organising a group discussion' (1999, 268); whereas with *strong teacher regulation*, a teacher might proceed by 'telling arguments in favour of and against a point of view, pointing out different possible conclusions' (1999, 267).

Table 48
A categorisation of learning activities

Cognitive processing	Affective/motivational	Metacognitive regulation
Relating/structuring	Motivating/expecting	Orienting/planning
Analysing	Concentrating/exerting effort	Monitoring/testing/diagnosing
Concretising/applying	Attributing/judging oneself	Adjusting
Memorising/rehearsing	Appraising	Evaluating/reflecting
Critical processing	Dealing with emotions	
Selecting		

Evaluative summary

Purpose and structure	Indicators of quality	Relevance for teachers and learning	Evaluation of presentation and other features (PMI)
Main purpose(s) To provide a theoretical framework for guiding research and practice in learning and instruction	**Terminology** Clear definitions for all categories Uses some specialist vocabulary Some overlap between categories	**Contexts of application** Education	**Presentation** Academic journal article
Domains addressed Affective Cognitive Conative	**Theory base** Cognitive and educational psychology	**Pedagogical stance** Teaching as the facilitation of self-regulated knowledge construction	**Plus points** All-embracing, with wide compatibility Related to Vermunt's work on learning approaches (styles) Deals with thinking, learning and teaching
Levels addressed Self-engagement Reflective thinking Productive thinking Basic thinking skills Knowledge recall	**Compatibility** Biggs and Collis Ennis Halpern Jonassen and Tessmer King and Kitchener Marzano Paul Pintrich	**Practical illustrations for teachers** Examples provided are at a general level	**Minus points** Focused only on academic learning Category overlap Combined categories The cognitive and affective categories are incomplete lists Assumption that students do not extend knowledge
Classification by Domain of experience Time sequence in regulation	**Values** Learning should be meaningful and have practical applications Independence in thought and action	**Relevance for key skills** Very high	**Interesting** Potential for informing research on congruence and friction between learning and teaching

Table 49
Evaluative summary of *Vermunt and Verloop's categorisation of learning activities*

Williams' model for developing thinking and feeling processes

Description

In 1970, Williams published the first volume of his work on classroom ideas for encouraging thinking and feeling. He makes use of a three-dimensional model and argues that developing different teaching strategies and adopting different teaching roles across a range of subjects can bring about changes in students' cognitive and affective behaviours, moving them towards a higher level of creative thinking (see also Williams 1972).

Williams describes 18 diverse teaching strategies which encourage not only thinking, but also the expression of feelings about both content and the learning process. He provides detailed lesson plans that envisage the three intersecting dimensions of subject content, teacher behaviour and pupil behaviours, coming together to encourage creativity. Williams is striving towards an increase in student creative output, placing equal value on cognitive and affective aspects.

Creativity is a complex mental process that is difficult to define or measure. For Williams, it involves putting together new, different and unique ideas by employing the four cognitive and four affective behaviours shown in dimension three of the model and outlined in Figure 13 opposite.

Cognitive behaviours:

1
fluency – generating a large number of ideas

2
flexibility – being able to change categories

3
originality – being able to come up with a unique thought

4
elaboration – being able to take one idea and embellish it.

Affective behaviours:

1
curiosity – willingness to explore and question

2
risk taking – courage to take a chance

3
complexity – facing the challenge of building order out of chaos

4
imagination – visualising and fantasising ideas.

It is worth noting that the four cognitive behaviours of *fluency*, *flexibility*, *originality* and *elaboration* are also to be found in the Torrance Tests of Creative Thinking (Torrance 1966).

Williams originally intended his model to be used in elementary schools, but it seems to have found more resonance with those delivering programmes for gifted and talented pupils. In 1986, Williams developed the 'cognitive-affective intervention model for enriching gifted programs', but this appears to vary little from his original work. He has also produced an assessment tool, the Creativity Assessment Packet (CAP) (Williams 1980).

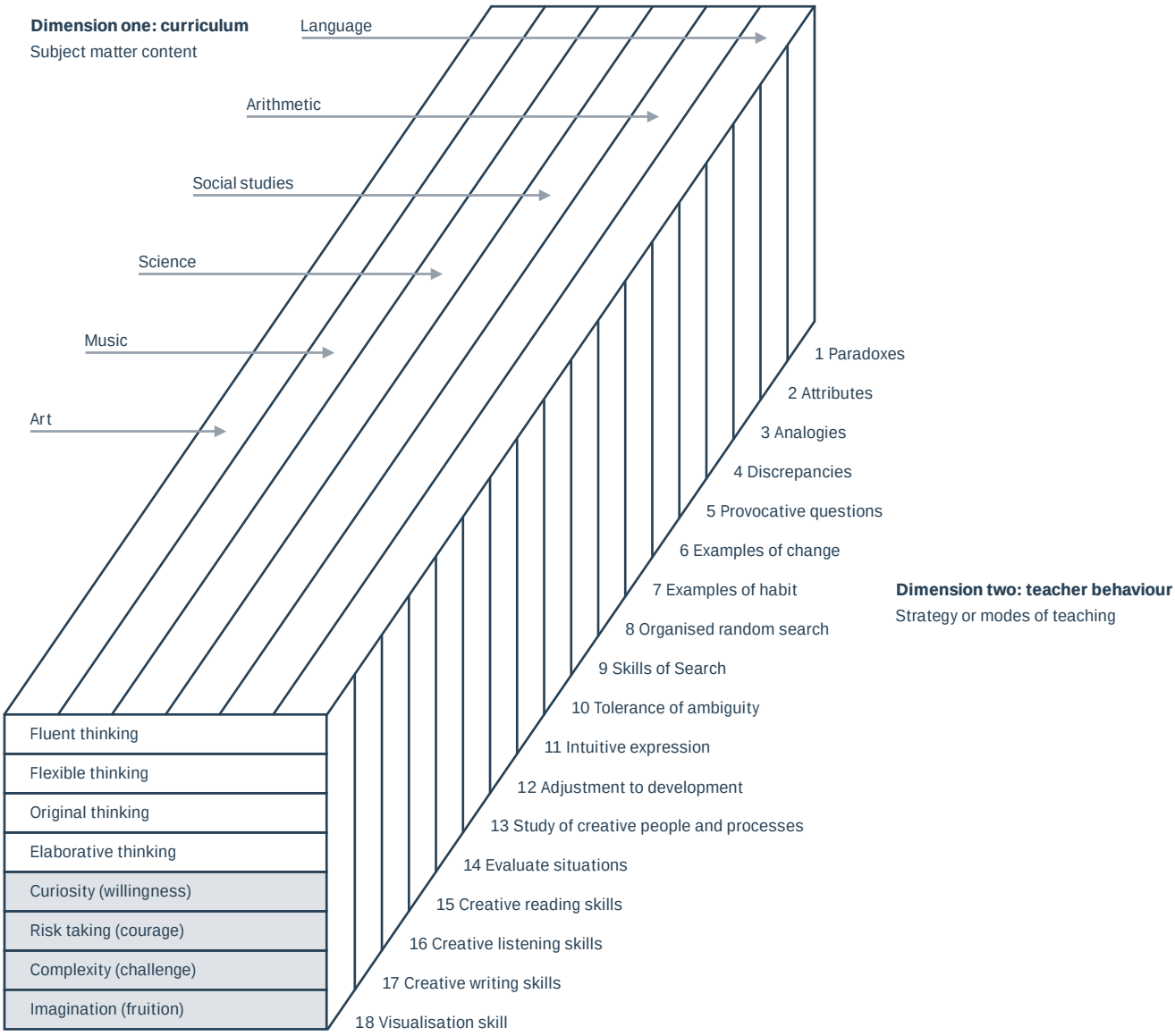


Figure 13
Williams' model for encouraging thinking and feeling

Evaluative summary

Purpose and structure	Indicators of quality	Relevance for teachers and learning	Evaluation of presentation and other features (PMI)
Main purpose(s) To encourage creative teaching and learning across the curriculum	**Terminology** Clear Fairly simple	**Contexts of application** Education	**Presentation** Easily understood Addressed to practitioners
Domains addressed Affective Cognitive	**Theory base** Guilford's structure of intellect model Torrance's work on creativity	**Pedagogical stance** Development of individual talents Interest in gifted education Cross-curricular emphasis	**Plus points** Provides a framework for understanding and developing creative thinking There is equal emphasis on skills and dispositions, thinking and feeling Lists teaching strategies which are relevant for all age groups
Levels addressed Self-engagement Productive thinking Basic thinking skills Knowledge recall	**Compatibility** Anderson and Krathwohl	**Practical illustrations for teachers** Several hundred in six curriculum areas	**Minus points** May not be comprehensive in coverage May be seen as appropriate only for the most able
Classification by Nature of learner behaviour (thinking or feeling)	**Values** Humanistic Individualistic	**Relevance for key skills** Moderate	**Interesting** Has been positively evaluated in field trials and widely disseminated

Table 5 0
Evaluative summary of *Williams' model for developing thinking and feeling processes*

Appendix 3

'Reason!Able' evaluations

Pintrich's general framework for self-regulated learning

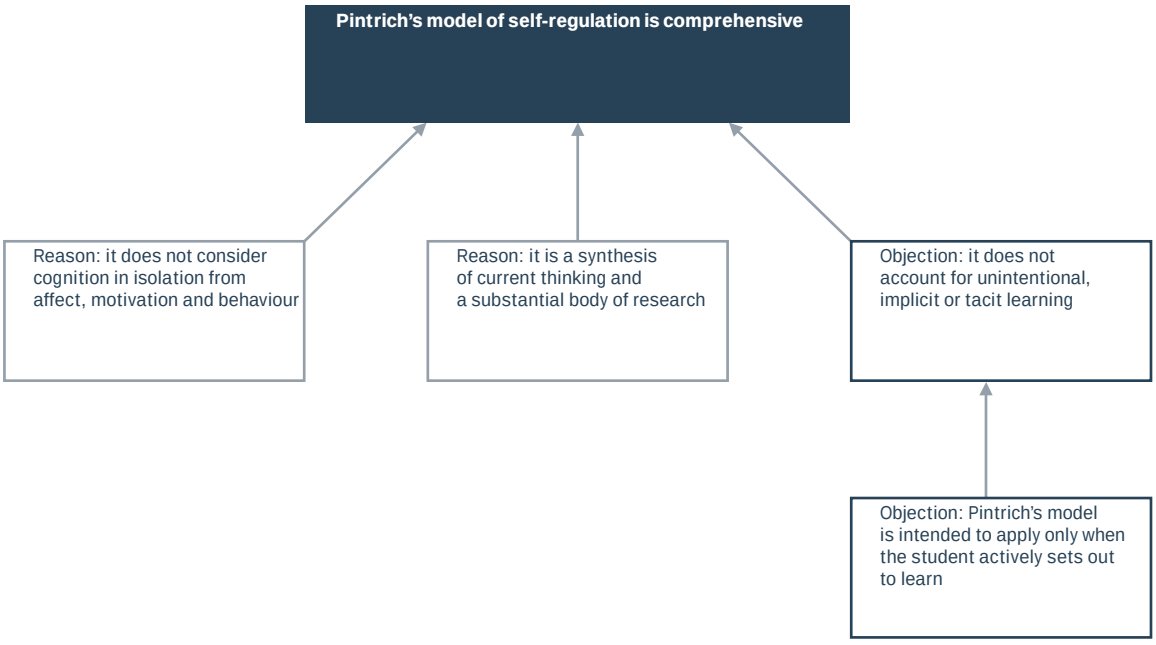
Pintrich identifies four phases of self-regulation. Cognition, motivation/affect, behaviour and context can be regulated by:

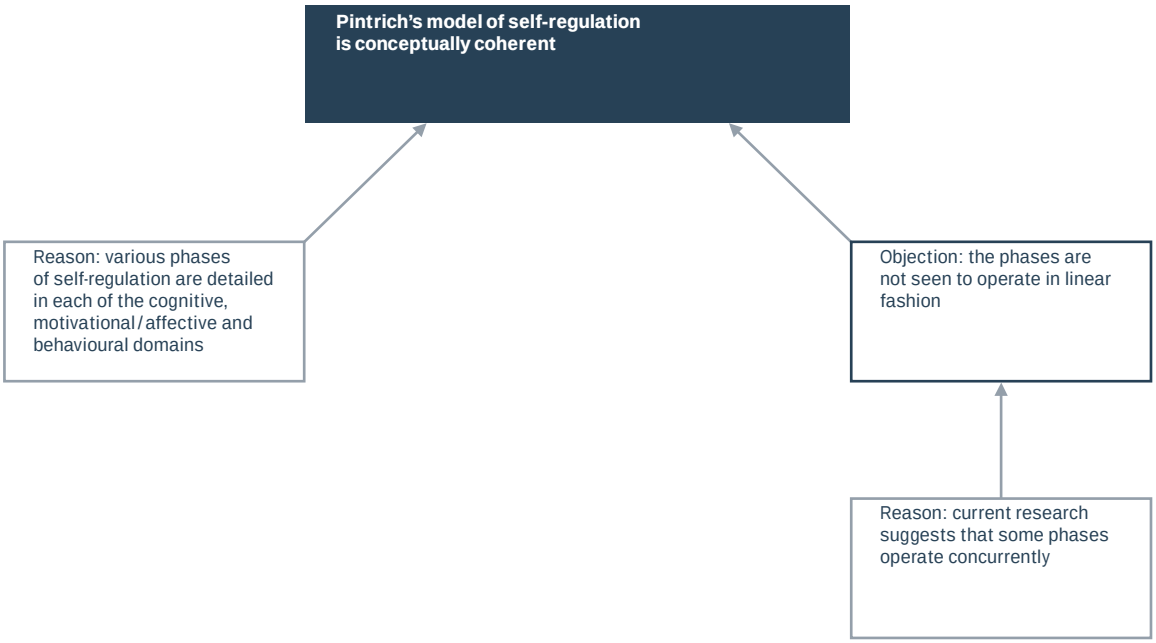
1
forethought, planning and activation

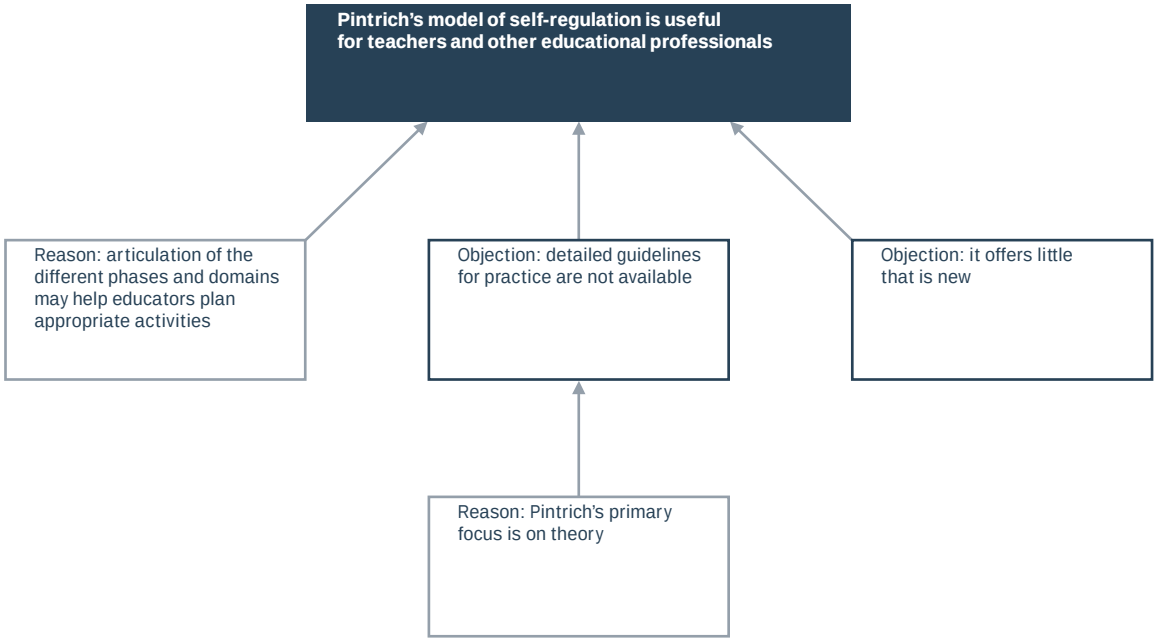
2
monitoring

3
control, and

4
reaction and reflection.

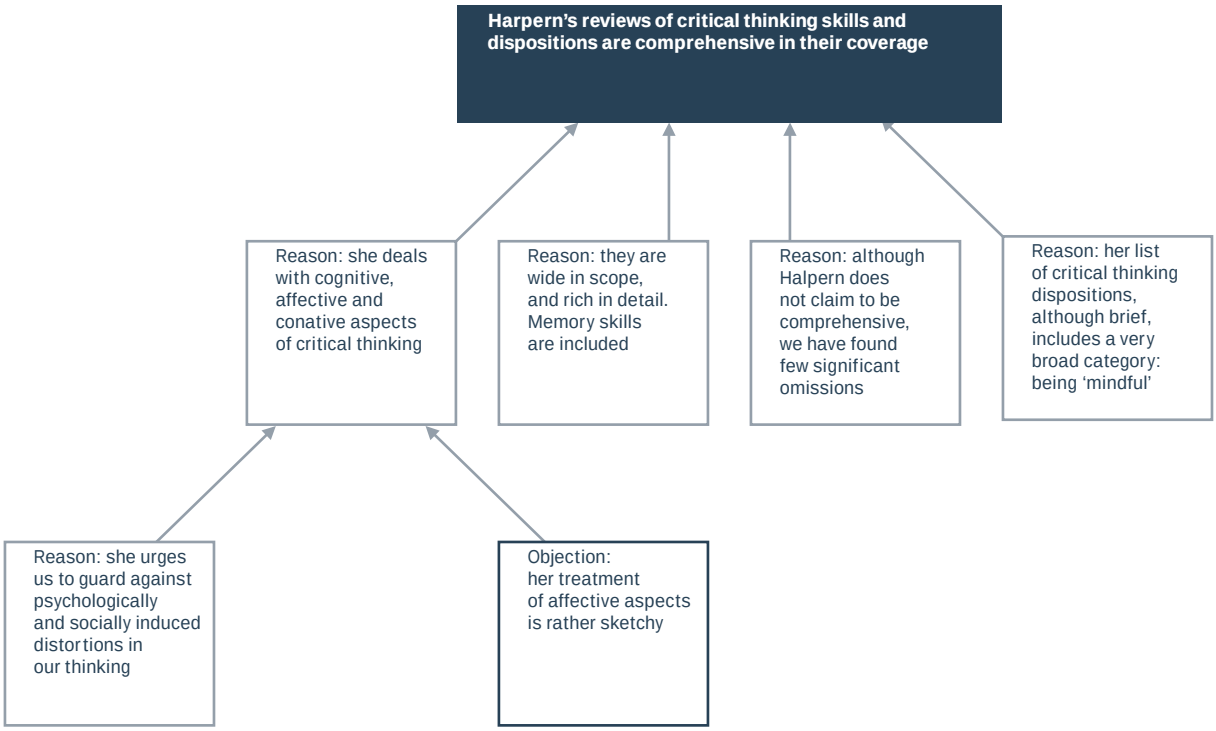


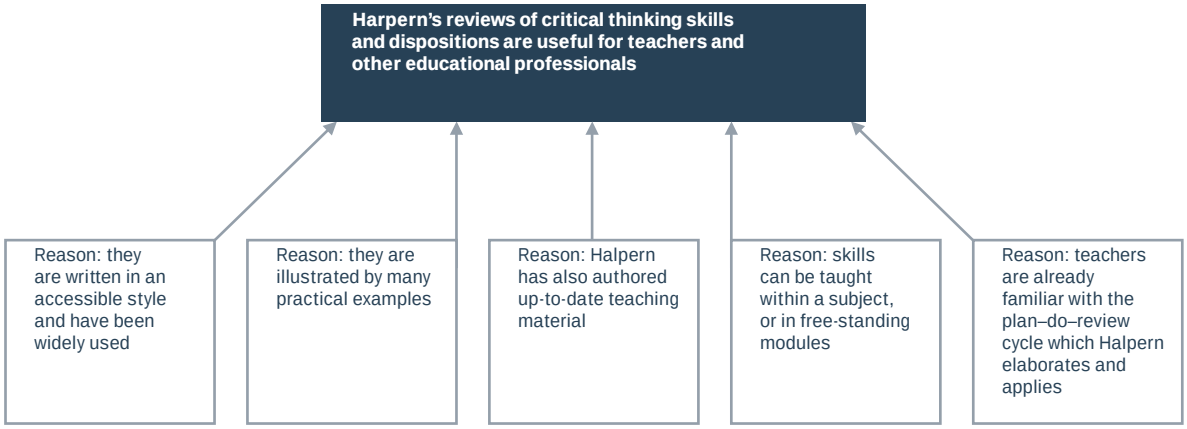



Pintrich's model of self-regulation is useful for teachers and other educational professionals
Reason: articulation of the different phases and domains may help educators plan appropriate activities
Objection: detailed guidelines for practice are not available
Objection: it offers little that is new
Reason: Pintrich's primary focus is on theory

Halpern's reviews of critical thinking skills and dispositions

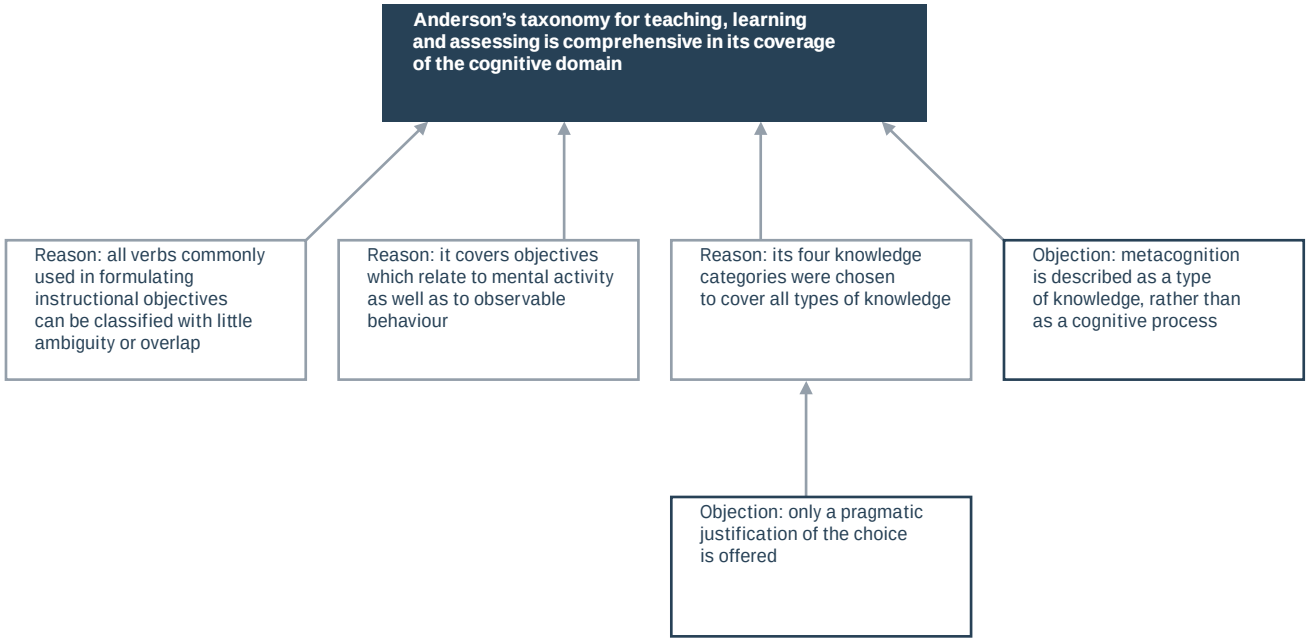
Halpern's skill categories are: memory, thought and language, deductive reasoning, argument analysis, hypothesis testing, likelihood and uncertainty, decision making, problem solving, and creative thinking. She also lists six relevant dispositions.

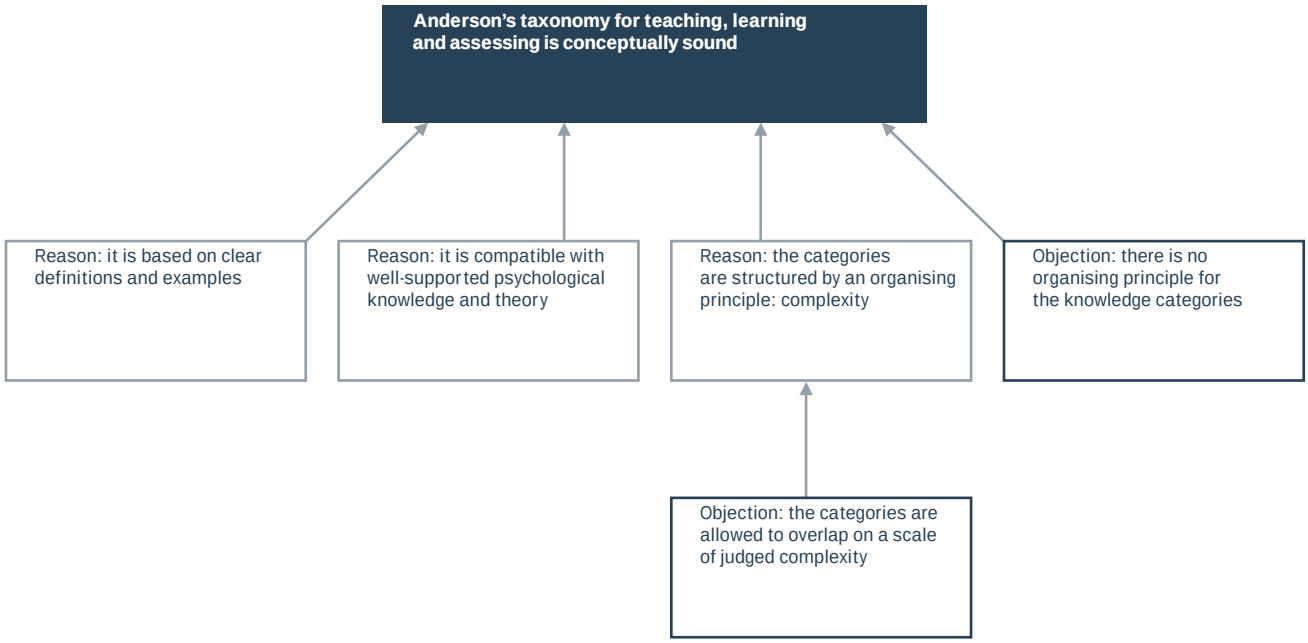


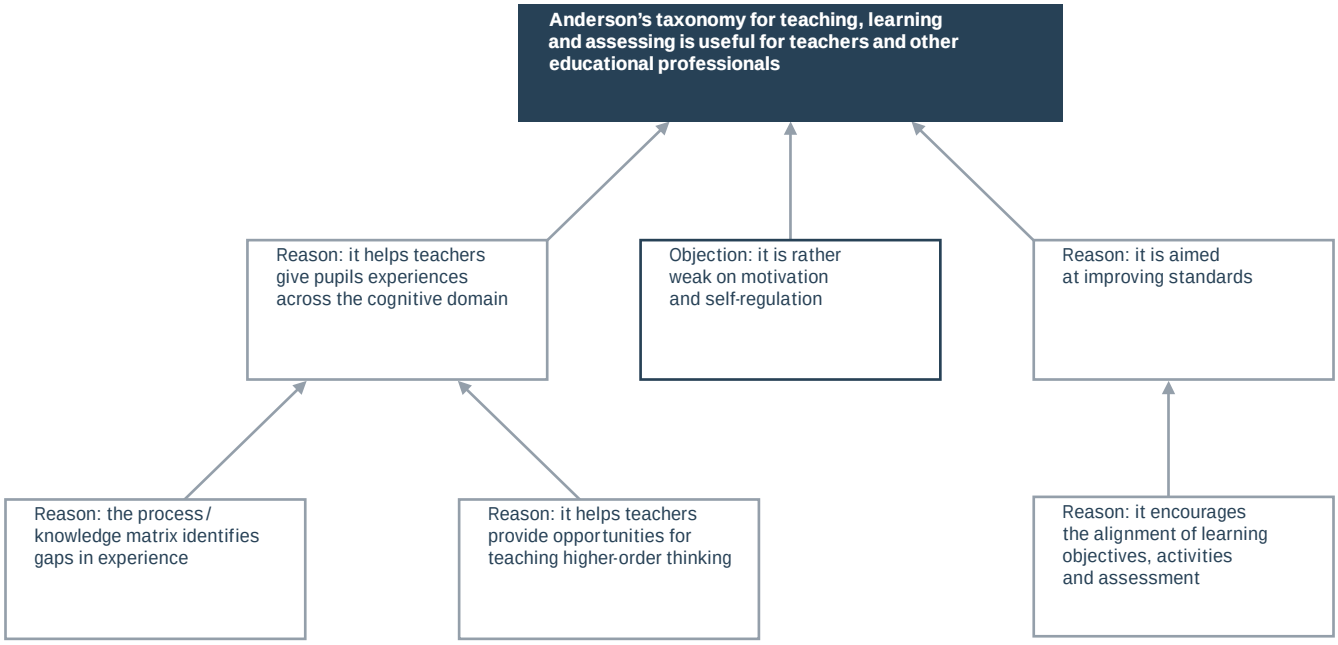

Harpern's reviews of critical thinking skills and dispositions are useful for teachers and other educational professionals
Reason: they are written in an accessible style and have been widely used
Reason: they are illustrated by many practical examples
Reason: Halpern has also authored up-to-date teaching material
Reason: skills can be taught within a subject, or in free-standing modules
Reason: teachers are already familiar with the plan–do–review cycle which Halpern elaborates and applies

Anderson and Krathwohl's revision of Bloom's taxonomy

Bloom's taxonomy (1956) has been refined and developed into a two-dimensional framework using six cognitive processes and four knowledge categories. There is an emphasis on aligning learning objectives with learning activities and assessment.






Anderson's taxonomy for teaching, learning and assessing is useful for teachers and other educational professionals
Reason: it helps teachers give pupils experiences across the cognitive domain
Objection: it is rather weak on motivation and self-regulation
Reason: it is aimed at improving standards
Reason: the process / knowledge matrix identifies gaps in experience
Reason: it helps teachers provide opportunities for teaching higher-order thinking
Reason: it encourages the alignment of learning objectives, activities and assessment

Appendix 4

Using an integrated framework for understanding thinking and learning to categorise Costa and Kallick's (2000a) 'habits of mind'

Engagement with and management of thinking/learning

Responding with wonderment and awe

Managing impulsivity

Remaining open to continuous learning

Thinking flexibly

Taking responsible risks

Persisting

Value-grounded thinking (including reflective and critical thinking)

Striving for accuracy

Thinking interdependently

Thinking about thinking (metacognition)

Productive thinking

Finding humour

Creating, imagining, innovating

Building understanding

Listening with understanding and empathy

Applying past knowledge to new situations

Thinking and communicating with accuracy and precision

Questioning and posing problems

Information gathering

Gathering data through all senses

How to contact the LSRC

The LSRC welcomes continuing interaction with researchers and research users. Please contact us with your questions, ideas and information.

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