This report examines methods of developing thinking skills for post-16 teaching and learning, and explores the merits and disadvantages of different approaches to teaching thinking skills. It identifies areas in which knowledge is extensive or widely accepted, and areas where knowledge is limited, non-existent or highly contested.
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**Executive summary**

**Introduction**

The Quality in Education Centre at the University of Strathclyde was commissioned in January 2002 by the Learning and Skills Research Centre (LSRC) to undertake research on post-16 pedagogy and thinking skills. This is our final report.

**Aim**

The underlying aim of the research was to support evidence-informed policy and practice, by examining methods of developing thinking skills germane to post-16 teaching and learning, and by evaluating key claims made on their behalf.

**Methodology**

The project involved identifying, evaluating and completing a descriptive map of current research literature from Australia, Israel, North America, Western Europe and the UK, analysing key principles and applying them to answer the research questions. A set of search terms was combined and criteria were used to locate and select the studies that were analysed. The research team began the project by clarifying terms used to describe thinking and aspects related to thinking.

**Research questions**

- What are the merits and disadvantages of different approaches to teaching thinking skills?
- What is the evidence that a thinking skill can be transferred from one subject or domain to another?
- Which models of teaching thinking skills are appropriate for post-16 learners?
- Which methods of assessing and evaluating thinking skills interventions are best suited to post-16 learning contexts?
- Are the approaches used to teach thinking skills to pre-16 learners applicable to post-16 learning contexts?
- In which areas is knowledge extensive or widely accepted?
- In which areas is knowledge limited, non-existent or highly contested? And what questions arise for further research?

**Key findings and recommendations**

1. **Relative merits and disadvantages of different approaches to teaching thinking skills**

   The project team was asked to consider three types of approach.

   - **Discrete programmes for teaching general thinking skills (programmes separate from existing components of a curriculum)**
     
     Very few interventions in the post-16 sector that took this form met the criteria for inclusion. Those that did produced some evidence that the students became better able to deploy the thinking skills within the confines of the programme, but there was little evidence of transfer to other contexts.

   - **Programmes in which the main purpose is to improve students’ ability to think with specific subject knowledge**
     
     Programmes classified in this way formed the largest proportion of the studies. In almost all reports of such interventions, sound evidence was presented to suggest that learners became more competent at cognitively complex course tasks.

   - **Programmes designed to incorporate thinking skills throughout the existing curriculum**
     
     In the few studies of this type that met the criteria for inclusion, there is evidence that the students used the targeted thinking processes to complete tasks in different areas of their course. What is not clear is whether the learners were able to transfer their thinking to contexts beyond their existing curricula.

   **Recommendation**

   Future research should be designed to build on findings from:

   - programmes in which the main purpose is to improve students’ ability to think with specific subject knowledge
   - programmes designed to incorporate thinking skills throughout the existing curriculum.

   Recently established discrete programmes (eg the AS level Critical Thinking programme) should be evaluated rigorously to establish the extent of transfer from the programme to other contexts.

   Peer interaction should be a component of the above types of programme.

   The programme purposes should include the development of students’ metacognitive and self-regulative abilities.

   Future research should focus particularly on further variables relating to peer interaction and conditions for successful implementation.
An important conclusion from the sample studies is that their successful implementation depends in large measure on certain features that often are not present in curricula in the current vocational education and training (VET) sector. Teachers/lecturers need opportunities to pursue their understanding of theoretical perspectives (constructivist) that informed the studies, as do students. Key conditions for successful implementation related to the following aspects: teacher/lecturer readiness; student readiness; learning environment and institutional support; course design and content; and post-16 culture.

Recommendation

- There should be a shift away from a curriculum context in formal post-16 learning settings that is too prescriptive to allow scope for students to express their thinking.

Evidence to support the view that a thinking skill in one subject or domain is transferable to another subject or domain

Since few studies were designed to provide evidence of transfer from one subject or domain to another, there is too little evidence to provide a definite answer to this question.

Recommendation

- If students’ thinking is to be developed through discrete units, such units should contain explicit statements about how the thinking is to be transferred to the range of learning contexts experienced by the students on their course.

Models of teaching thinking skills which are appropriate for post-16 learners

All of the following key principles of thinking skills programmes that are relevant to the post-16 context have been highlighted in the research reviews, reports and articles reviewed for this study:

- They encourage the learners to change their understanding – in general, they are constructivist in origin.
- They help students to transfer their learning.
- They promote learning with others.
- They encourage students to regulate their behaviour.
- They challenge the learner.
- They are carefully structured to employ measures to ease students into tasks and to establish personal meaning for the learners.
- They develop skills such as concept formation, enquiry and reasoning skills, which better equip students to be independent learners.
- They make students think about thinking.

The emotional and motivational dimensions of thinking were rarely discussed in the articles reviewed.

Recommendations

- Future research should focus on the following issues:
  - examining the links between the affective characteristics of learners (including motivational factors), the instructional strategies adopted and the educational outcomes of interest
  - the development and evaluation of differentiated instructional strategies which take account of individual learner characteristics, such as differences in pace of learning and learner preferences.

Methods of assessing thinking skills and of evaluating thinking skills interventions that may be suited to post-16 learning contexts

The following were identified as key characteristics of promising methods for assessing growth in student thinking within post-16 education:

- effective formative feedback, including peer feedback and assessment
- the use of shared and public criteria
- more focused and in-depth assessments
- assessments contributing to instructional goals that include performing ‘authentic’ tasks in varied contexts to enable students to apply a range of thinking skills
- teachers with a range of expertise relevant to assessing growth in student thinking.
Recommendations

- Further evaluation of existing methods of assessing thinking for post-16 learners is needed.
- Those methods that have been evaluated successfully in schools should be appraised to determine their suitability for use with post-16 learners in specific learning contexts.
- The above key characteristics should inform the development of new methods of assessing thinking for post-16 learners across varied educational settings.
- Further development and evaluation of formative techniques to assess growth in student thinking should be conducted.
- The development of teacher expertise should be prioritised, since the teacher's role is central to the design and successful implementation of classroom-based assessment techniques.
- More training opportunities are needed for researchers and teaching teams to equip them with the necessary knowledge and skills to conduct robust evaluations.
- Examples of broadly conceived, well-constructed and well-documented evaluations should be disseminated to researchers and teachers.
- A guide to good practice in evaluation design for thinking skills interventions should be produced.

Evidence which suggests that approaches to teaching thinking skills used with pre-16 learners are applicable to post-16 learning contexts

A key question to examine for post-16 learners is whether the incorporation of thinking skills throughout the existing curriculum can be made to work within modular programmes.

The potential of the Cognitive Acceleration through Science Education (CASE) model, and of other successful models developed for use in schools, should be explored in relation to post-16 contexts.

Within modular programmes where there is the intention to 'infuse' key/core thinking skills across the curriculum, careful attention should be paid to how these skills are mapped onto the discrete elements of the curriculum and to transfer of learning.
The Quality in Education Centre at the University of Strathclyde was commissioned by the Learning and Skills Research Centre (LSRC) to carry out this research project.

Project aim
The aim of the project was to support evidence-informed policy and practice by examining key claims in the literature concerning methods of developing thinking skills germane to post-16 teaching and learning, and by evaluating evidence of these claims.

The notion of teaching thinking skills is widely covered in the literature. However, the potential of this literature to inform educational policy and practice is not being realised. If stakeholders are not easily able to access information from the literature, they are unlikely to be able to reach informed decisions about the advantages and disadvantages of different approaches to teaching thinking skills. Consequently, this research project aimed to provide a codification of the literature which would enable the stakeholders to understand better the variety of approaches used to develop thinking skills with post-16 learners.

Research questions
- What are the relative merits and disadvantages of different approaches to teaching thinking skills?
- What is the evidence to support the view that a thinking skill in one subject or domain is transferable to another subject or domain?
- Which models of teaching thinking skills are appropriate for post-16 learners?
- Which methods of assessing thinking skills and of evaluating thinking skills interventions, may be suited to post-16 learning contexts?
- Is there evidence to suggest that approaches to teaching thinking skills used with pre-16 learners are applicable to post-16 learning contexts?
- In which areas is there knowledge that is extensive or widely accepted?
- In which areas is knowledge limited, non-existent or highly contested? And what questions arise for further research?

This report addresses the research questions set out above. Section 2 sets out the method used in the research project, explaining its three stages: identifying, evaluating and completing a descriptive mapping exercise of literature; analysing key principles; and applying them to answer the research questions. It also explains the search terms and the criteria used to locate and select the studies that were analysed by the research team.

Section 3 discusses four key studies from three different geographical areas (North America, Western Europe and the UK). These studies have been selected from the large number of studies analysed during the project because they illustrate key features of successful thinking interventions, and they had been subjected to a rigorous peer review process and had strong implications for pedagogy.

During the analysis of the reviews and studies, the research team were aware of the complex range of terms used. For example, it was not always clear in some studies how terms such as ‘thinking skills’, ‘cognitive skill’, ‘critical thinking’, ‘transfer’, ‘metacognition’, etc were defined. For this reason, Section 4 of this report provides clarification of the key terms used in the studies selected for inclusion. A brief glossary is provided which is illustrated by reference to sample studies.

From the detailed analysis of the studies, several cross-cutting themes emerged. Each of these themes has a section devoted to it. Section 5 addresses transfer in relation to thinking skills and pedagogy in the post-16 sector. Whatever method is chosen to teach thinking skills, the concept of transferability is crucial. This section explores the problematic nature of the concept of transfer. The discussion draws on evidence of some forms of transfer within a domain and highlights the limited evidence to support transfer from one domain to another.

In many of the studies reviewed, the approach to teaching thinking skills incorporated some form of peer learning. In addition, there is growing evidence to suggest that interactions with technology offer new possibilities for interdependent, collaborative learning. Consequently, Section 6 explores the role of peer learning and information and communications technology (ICT) in promoting students’ thinking.

Section 7 explores issues concerning the conduct of evaluations of thinking skills interventions, and examines the related topic of how growth in students’ thinking can be assessed in ways that are appropriate for post-16 learners. The section draws on evidence from studies analysed.
Many of the studies selected by the research team provide an indication of a range of conditions that are central to the successful implementation of thinking interventions. A systematic categorisation of the conditions was carried out. Section 8 discusses the conditions under the following headings: teacher/lecturer readiness; student readiness; learning environment; course design and content; and post-16 culture.

Section 9 draws together the discussion in the earlier sections about each of the research questions in order to form conclusions and make suggestions concerning recommendations for future research.

A full explanation of the search terms used to locate the studies and how the terms were combined is provided in Appendix 1. A selection of the reviews and studies analysed during the research project is included as Appendix 2 and they are listed by author name in Appendix 3.
Introduction

The research project was carried out in three stages. The first two stages focused on identifying, evaluating and completing a descriptive mapping of literature; and the third stage, while further refining the work undertaken in stages 1 and 2, focused on analysing key principles and applying them to answering the research questions outlined in Section 1.

Systematic review of post-16 pedagogy and thinking skills

The first task of the review process involved identifying the key concepts and scope of the survey and establishing criteria for the selection of studies. There is a vast literature on teaching thinking and in order to make the task of reviewing this literature manageable, a set of boundaries to limit the types of article and review that would be examined was identified.

A series of keywords were selected because of their relevance to the present study. In summary, they are concerned with:

- thinking skills (and synonyms)
- pedagogy
- post-16
- relevant issues (e.g., ICT) identified as important through other reviews in this field (e.g., McGuinness 1999).

Systematic electronic searches were undertaken using the following 17 sets of keywords in combination:

1. thinking or cognition or cognitive or cognitive skills or thinking skills or thinking strategies or thinking dispositions or thinking frames or higher order thinking
2. critical thinking or logical thinking or strategic thinking or reasoning or argumentative reasoning or problem solving or informal logic or practical reasoning or everyday reasoning
3. creative thinking or creativity or lateral thinking
4. positive thinking or motivation
5. peer interaction or collaborative learning or collaboration
6. metacognition or metacognitive skills or metacognitive strategies or self-regulation or self-regulated learning or learning strategies or autonomous learning or independent learning or learning to learn
7. ICT or computers or technology
8. transfer or generalization or generalizing or generalisation or generalising
9. domain knowledge or domain specificity or domain-specific or domain specific knowledge or subject knowledge or disciplinary knowledge
10. core skills or key skills or basic skills or transferable skills
11. post-16 or AS level or A level
12. further education or higher education or university or college
13. vocational education or workplace learning or work based learning or learning at work
14. informal education or lifelong learning
15. pedagogy or teaching or teaching approach or infusion or infused
16. assessment or evaluation
17. review or meta-analysis.

The comprehensive series of complex searches of titles and descriptors used a combination of terms including and/or statements. For example:

1. thinking or cognition or cognitive or cognitive skills or thinking skills or thinking strategies or thinking dispositions or thinking frames or higher order thinking and
2. pedagogy or teaching or teaching approach or infusion or infused and
3. post-16 or AS level or A level or further education or higher education or university or college or vocational education or workplace learning or work based learning or learning at work or informal education or lifelong learning.
A complete listing of all searches can be found in Appendix 1. The searches were undertaken using the ERIC, International ERIC and PsycINFO databases.

The electronic searches using the keywords resulted in the identification of a large number of abstracts. A set of criteria was agreed to enable the project team to identify articles and reviews from the abstracts that were relevant to the project aims. The robustness of the criteria to select relevant articles and reviews was tested by the project team on two data sets - one from Cambridge Scientific Abstracts and the other from the British Education Index. Independently, each team member used the criteria to make decisions about the relevancy of the two lists of studies and then the team came together to check if there was agreement concerning the studies to be selected for more in-depth analysis. This led to a refinement of the selection criteria.

An iterative process was adopted throughout the study and this refinement was, in fact, only one of a number of revisions made to the selection criteria. A principal reason for the refinement of the selection criteria was the need to ensure that the number of studies included in the review was kept within a manageable limit, appropriate to the scope of the project. The criteria were refined and extended through scrutiny of the guidelines provided for reviewers of articles by editorial boards of some of the more prestigious academic journals that publish empirical research. The finalised criteria were as follows.

Key requirements for including a study:
- based in Australia, Israel, North America, Western Europe or the UK (according to the parameters set by the LSRC project specification)
- has been subjected to peer review (either through publication in a fully refereed journal, as a book or book chapter or as a refereed conference paper)
- has strong implications for pedagogy (‘Pedagogy’ was used in a way that did not exclude research that might be very significant for developing a pedagogy for enhancing students’ thinking about curricula. This enabled some studies which did not take the form of interventions to be included.)
- published 1998 onwards (pre-16)/ published 1992 onwards (post-16); an examination of other reviews (Blagg, Lewis and Ballinger 1994; McGuinness 1999) led to the selection of these dates.

Key criteria for rejecting a study:
- focus on learning difficulties
- focus on teaching English as a Foreign Language/ Second Language/ for Academic Purposes (EFL/ ESL/ EAP courses)
- where the main purpose was to:
  - establish correlations between variables such as age, gender, personality, locus of control, learning styles and thinking; often the purpose of such studies is theory/ model building
  - depict the extent of thinking in post-school populations, without any attempt to engage with pedagogical factors influencing students’ ability to think about what they are studying; often the purpose of such studies is theory/ model building
  - investigate the psychometric properties of well-known standardised tests of thinking
- no commentary could be made about the sense that a research paper might make to teachers, administrators and policy-makers in work-related education and training.

The first three criteria for rejecting a study were selected because there is a huge literature in each of the exclusions. It was not possible to represent this literature adequately alongside the literature to be dealt with in accordance with the objectives of the project. The fourth criterion was selected because these studies would not be relevant to this project.

All abstracts identified through the database searches were reviewed using the selection criteria outlined above. Additionally, judgements were made about the relevance and quality of the studies, as follows.

- For studies conducted in school settings, is there a clear message which is translatable to post-16 learning contexts?
- If the work is empirical, is there clear evidence of evaluation, systematically conducted?
- Is the work theoretically grounded?

The overall aim of the selection process was to find research reports in which the authors’ findings about teaching thinking were justifiable on the basis of a variety of interpretative considerations, such as the weight of the evidence, the explanatory value of the interpretations, the consequences of alternative judgements, the risk of erroneous conclusions and the interrelationships of these factors.
The searches led to 5846 studies being identified. The three members of the research team made a total of 315 selections from the 5846 positive hits that emerged from the search of databases. The reliability of the whole selection was checked by two of the three researchers judging whether the studies included in the review met the criteria. Together with four key studies that are described in Section 3, a selection of the reviewed items is discussed in the main text of this report. A sample of some of the items reviewed is included as Appendix 2.

Some narrower searches were carried out in an attempt to identify studies related to research of particular interest; for example, a single search for studies that evaluated the AS level Critical Thinking course. In addition, the research team drew on other sources of literature, such as items cited in the bibliographies of material identified through the database searches. The studies selected on the basis of the abstracts were retrieved and read in detail. Not all of the empirical studies that were reviewed provided satisfactory evidence of systematic evaluation. One could not always judge from the abstract whether systematic evaluation had taken place.

The studies were classified as follows:

1. review of literature post-16
2. studies in the post-school sector from 1992:
   2.1 discrete programmes for teaching general thinking skills (programmes separate from existing components of a curriculum)
   2.2 programmes in which the main purpose is to improve students' ability to think with specific subject knowledge
   2.3 programmes designed to incorporate thinking skills throughout an existing curriculum
3. studies whose purpose is to identify features of curricula and teaching associated with development of thinking in one or more than one domain
4. research whose purpose is to examine and synthesise knowledge relevant to pedagogy for teaching thinking
5. studies describing teachers' thinking skills or conceptions relevant to teaching thinking skills
6. studies of the transfer of thinking skills from one domain to another
7. reviews and studies of learning to think conducted in upper primary and secondary education:
   7.1 reviews of literature
   7.2 discrete programmes for teaching general thinking skills (programmes separate from existing components of a curriculum)
   7.3 programmes in which the main purpose is to improve students' ability to think with specific subject knowledge.

The team undertook a detailed analysis of the evidence emerging from the review. In particular, this included the following tasks.

- Identifying similarities and differences in approaches used to teach thinking skills.
- Identifying key principles and issues for practitioners and policy-makers.
- A more detailed analysis of pre-16 studies and an investigation of transferability from pre-16 to post-16 programmes.
- Synthesising the evidence to provide responses to the research questions (see Section 1) and identification of areas for further research.

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1 It should be noted that some studies were identified by more than one search.
From this detailed analysis, the main cross-cutting themes to emerge were:

- transfer in relation to thinking skills and pedagogy in the post-16 sector
- the role of cooperative learning, peer tutoring and peer interaction in promoting students' thinking, and how ICT can contribute in these areas
- the assessment of thinking skills and evaluation of thinking skills interventions
- conditions for the successful implementation of thinking skills interventions in post-16 settings.

Each of these themes has a section devoted to it in this report (Sections 5–8). Other important themes, such as the role of metacognition in learning to think, are discussed at relevant points throughout the report.
The purpose of this section is to illustrate key features of successful interventions designed to enhance students’ ability to think productively about whatever they are studying. This is done through exploration of four studies in three different geographical areas (North America, Western Europe and the UK). These studies are some of the better examples of interventions that met the criteria for inclusion set out in Section 2. Each study had been subjected to a rigorous peer review process and had strong implications for pedagogy. Together, the studies provide evidence about ‘what works’ in teaching thinking. Key terms used below are explained in Section 4 and appear in italics in this section.

All four studies were conducted in the post-16 formal education sector, as were the studies that met the inclusion criteria. Although the organisation and structure of post-16 education differs in the different countries included in this project, often the student populations have similar entrance qualifications and aspirations (eg in community colleges in the US and FE colleges in the UK). In the UK, many students enrolled in Higher National Diploma (HND) programmes are working towards learning outcomes similar to those in the university-sector studies that emerged from the searches for all countries covered by this review, particularly in first- and second-year programmes in vocational areas (eg applied science courses). Most university interventions targeted first- and second-year students.

Discrete post-school programmes for teaching general thinking skills:

Key study 1 (Butler 1998)

In this intervention, Butler (1998) worked with students in accordance with principles outlined below in order to improve their ability to set task goals for themselves, to plan strategies for achieving their goals efficiently and effectively, and to monitor and evaluate their own progress towards their goals. Butler and many other researchers (eg Moseley et al. 2003) describe this process as ‘self-regulation’ (one of the ‘key terms’ explained in Section 4). The aims of Butler’s Strategic Content Learning (SCL) approach can be summarised in terms of helping students to get a sense of what they are trying to achieve, and in guiding students to consider options and make strategic decisions for themselves, without telling them what to do. These self-regulation aims seem to be connected with employability and lifelong learning.

What is to be self-regulated is often summarised by the term cognitive skill or thinking skill, terms that are often used interchangeably. Some cognitive or thinking skills such as evidence evaluation are included in definitions of critical thinking. For example, when students are working on an assignment, they might identify a strategy that is made up of several cognitive skills such as comparing present and previous task requirements to find common features, generalising and adapting previous task approaches, and classifying available information as more or less relevant to the task. The literature on self-regulation research implies that, although people develop such cognitive/thinking skills from everyday experience, probably in an elementary form, there is significant scope for enhancing adults’ deliberate activation, monitoring and evaluation of such skills in work- and college-based learning situations.

Butler’s intervention was conducted in North America with post-16 learners who either had no formal academic qualifications at entry to their course, or whose entry qualifications were equivalent to one or two passes in the UK GCSE examinations and who struggled to complete course tasks. Butler’s interest in enhancing the students’ self-regulation arose from observations that the students’ approach to learning was ‘actively inefficient’. A member of the project team discussed this observation with 20 Scottish FE lecturers. The idea that students’ difficulties with coursework might be related to their ‘actively inefficient’ approaches to thinking about tasks resonated with the lecturers’ experience of working with students in the early stages of National Certificate programmes. They reported that students often did not try to clarify what would count as a good task performance and did not try to identify any relevant strategies, which meant that they could not consider what strategies might be more effective ones; or monitor, evaluate and adapt their strategy use in relation to their course tasks.

Butler was successful in helping her students to become more skilful self-regulators by designing instruction around principles that have emerged from many studies that the project team reviewed, and that are used to some extent in post-16 settings, but rarely as systematically as in this intervention. This is not to say that there have been no challenges to any of these principles, but rather that the evidence that supports them stands up quite well to scrutiny. According to Butler (and many other researchers whose output was reviewed by the project team), the application of these principles has been associated with improved task performance, development of knowledge about learning processes, construction of positive motivational beliefs, and independent transfer of what has been learned to other situations. Thus, Butler adhered to the following principles in the intervention reported here and in other connected studies.
Develop thinking in meaningful academic or work contexts on a long-term, ongoing basis: thus, Butler calls her pedagogy a Strategic Content Learning (SCL) approach: that is, self-regulating cognitive/thinking skills should be practised in every module/unit (termed ‘infusion’ in the literature), rather than locating such practice in a separate module/unit. Butler worked with students while they performed course tasks such as solving mathematics problems, or listing and organising ideas for essays/reports.

Butler's intervention is consistent with research that this work is better done in the following ways.

- Use an explicit, structured approach: this means planning into each class meeting points at which thinking will be discussed and practised (eg when the student is to colour a client's hair: 'Talk me through the questions you will think about before you begin/ during the task:'); ensure plenty of opportunities for students to practise self-regulatory activities such as:
  - analysing task requirements, to define or interpret performance criteria and how to set themselves learning goals
  - selecting, adapting or generating strategies to match the task goals they have identified
  - monitoring their task performance by comparing their current progress with their goals, to judge both the appropriateness of the goals and their own strategic behaviour: this includes identifying distractions, obstacles, boredom.
  - Engage students in discussion about learning processes: help students to shift frequently between performing tasks and talking about task-relevant thinking (eg 'You say you are finding it tedious to learn the information about hair colouring on each product sheet – what ways do you know of making tasks more interesting for yourself?').
  - Provide assistance, contingent on students’ progress in thinking about tasks – sometimes called ‘scaffolding’: Intervene only when the student’s thinking seems to be poorly formulated and then help them to clarify/extend their thinking to move forward with a given task (eg ‘How would that step help you to finish the task?’; ‘What happened last time when you did it that way?’; ‘Is there a way you could classify wines to make information about them more manageable?’; ‘How do you know that some hair-colouring information is relevant to what you are doing – how can you check if it is relevant?’).
  - Require students to apply and adapt thinking strategies across tasks and domains (eg ‘We have been classifying financial information into expenses and gains to find net profit – now we have to classify … to find out … what relevant information do we have – how should we classify it to find this out?’).

- Help students to recognise the applicability of strategies they are learning in tasks beyond the one in which they are being learned (eg 'You have been learning to recognise the features that tell you that fish is fresh enough – in what other jobs might you think about features that will tell you what you want to know; and how might you need to adapt what you have learned?’).

Butler points out that there are two main variants of the ‘explicit and structured’ feature in the list above. Butler's (1998) study puts more emphasis on the second of the two variants outlined below.

- Variant 1: in some research studies, the ‘explicit and structured’ feature is fulfilled by the tutor modelling for the student the kind of thinking that makes up an effective strategy for dealing with the task. For example, a tutor might say to a student who has come for advice on how he can retrieve pastry that has not turned out well enough for the training restaurant: 'I would think first about what might have caused the problem – has it had enough liquid? I would think about how I could test this idea without ruining the whole batch – if it turns out to be right, I would think about what would be a suitable liquid to add to the batch: egg, milk, water, and why.' Students then practise the thinking on set tasks and are encouraged to adapt the thinking in the light of their experience of applying it to tasks.

- Butler and her co-workers put less emphasis on the sort of modelling described above as Variant 1 and more emphasis on Variant 2: engaging students in discussion about the thinking skills they themselves brought to coursework, to help them to see weaknesses in their assembly of these skills into strategies, and to develop their weaker ones into more effective ones. For example, ask the student: 'Tell me how you think through what to do when a (cooking/welding/construction work) calamity happens. How well did that work? Was there something you missed out in your thinking? What might you take into account when you have to deal with things like this again? Could it (the calamity) have been prevented?'

The findings Butler reports from this study and from related large-scale studies include the benefits outlined below. All gains were statistically significant compared to the results from a group who had not participated in the SCL approach.

- Their task performance was better.
- They increased their perceptions of self-efficacy (their beliefs that they had effective self-regulation of cognitive skills for course tasks).
- They actively evaluated and developed their cognitive skills and generated others.
- They reported that they transferred their cognitive skills to other contexts, developing and adapting them as required to fit the new task demands.
Although there is strong evidence that the SCL approach is sound, some might argue that its implementation is highly labour-intensive and would require very small classes; or at least classes with trained support workers. On the other hand, in the post-16 sector, while a class is working on tasks, tutors commonly comment on individual students' work. The SCL approach can be interpreted as being a more effective way of providing such feedback - one that focuses on asking how the students thought their way through the task. Such a switch of focus (for tutors who are not doing this at present) need not take up much more time than the sort of feedback that tells students what to do next to get their performance on track.

Many FE students work independently, from packaged materials. Butler's study suggests how tutor support time might be profitably spent. The use of an SCL approach might be particularly cost-effective in the early stages of post-school courses, particularly for disadvantaged learners, in that the evidence gathered by the project team suggests that the development of self-regulation might yield high dividends in later study. Butler's model of self-regulation in academic domains includes the idea that self-regulated performance is influenced by a variety of beliefs and knowledge. For example, if lecturers' behaviour encourages students to believe that each step of their work should be checked against the lecturers' notion of acceptable output, they will see little point in self-regulating their work.

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Set within a larger, prestigious and well-funded research project, Masui and De Corte (1999) describe their aims as the enhancement of students' metacognitive knowledge. As noted in Section 4, although psychologists make distinctions between metacognition and self-regulation, for teaching purposes, the terms have much in common, since the expected benefit of improving metacognitive knowledge is that one is better able to manage one's own thinking during task performance in the ways described in the Butler (1998) study above. Masui and De Corte use the terms: 'orienting and self-judging activities' to describe aspects of metacognition that were the focus of their study. For Masui and De Corte, 'orienting and self-judging activities' are learning tools that can influence performance. Therefore, the authors focused on teaching students to orient themselves towards the study of their course by gathering data about:

- learning goals
- the study load of the course
- the practical organisation of instruction
- the study material and other instructional aids
- the learning content
- the necessary study activities
- assessment requirements.

Orienting activity involves making use of appropriate informants or sources of information. Self-judging involves making judgements about oneself as a learner or problem solver. For example, students might evaluate their own learning as being too slow, and might locate this problem in insufficient prior knowledge to start a specific assignment. In this study, the authors restricted self-judging to students' orientation to the course.

Orienting and self-judging seem to have wide applicability in the post-16 education and training sectors. Both activities can be applied to specific tasks such as an assignment or problems, as well as to whole courses or modules within courses. Armed with orientation data, a student can better plan his/her problem-solving or learning process and regulate his/her own learning by self-judging progress with tasks. Modules with aims that are apparently similar to those in Key study 2 are common in the UK post-16 context. However, it is unusual to find an approach to realising such aims that is as explicit and structured, or as robustly evaluated as the one described in this key study, or that conforms so closely to the other principles for developing students' self-regulation that are set out in the previous sub-section.
An experimental group and two control groups participated, each comprising 47 first-year business economics students in a Flemish university. The intervention was embedded in the natural context of university teaching over 10 class sessions. In order to promote transfer of learning, the students in the experimental group practised orienting and self-judging – not only in their business economics modules, but also in all nine subjects in their first-year programme. One of the two control groups practised more specific cognitive activities such as breaking down problems into parts, concretising and relating concepts in their textbooks and summarising chapters. The longer-term impact of the intervention on academic performance was evaluated by looking at students' scores in each of their courses at the end of the third trimester (ie two trimesters beyond the intervention).

After the final intervention session, students' progress was measured in various ways, which included asking students to write their response to the question: ‘What do you have to know at the start of a trimester in order to be able to organise and plan your study for a particular course? Also mention how you can obtain that information.’ Self-judging was assessed by asking students to write responses to questions such as: ‘What personal characteristics of a student can be an advantage and disadvantage for studying this course?’

A test of transfer was included to assess the extent to which students could use the orienting and self-judging activities in a course that was not involved in the intervention.

All the students' writing was content-analysed in order to perform a statistical analysis. This produced the following observations.

- Students in the experimental group had significantly more knowledge of orienting and of self-judging than students in both control groups, and these activities mattered with regard to academic performance.
- The students in the experimental group provided more evidence of orienting and self-judging in relation to the courses not involved in the intervention than did their peers in the control groups. Thus, there was evidence of transfer of learning.
- There were no overall differences between the two control groups.

The longer-term impact of the intervention on academic performance was evaluated by looking at students’ scores in each of their courses at the end of the third trimester (ie two trimesters beyond the intervention).

The authors point out that they measured knowledge rather than action competence. However, many studies point to strong relationships between knowledge as beliefs and action in learning. Given the wide applicability of these educationally significant findings, the rigour of the research design and the international reputation of the authors, this study merits wide dissemination.

Post-school programmes designed to incorporate thinking skills throughout an existing curriculum: Key study 3 (Jones and Merritt 1999)

The third key study is one of a series of papers arising from the UK TALESSI (Teaching and Learning at the Environment-Science-Society Interface) Project. The greater part of TALESSI’s financial support came from the Higher Education Funding Council for England’s (HEFCE) Fund for the Development of Teaching and Learning (FDTL). Although the lecturers were operating in the HE sector, the original course intentions and content were similar to those of many HND modules in the FE sector. The paper includes three appendices that provide operational information. The aims and approach to learning and teaching are well thought out. One of the reasons for designating TALESSI as a key study is that it offers practitioners a wealth of teaching/learning resources that can be adapted for other vocational courses. Information on these resources is readily available at the TALESSI website (www.greenwich.ac.uk/~bj61/talessi) together with practitioners’ views of the programme and resources.

The method of evaluating the success of this project differs from that in Key studies 1 and 2, in that user appraisal is a more central feature of the evaluation. Comments from teachers in higher education who were introduced to the TALESSI ideas and materials are presented as data (interesting and highly positive comments). The evaluative data includes comments on the project, on the teaching and learning resources, and on the workshops and a conference.

Many of the studies that the project team selected (see examples throughout Section 8) provide indications of a range of conditions that seem to be central to the successful implementation of thinking interventions. The TALESSI Project was chosen because many of these conditions were present. In particular, this project operated within a wider strategic framework that facilitated changes in curricula that seem to support successful implementation of initiatives to promote students’ thinking (see Section 8).

Another reason for choosing the TALESSI Project as a key study is that the notion of thinking that underlies this project is wider than in most studies reviewed, and is consistent with the view of King and Kitchener (1994) that it is not possible to think well until one understands that much knowledge is contestable rather than absolute, that methods of enquiry exist for evaluating claims that people make about good practice or anything else, and that values have an important role in environmental debate.
TALESSI aimed to enhance three aspects of environmental learning through active learning:

- Interdisciplinarity
- Values awareness
- Critical thinking.

Disciplinary perspectives include those of the natural sciences, the social sciences and the humanities. For Jones and Merritt, values awareness involves being able to recognise values that come into environmental debate from various sources, and to question whether these sources are as neutral and value-free as is commonly assumed. Values come into environmental debate from natural and social sciences and through the learning context of environmental higher education. Critical thinking is defined as the means to question and reveal the contestable character of ‘knowledge claims’ advanced in relation to many environmental questions, and the means to incorporate this critical awareness into academic writing.

One of the merits of the TALESSI Project is that it takes account of research findings that good thinking requires a rich, well-connected knowledge base by constructing interdisciplinary curricula. The definition the project uses of critical thinking is translated into learning outcomes that emphasise being able to understand that knowledge is uncertain and provisional in nature, and that there are conflicting views. Learning activities reflect this emphasis.

The project’s aims and approach to learning and teaching reflect a view that the development of critical awareness is one of the more important purposes of post-school education. Although the ideas for developing such awareness seem sound, their application in programmes offered in many parts of the FE sector would seem to entail radical revision of aims and approaches. If such radical thinking were to be contemplated, TALESSI offers an excellent prototype for research.

Key study 4 (Hanson and Wolfskill 2000)

The fourth key study identified by the project team focused on the implementation and evaluation of a new model of instruction, termed ‘process workshops’, which was designed for teaching general chemistry students at a US university.

A process workshop is defined by Hanson and Wolfskill (2000, 120) as follows:

...a classroom environment where students are actively engaged in learning a discipline and in developing essential skills by working in self-managed teams on activities that involve guided discovery, critical thinking, and problem solving and include reflection on learning and assessment of performance. The essential skills ... lie in the areas of information processing, critical thinking, problem solving, teamwork, communication, management and assessment.

One of the reasons for identifying this intervention as a key study is that the pedagogical and assessment strategies incorporated into the process-workshop model are well grounded in the evidence about successful methods of teaching thinking, and many also feature strongly in the three preceding key studies and across the range of studies which met the project team’s evaluation criteria. There is a particular emphasis on guided discovery and problem solving. The process workshop has as its foundation a constructivist theory of learning. The study examines in some depth the important features of the process workshop, such as the role of the instructor, and the use of learning teams, guided discovery and exercises, problem solving, reporting and assessment. There is, in addition, an instructors’ guide and sets of activities. The discussion and resources would enable other teaching teams, not only those in chemistry or science departments, to implement and evaluate aspects of the model within their own settings.

Another reason for identifying this intervention as a key study is that it was stimulated by a set of difficult circumstances, many of which may be experienced across a range of FE and HE settings. Some of these circumstances were as follows.

- A large number of students (1300) were registering for chemistry courses each semester.
- Staff perceived that traditional teaching methods (lectures, and tutorials in which faculty and graduate teaching assistants worked problems and answered students’ questions) were becoming less effective, with students becoming less actively engaged in course-work and only about 10–20% of students attending the tutorials.
- Other studies confirmed that students respond poorly to the lack of human interaction and exchange of ideas in traditional lecture formats, and do not see the relevance of what they are learning.
- Students had difficulty applying concepts when solving problems.
- Negative perceptions and attitudes regarding chemistry and science which appeared in the press were shared by many students.
- Students made few connections in their writing between university and work experience.
- Industry reports confirmed that desirable employees are quick learners, critical and creative thinkers, problem solvers, communicators, and team players, but these aspects are not much focused on in traditional teaching methods.
Hanson and Wolfskill (2000, 120) contrast the university and industrial experience as follows:

In the university, they mostly were told what must be done, worked individually, and were held accountable as individuals. In industry, they worked as part of a team that decided what must be done, and the team was held accountable. They also saw that their success on examinations depended to a great extent on what they understood and could remember from textbook and homework assignments and lectures, whereas their success on the job depended on analysing new situations and applying their knowledge in new contexts.

The strategies adopted in the process workshop are geared towards developing in chemistry students the key skills that many employers claim to value highly, and this makes it highly relevant to post-16 education. Hanson and Wolfskill posited that introducing process workshops can provide a mechanism by which a lecture-based course can evolve into a more interactive, learner-centred, process-oriented format. The main premise is that if students are actively engaged in learning and have the opportunity to exercise process skills in key areas, then they will grow intellectually and become better learners, thinkers and problem solvers, and will improve their examination grades and be more successful in the real world. Such general claims are rarely substantiated by research, and this study is no exception; for example, there was no attempt to measure any transfer effects. Nevertheless, clear evidence emerged from the outcomes of evaluation that process workshops were of benefit to students' learning of general chemistry and had a positive effect on their motivation.

The research itself took the form of a case study that examined one implementation of the process-workshop classroom involving over 1000 students over a semester. Workshops have up to 40 students divided into teams of three or four. Essentially, students work in teams to acquire information and develop understanding through guided discovery. They accomplish tasks and examine models or examples in response to critical thinking questions. The questions compel students to process information, verbalise and share their perceptions and understanding with each other, make inferences and draw conclusions. They then apply this knowledge to simple exercises, and problems which require higher-order thinking.

An example of a problem set in a realistic context is: “You are camping at your cabin in the woods. One pound of propane remains in the tank. Will you be able to take a hot bath tonight?” Such problems are designed to promote discussion of what must be done and how to do it, the identification of key issues and the making of assumptions or approximations, aspects which Hanson and Wolfskill link to the development of critical thinking and problem-solving skills (they provide no formal definition of critical thinking or problem solving).

The teams report their results to the class, assess their performance, develop strategies for improving their skills, reflect on their learning and submit a written report. The importance of getting students to articulate their method of solution is stressed. It is claimed that through developing their solutions with others and explaining concepts and methods to others, students deepen their knowledge while exercising skills in learning, thinking, problem solving and communicating.

In order to evaluate the success of the approach, a range of comparisons was drawn with the previous cohort of students. The text and instructors were kept the same and efforts were made to make the examinations equivalent (however, it should be noted that no measures were taken to establish the equivalence of the student cohorts). Positive findings were reported on: attendance at the sessions; students' affective responses to the workshops; ratings awarded by the students to their instructors; examination performance; enrolment in the second-year organic chemistry course; and instructors' reports on improvements in student skills. The instructors reported that students were becoming more active in their learning and were encouraged by their own accomplishments and by sharing experiences with other students.

Conclusion

The key studies presented above illustrate an important point made by Moseley et al. (2003, 79) in their final report to the LSRC:

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 ... their effectiveness is likely to be greater if they are used for learner self-regulation [our emphasis] rather than coming under the control of teachers.
Introduction

The review of literature suggests that the nature of thinking is highly contested. Embedded in any description of thinking are important assumptions, that are yet to be fully examined, about what it might mean to think well. In deciding how to define key terms, the project team drew on the selected research reports included in Appendix 2 and on a related project funded by the LSRC (Moseley et al. 2003).

Terms used in the studies selected for inclusion in the report – a brief glossary illustrated by reference to sample studies

The terms below are key ones in the studies included in the report. The meanings that the project team assigned to these terms are explained and illustrated by reference to studies selected for inclusion in the report.

The key terms used in the reports of selected interventions are:

- higher-order thinking
- transfer
- thinking skills
- taxonomy of thinking skills
- cognitive skill
- critical thinking
- creative thinking
- metacognition and self-regulation.

Often the authors of the selected studies offer no precise definition. For example, the term ‘higher-order thinking’ is used loosely in many studies to capture some features of the following terms: ‘thinking skills’, ‘cognitive skill’ or ‘critical thinking’.

Higher-order thinking

The term higher-order thinking in Vygotskian theorising (Vygotsky 1978) is used to make a distinction between relatively basic mental functions, such as the ability to perceive the outside world, and higher mental functions such as thinking, and the cultural tools such as language that are connected with thinking.

Transfer

Transfer is discussed in more detail in Section 5. Explanations of some terms from that section are repeated here.

Following Haskell (2001), in this report, the term transfer of learning is used to mean a person’s use of past learning when learning something new and the application of that learning to both similar and new situations.

Two types of transfer are distinguished in Section 5: application transfer and context transfer. These two terms are explained in the next sub-section that defines ‘thinking skills’.

Illustration of the term transfer in the selected studies

In Section 3, there are examples of transfer of learning in the Butler (1998) study and in the Masui and De Corte (1999) study.

Thinking skills

In the empirical studies that are described in Appendix 2 as: ‘discrete programmes for teaching general thinking skills (programmes separate from existing components of a curriculum)’ and as ‘programmes designed to incorporate thinking skills throughout the existing curriculum (“infused” programmes)’, the term thinking skills is used to mean translatable mental processes.

Translatable means that the mental processes are re-usable in the sense that, if students learn to evaluate alternative ways of colouring hair in an FE class lesson, they might be able to evaluate alternative ways of doing a variety of other tasks in the workplace or in their personal lives. It is supposed that, for example, they might be able to evaluate alternative strategies for improving day care arrangements for pre-school children. Similar assumptions are made about other supposedly translatable processes. If such students learn to classify products for colouring hair, for example, it is assumed that they might be able to classify plumbing materials or wood veneers.

In the two types of intervention described above, the term thinking skills is used.
Thus, the term thinking, rather than thinking skills, is used to describe the aims and outcomes of these programmes.

The term ‘domain-specific’ is not used to describe such programmes because, although the thinking was practised within a domain in the selected studies, these studies are not entirely consistent with what are known in cognitive science as domain-specific models of cognition. Such models imply that the mind is a collection of enduring and independent subsystems designed to perform circumscribed tasks, such as troubleshooting faults in equipment, and that the ability to fine-tune and apply the relevant knowledge develops through practice. Consequently, according to domain-specific models of cognition, there is little need for the sorts of intervention included in this report that pick out and teach particular sorts of reasoning.

Moreover, in some of the selected interventions, students were taught not only reasoning that was useful in the domain, but also more content-general reasoning, represented by questions such as ‘What is it I’m trying to achieve, what are alternative lines of action and the possible consequences of each?’

**Taxonomy of thinking skills**

Following Moseley et al. (2003), the term taxonomy is defined for the present report to mean: a description and a principled classification of the domain of thinking skills.

Thus, a taxonomy might include lists of the sorts of mental processes illustrated above, classified in some way.

Since many significant taxonomies are discussed in Moseley et al. (2003), examples have not been included in this section.

The findings from the sample interventions suggest that greater use of taxonomies would have helped researchers in specifying thinking goals and that, more generally, the taxonomies set out by Moseley et al. provide a language that is helpful to course designers.

The results of the searches made during this project support Moseley et al.’s finding that there were no UK studies in the post-school sector in which syllabuses, course planning, assessment tools or learning-related discourse have been analysed using the framework of a taxonomy of thinking skills. However, in almost all the selected interventions, the authors targeted some aspects of thinking that can be found in one of the taxonomies reviewed by Moseley et al.; and in some reports, but by no means all, there was a reference to a taxonomy. In many of the studies that were designed to promote thinking about ideas in a particular discipline, the starting point for the authors seemed to have been their own experience of thinking with and about their field of knowledge, rather than drawing on any particular taxonomy.
Only a few of the studies that emerged were consistent with the idea that syllabuses, course planning, assessment tools and learning-related discourse are interacting parts of a system and that all parts might need to be revised in initiatives to enhance students’ thinking. One intervention that aimed to create such an initiative is the TALESSI Project (Jones and Merritt 1999), which is included in Section 3 as one of the ‘key studies’.

**Cognitive skill**

The term cognitive skill pervaded the research reports that were reviewed. It seemed to be used in the sense outlined in the Moseley et al. (2003) report: ‘a mental process such as classifying, inferring, generalising or questioning, often assumed to be translatable from one task to another’. Often, the terms cognitive skill and thinking skill were used synonymously.

**Illustration**

In many interventions that emerged from the search, the term critical thinking was not defined. Often it was used to describe whatever cognitive skills the researchers wanted to promote. For example, Cowles, Strickland and Rodgers (2001; see Appendix 2) claimed to be promoting critical thinking when they tried to help students with processing, analysing and articulating concepts, sorting through ideas, connecting thoughts and reflecting on their constructions.

Many writers argue that such thinking falls short of being critical if it does not include addressing the question: how do I (or others) know this, and how sound is my basis for knowing this?

The project team acknowledges that critical thinking is one of the most highly contested terms in the literature. They chose a definition that has attracted strong support in the research literature, and that summarises many characteristics of critical thinking in taxonomies (see Moseley et al. 2003). Other definitions tend to elaborate/unpack this definition: ‘Critical thinking is thinking that can be assessed by appeal to criteria’ (Lipman 1991).
Creative thinking

There is no consensus view among researchers and practitioners on the meaning of terms such as creativity, creative thinking or creative learning, and what it means to teach these things (Puccio and Murdock 2001; Treffinger and Isaksen 2001). When considering the nature of creative thinking, Puccio and Murdock (2001) begin by examining the broader construct of creativity. They view creativity as not being limited to one theory, model, definition, concept or approach, and consider that it is best understood through a dynamic, multifaceted perspective. They argue that a simple, brief definition of creativity cannot serve well in all circumstances and for all purposes. Nevertheless, there is agreement among many scholars that the multifaceted nature of creativity involves at least four discrete elements concerned with, in turn:

- the characteristics and skills associated with the creative person
- the stages of thinking that comprise the creative process
- the qualities of the creative product
- the nature of the environment that is conducive to creative thought.

The term creative thinking is thus most closely associated with the process element. Puccio and Murdock (2001, 69) stress the ubiquitous nature of creative thinking, since every problem that has no preset solution and every opportunity that has no prescribed pathway to success demands creative thinking. They define creative thinking broadly as: ‘a rational process that enables people to successfully produce novel and useful responses to open-ended challenges and opportunities’.

Treffinger and Isaksen (2001) discuss present-day programmes that highlight flexibility in process and engagement in real-life problems and challenges. There is an emphasis on a natural, dynamic and flexible approach to creative problem solving linked to people’s needs and tasks, rather than always deploying a single fixed set of steps and stages.

From this analysis, creative thinking does not emerge as a separate type of thinking, but rather as a complex combination of multiple factors.

Illustration of the term creative thinking in the selected studies

Few reports on empirical studies on the theme of creativity or creative thinking were uncovered by the literature search for this review in comparison to the number of empirical studies investigating aspects of critical thinking. One finds in some thinking skills taxonomies and frameworks that creative thinking skills, such as finding analogies, are subsumed under a broader heading of critical thinking skills (see Moseley et al. 2003). In the field of engineering design, Sadowski and Connolly (1999) discuss the need to develop creative thinking in students and examine the nature of the creative thinking process, linking creativity to problem solving. Robbs and Wells (1999) and Coleman and Colbert (2001) report on interventions which develop teaching approaches to enhance creativity within courses for students who would enter creative professions; for example, creative advertising and magazine design. Robbs and Wells identify the importance of thinking conceptually and strategically within a creative field. In the context of school chemistry teaching, Reynolds and Brosnan (2000) develop the concept of ‘speculative thinking’, linking it to the use of imagination and the free use of analogy, both associated with the processes of being creative.

Metacognition and self-regulation

The use of the term metacognition in the present report is similar to that of Moseley et al. (2003). Moseley et al. use this term to mean an awareness of the mental processes that people use to specify their goals, to carry them out, to monitor how they are getting on with executing their goals, and to evaluate their thinking and learning. Moseley et al. also refer to metacognitive knowledge and to the metacognitive monitoring of dispositions. They note that metacognition itself involves knowledge, skills and dispositions (eg a disposition to focus one’s effort on the task in hand).

Other interventions set out to promote students’ self-regulation capacities. In this report, Moseley et al.’s (2003) distinction between metacognition and self-regulation is used: that self-regulation includes control of feelings and actions as well as cognition. Thus, the project team use the term self-regulation to include a person’s consideration of whether their emotional state is conducive to coping with the task in hand, and using this information in deciding whether to continue or postpone the task.
In other words, metacognitive processes are those that enable people to orchestrate their knowledge and ways of thinking towards desired ends, and that play a part in choosing those ends. For example, a person's exercise of their metacognition might influence them to forego an available, but tight, parking space in a busy city centre because they recall difficulties inherent in this parking task, appraise the mental processes required to overcome these difficulties, and conclude that the consequences of failure far outweigh any benefits.

In the literature on metacognitive processes, it is usually assumed that such processes transcend content. Thus, once a person is able to exercise metacognitive control, a person's efficiency in orchestrating their intellectual and emotional resources should not depend on the nature of the task.

**Illustration of the terms metacognition and self-regulation in the selected studies**

Butler's (1998) intervention to enhance post-school students' self-regulation is discussed in Section 3, along with similar research by Masui and De Corte (1999).

**Relevance of key terms outlined above in judging the relative merits and disadvantages of different types of programme**

A starting point for judging the relative merits and disadvantages of different approaches to teaching thinking skills is consideration of the purposes of each approach. The type of intervention described as a ‘discrete programme’ in Appendix 2 works with a notion of thinking skills as translatable mental processes. Such programmes are intended to enable students to re-use the processes in contexts other than the one in which they were learned. Therefore, one reasonable criterion for judging their merits is the extent of evidence of context transfer of learning. In view of the extent of literature on the research question about transfer, and the centrality of this question in learning and thinking, it has been given a separate section (§).

In the type of intervention described in Appendix 2 as a ‘programme in which the main purpose is to improve students’ ability to think with specific subject knowledge’, context transfer is not an appropriate criterion in the absence of a clear intention to enable the students to use the thinking learned beyond the domain. If it is clear that the intention of the study is simply to enable students to think with subject knowledge, the programme can be judged on advances in students’ thinking within the context of the intervention. In this type of intervention, the programme goals are referred to as thinking rather than thinking skill goals to avoid implying that the designers of the intervention had context transfer intentions.

The conception of the thinking underlying programmes might be considered in judging their merits. Most researchers whose studies are included in Appendix 2 worked with fairly narrow conceptions of thinking. Further research might focus on the extent to which interventions would benefit from proceeding from broader descriptions of thinking. In most of the studies, there was no intention, for example, to influence students’ epistemological understanding. There is no point in students thinking about something if they believe that the absolute truth is known about that matter; and that a tutor can transmit that truth unproblematically. For example, theories of motivation that might inform the work of a human resource development department rest on assumptions and values that are fundamentally different from those held by researchers in thinking, have different explanatory value, are supported by different sorts of evidence and in application, can have serious consequences for employees. If part of learning to think is becoming able to arrive at a principled understanding of why one prefers to practise in some ways rather than others, then pedagogy needs to rest on conceptions of thinking that encompass all that is involved in achieving this end.

Programmes might also be judged on how the researchers identified and described the thinking they wanted to promote. Arguably, a significant advantage in using a sound taxonomy of thinking skills in course planning is that it can provide a language for describing the alignment of intended thinking goals with content, instructional approaches and assessment across the course. For example, it is difficult to promote students’ ability to understand why they prefer one theoretical perspective on motivation to another if the course content includes only one perspective; or if the aims are not described in terms that emphasise the ability to question assumptions and values within perspectives; or if the assessment system does not offer adequate credit for proving possession of such abilities.

It can be concluded that significant ground-clearing work with post-16 sector staff remains to be done. Further areas for research include finding ways of ensuring that unit learning outcomes and assessment criteria describe thinking in ways that make sense to tutors and learners, and that due weight is given to evidence.
The project team reached three main conclusions from their literature review.

Knowledge of transfer is one of the most highly contested ideas in research on post-16 pedagogy and thinking skills.

Transfer is often described in ways that are likely to confuse teachers. Since it is reasonable to suppose that it is difficult to teach something one does not understand well, it is suggested that developing a pedagogy that promotes transfer involves helping teachers to understand better the following matters:

- what students are supposed to transfer from their current learning
- where the transferred knowledge can be used to advantage
- mental processes underlying transfer of knowledge.

The findings from the studies cited in this section (and presented in Appendix 2) constitute quite extensive and widely accepted evidence of some forms of transfer within a domain, but evidence of transfer from one domain to another is very limited, as is knowledge of how transfer might work.

This section includes suggestions as to how these matters might be clarified for the purpose of teaching to promote transfer of learning. It is also suggested that there is a need for further research on teaching for transfer across domains, and that enquiry into the cognitive mechanisms underlying transfer of learning has a significant role in such research. The last part of this section lists features of interventions from which the more convincing empirical evidence emerged of transfer within a domain.

Transfer - a problematic construct

Singley and Anderson (1989, 25) encapsulate important ideas in the literature on transfer:

One reason why the notion of general transfer keeps arising from the grave is that it is such an attractive proposition for psychologists and educationalists alike ... Sustaining these longings is the fact that it is very difficult to prove that something does not exist. There is always another manipulation in the psychologists’ tool box to try.

Haskell (2001) argues that, although it is generally agreed that transfer is elusive to demonstrate, it is the key to all effective instruction. The reasons proposed for poor transfer differ according to theoretical persuasion. Very few studies that emerged from the review explicitly included transfer in their aims. Nevertheless, they did not seem to be rejecting the idea that students would make use of what was learned in another situation. However, seldom was there any indication as to where the learning might be used again. Butler (1998; see Key study 1 in Section 3) suggests that students who do not achieve well may be ‘actively inefficient’ in terms of regulating their own cognition in ways that enable them to bring past learning to bear on later tasks. According to Butler and another key study discussed in Section 3 (Masui and De Corte 1999), teaching for transfer means teaching students to self-regulate their thinking.

One difficulty in realising ‘these longings’ for transfer seems to be that teachers do not have a clear enough idea about what sort of transfer is likely to be achievable. According to Bennett, Dunne and Carre (2000), a major problem in descriptions of ‘transferable’ skills has been the assumption that such skills transfer easily from educational to work contexts. For example, it is often assumed that cognitive skills (defined in Section 4) such as classifying, which might have been learned in, say, a biology course, will transfer easily to classifying sales invoices. Many writers (e.g., Bennett, Dunne and Carre 2000; Haskell 2001) point out that available research suggests that this sort of transfer, if it takes place at all, requires teaching approaches that in turn require radical changes in current post-16 curricula that might not be practicable.

In this report, it will be assumed that, while knowledge of transfer is uncertain and highly contested, there is sufficient evidence to support a view that educators can increase the probability that learning can be transferred. Further research is required on identifying the conditions that most effectively allow knowledge use across contexts. Such research will entail pursuing greater understanding of the social, cultural and technical contexts in which transfer takes place.

While there are weaknesses in descriptions of transfer, and in models of how it happens, they are included in this section because it is difficult to plan to teach for transfer without some clarification about what is to be learned and transferred. Greater clarity might help stakeholders to generate more productive ideas for developing and implementing curricula for post-16 learners.
Terms used in this section and in literature that discusses transfer
The definitions are supported by reference to key studies.

Definition of transfer
Following Haskell (2001), in this report, the term ‘transfer of learning’ is used to mean a person’s use of past learning when learning something new and the application of that learning to both similar and new situations.

Other terms used to mean transfer of learning
Terms often used for transfer of learning include generalisation of learning, analogical learning, and the application of core and key skills (sometimes called transferable skills).

Descriptions of types of transfer – terms used in the report
The term application transfer will be used in this report to describe the extent of transfer in most of the interventions described in Appendix 2 as programmes in which the main purpose is to improve students’ ability to think with specific subject knowledge. Application transfer refers to the situation where students learn something, such as transposing formulae, and apply this learning appropriately in order to complete tasks within the module.

In describing transfer in studies that involved applying knowledge learned in one part of a course to tasks in other parts of the course, the term context transfer will be used in this report. A much stronger example of context transfer would be the situation where students transfer what they have learned in a work placement to their coursework, or vice versa. Context transfer is often used to describe quite a wide range of situations. It is used, for example, to describe a situation where students transfer their competence in selecting from the college store a laminate that meets certain criteria, to making an appropriate selection when confronted with a range of laminates in the local DIY superstore. Context transfer is also used to describe the situation where people who have learned about supervisory management in an HND course transfer this knowledge effectively to managing aggrieved, intransigent employees in the workplace. No interventions emerged from our searches that involved transferring knowledge from classrooms to workplaces or everyday life. This is not to say that no such research exists, but rather that it did not meet the criteria for inclusion, such as methodological rigour.

Other terms used in the literature, but rejected for this report in describing extent of transfer
‘Near transfer’: typically, in the literature on transfer, distinctions are made between ‘near’ and ‘far’ transfer, but in neither case is there a sound way of determining distance. ‘Near transfer’ has been used widely to describe previous knowledge being transferred to new tasks that are closely similar, but not identical to previous tasks.

Illustration of near transfer
People who have learned to use a word processing menu to copy and paste a paragraph might be able to generalise this knowledge to working out how to cut and paste text or files. Bennett, Dunne and Carre (2000) offer, as an example of near transfer, the situation where students are required to deal with the same kind of problems in examination papers as they dealt with in class. ‘Near transfer’ in this sense is commonly required in almost all courses in the FE sector. This description seems to overlap with the description of application transfer, which can be made more precise by describing a range of tasks in which the application is to take place. For example, the range might be algebra word problems, or it might describe the kind of task that confronts student chefs who have to learn to multiply or divide the quantities of ingredients in recipes according to numbers of expected diners.

The term ‘near transfer’ will not be used in this report, other than when the author of a study explicitly uses it.

‘Far transfer’: this term is rarely elucidated beyond saying that it describes the application of learning to situations that are quite dissimilar to the original learning.

The examples offered in the literature are often unhelpful in distinguishing between ‘near’ and ‘far’ transfer. A student who is able to adjust accounts for expenses owing might transfer this knowledge to adjusting accounts for expenses paid in advance. In the literature, this basic accounting example of transfer is variously described as application transfer and as both ‘near’ and ‘far’ transfer. It is suggested in the literature that teachers should use the term application transfer and indicate to students that they want them to select and apply their existing knowledge to work out how to deal with a new task.

In view of the difficulties in determining distance, the term ‘far transfer’ will not be used in this report.

Creative transfer: Given the problematic nature of creativity, the term ‘creative transfer’ will not be used in this report.
Illustrations of teaching for application transfer in the selected studies

In most of the interventions described in Appendix 2 as programmes in which the main purpose is to improve students’ ability to think with specific subject knowledge, the tutors modelled and discussed an aspect of thinking that was important in the particular subject, and the students went on to try out the form of thinking in completing relevant course tasks and discussed their experience of doing so.

Aspects of thinking that were applied in course tasks included hypothetical-deductive reasoning (eg Chapman 2001), literary analysis (eg Law 1998), analysis and evaluation of management information (eg MacPherson 1999). MacPherson reports on the efficacy of a module designed to develop 31 students’ critical thinking skills in the context of peer evaluation in a year-long second-year supervisory management unit. Statistical analysis of data led to the conclusion that the participants achieved higher average grades on a similar (literature reviewing) assignment of 2000 words than students in the previous year who had not had any such training.

From a rigorously evaluated study of US college students that was designed to promote the development of their ability to handle a set of questions that must be raised and answered before drawing a firm conclusion about the relative truth or falsity of any particular causal claim, Lawson et al. (2000) claimed transfer within the domain of science. The programme was designed to train students to handle questions such as ‘What alternative causes are possible in addition to the proposed cause?’, ‘How can each possibility be tested?’, ‘How does the evidence, once gathered, match the expectations?’ One of the research questions asked was about the extent to which ability to use such questions plays a role in concept construction – in other words, in learning a knowledge base in science. The programme was evaluated using a modified version of Lawson’s Classroom Test of Scientific Reasoning (1978, cited in Lawson et al. 2000) at the beginning and end of the biology course, and by performance in end-of-course examinations. Although the pre- to post-test improvement was small, the authors point to difficulties reported in the literature of bringing about any improvement on the skills targeted. Most of the students who were deemed to possess the targeted skills used them to succeed on the course examinations covering a wide range of theoretical topics.

Similarly, there are good examples in Appendix 2 of mathematics and physics courses, where the researchers often modelled strategies for solving problems and students applied the strategies to problems for which they were judged to be helpful. One such study was part of a large initiative called the Student-Centered Activities for Large Enrollment University Physics (SCALE-UP) project at North Carolina State University (NCSU). Beichner et al. (2000) presented findings from this SCALE-UP project showing that, relative to students taught in traditional classes, SCALE-UP students are better problem solvers. The experimental group seems to have been better, therefore, than its control counterpart at transferring knowledge from problems practised in the classroom to those encountered in test situations. There is extensive evidence from the interventions included in Appendix 2 that students transferred learning within the targeted domain in that they solved mathematical, technological and business-type problems, or they became better able to read with comprehension.

The Dyas and Bradley (1999) intervention in undergraduate geography is another example of a study that was designed to help students to think with specific subject knowledge. However, it is unlike the studies cited in the previous paragraph in that it makes the explicit claim that the ‘skills’ are generic, and that the materials are structured to allow for easy adaptation to an alternative topic or even, as they suggest, another subject area. However, the researchers provide no evidence that this potential transfer was achieved. In most interventions that targeted thinking with specific subject matter, the researchers did not describe their aims in terms of transfer. The purpose of such interventions was to improve students’ performance in applying principles across tasks in a particular part of a course. The evidence often was that the participants were better able to complete cognitively complex tasks that were included in learning outcomes for the course within which the intervention took place.

The term application transfer will be used in this report, since it provides a good fit with the studies reviewed, particularly those concerned with improving the ability to think with specific subject knowledge (see Appendix 2). This purpose seemed to involve students in applying principles to a range of tasks within the discipline.
Models of transfer and related pedagogies in the selected studies

Consideration of models of transfer can help educators understand what mental processes might need to be engaged if students are to transfer learning. If educators are more convinced by some models than others, they are in a position to design teaching to promote the processes described in their preferred model. A brief outline of common models, of the evidence that supports them, and the pedagogies they informed in the selected studies are presented below.

A cognitive skills model

A longstanding idea in psychology is that for transfer to occur, the learner has to notice that there is a common set of features between two tasks. For example, it might explain why people can transfer their knowledge of cooking on an electric hob to using a ceramic hob. Although the idea of common elements is a problematic notion, there is some evidence that transfer occurs in this way.

Gray and Orasanu (1987) argue that the idea of transferring cognitive ‘operations’ (or cognitive skills, a key term explained in Section 4) is a modern version of the common elements approach, although the cognitive common elements are much more abstract, such as classifying, generalising and hypothesising.

Pedagogies in the selected studies that rested on a cognitive skills model of transfer

Haskell (2001) argues that freestanding thinking programmes basically rest on this model (eg in Guest 2000 – see Appendix 2; the AS level Critical Thinking course offered by OCR). Haskell argues that there is no good evidence to support assumptions that transfer occurs outside the programme in which the students developed the thinking. The output from the searches made in connection with this report supports Haskell’s conclusion. For example, there was little evidence to support the model’s claim that once one learns a cognitive skill such as looking for features that distinguish one building material from another during a construction trades class, one can transfer this cognitive skill – feature extraction – to distinguish between different types of cell when working with a microscope in a biology laboratory.

However, there was strong evidence that when people learn such cognitive skills in the course of studying subject knowledge, rather than in a freestanding thinking programme, they can transfer the skills to other problems within the subject. Most of the interventions described in Appendix 2 as programmes in which the main purpose is to improve students’ ability to think with specific subject knowledge implicitly rely to some extent on this cognitive approach to transferring cognitive ‘operations’ such as hypothetical-deductive reasoning. As noted above, there is fairly substantial support in psychological literature for the idea that students can be taught to recognise when it is relevant to apply previously learned cognitive skills (eg Chapman 2001). The Chapman project was designed to ‘develop scientific thinking related to the hypothetical-deductive approach’ and to focus on ‘scientific thinking and higher-order reasoning … inductive, deductive and hypothetical reasoning and problem solving ability’ (2001, 1160). However, like the Chapman intervention, some studies included in this section rely both on a cognitive skills model and on the general principles model described below.

In the Dyas and Bradley (1999) intervention in undergraduate geography, there is a greater emphasis on the cognitive ‘operations’ model, and greater commitment to the belief that the cognitive skills are generic, that they are expected to transfer to an alternative topic or even another subject area. Thus, Dyas and Bradley put great emphasis in their teaching on the cognitive skills because they expect these skills to put students in a position to effect transfer of their learning. In its assumptions about transfer, the Dyas and Bradley study is therefore close to the interventions described in Appendix 2 as discrete programmes for teaching general thinking skills (programmes separate from existing components of a curriculum) which rest mainly on the assumptions underlying the cognitive ‘operations’ model.

The evidence from these studies implies that an emphasis both on cognitive skills and general principles (explained below) produces at least application transfer.

General principles model

It is assumed that transfer occurs by way of understanding a general principle that can then be applied to situations that do not possess obvious common elements. In the example cited earlier – of a student who is able to transfer knowledge of how to adjust accounts for expenses owing to adjusting accounts for expenses paid in advance – this model would describe the transfer in terms of the student’s knowledge of the accounting principle of excluding expenses not attributable to the period covered by the accounting statement. Thus, the model would predict that students who could apply this principle in establishing net profit could apply it in computing allowable expenses in a personal income tax calculation.
Pedagogies in the selected studies that rested on a general principles model of transfer

Implicit in many of the interventions described in Appendix 2 as programmes in which the main purpose is to improve students’ ability to think with specific subject knowledge is the idea that learning cognitive ‘operations’ that are thought to be central in a discipline will enhance understanding of that discipline. In this sense, most of such interventions rest both on assumptions underlying the cognitive ‘operations’ and on the idea that if students learn an abstract general principle underlying a phenomenon, they will be able to transfer that principle to situations that have no very obvious similarities to the situation in which the principle was learned. Thus, in such studies, there was enormous emphasis on promoting students’ understanding of fundamental principles in areas such as molecular biology, chemistry, environmental science, literature and psychology. This emphasis in most cases was associated with transfer within the domain, although not outside it. Good examples of these studies are Chapman (2001) and the TALESSI Project (Jones and Merritt 1999) discussed as a key study in Section 3. Such mindful abstracting of important principles from a specific situation was described by Salomon and Perkins (1989) as ‘high road’ transfer.

All the literature reviewed for this project supported the idea that a pedagogy for transfer should take account of this model.

Cognitive information processing model (‘schema’ models)

What might be involved in transfer has been dealt with in ‘schema’ research. For example, according to this model, it might be assumed that we have schemata for different kinds of meeting (eg steering groups, course validation panels, research strategy committees). Such schemata might include knowledge of what conflicts might arise, means of resolving conflicts that are helpful for some purposes but not others, and the sorts of contribution that are helpful for different purposes (eg conceding something in the interest of achieving consensus). Such schemata are thought to be mental packages about aspects of the world (a cognitive structure), which enable new knowledge of a particular matter to be organised and processed. Since it is assumed that previous learning contained in the schema is transferred onto new situations, the post-16 student with ‘good’ and plentiful schemata is expected to learn more readily than the one with impoverished schemata.

Schema theory suggests that a pedagogy for transfer should focus on helping students to build schemata that will serve them well in interpreting new information rapidly and deeply. This model does not account for the underlying processes by which people discover or recognise similarity, or when to apply an existing schema. However, it does offer plausible reasons why it is unhelpful to regard learning to learn as some generic, content-free process, and therefore why a pedagogy informed by such a generic notion is unlikely to be productive.

Pedagogies in the selected studies that rested on a schema model of transfer

Almost all the interventions described in Appendix 2 as programmes in which the main purpose is to improve students’ ability to think with specific subject knowledge embody assumptions in ‘schema’ models, although this is rarely explicit. The cognitive skills would be assumed to be part of the developing schemata that the students are being helped to build up. In these interventions, the researchers seem to hope that in learning to think with subject knowledge, the students will use cognitive skills to extract important principles from what they are studying. In this way, they are expected to build up a body of knowledge that is more well organised and more readily brought to bear in relevant situations. This model draws support from extensive, rigorous research on differences between experts and novices (Chi, Glaser and Farr 1988).

Metacognition model

This is a cognitive model that is composed of self-monitoring strategies that students can learn to transfer within and across tasks or fields of knowledge (see also Section 4). This model describes general strategies that seem to promote transfer, but does not provide a theoretical account of the development of the processes underlying transfer. This model seems to include self-regulation, as described in Section 4, along with metacognition.

Two of the key studies in Section 3 (Butler 1998; Masui and De Corte 1999) provide strong support for this model by deriving a pedagogy from it, and offering substantial evidence of context transfer (see below).

Pedagogies in the selected studies that rested on a metacognition or self-regulation model of transfer

One of the most rigorous studies in this category that produced the most convincing evidence of context transfer (Masui and De Corte 1999), was set within a larger, prestigious research project aimed at improving metacognitive knowledge. Evidence for context transfer was found in the sense that improvements were noted in course subjects beyond those in which the intervention took place. This study is described in detail in Section 3 as are Butler’s (1998) findings that low-achieving adults can be helped to select, adapt or invent strategies to match task demands, to monitor outcomes associated with strategy use and to adjust strategies accordingly. The Masui and De Corte (1999) and Butler (1998) findings support the metacognition/ self-regulation model, when this model was used in the course of the students’ normal coursework. These are the only two studies that produced rigorous evidence of transfer outside the classes in which the learning took place. There were other interventions that reported such transfer, but they either did not meet the inclusion criteria or the evidence presented to support their claims was weak.
In Appendix 2, there is a discussion of Kincannon, Gleber and Kim's report (1999) of the positive effects of metacognitive training on performance and the use of metacognitive skills in self-directed learning situations in a beginners' photography course for non-art majors in the US. Although there are robust findings to support the idea that application transfer across the course tasks occurred, in that students improved their use of metacognitive strategies in their photography work, there is no information that sheds light on whether the students transferred their improved metacognitive strategies to tasks in other courses. The Kincannon, Gleber and Kim intervention reflects Butler's (1998) insistence on the importance of integrating the teaching of self-regulation/metacognitive competence with coursework.

Rickey and Stacy (2000) claim that their results show that insufficient metacognitive skills caused a graduate chemistry student to fail to solve a problem for which she clearly possessed the relevant domain knowledge. A pair of undergraduates working collaboratively solved the problem, apparently using metacognitive skills. Although the findings in this study are consistent with a metacognition model, the sample is too small to make any firm claims. Gourgey's (1998) findings, from a methodologically rigorous study, support the usefulness of self-regulatory processes in the basic skills of reading (clarifying purpose, understanding meanings, drawing inferences, looking for relationships, reformulating text) and mathematical problem solving (clarifying problem goals, understanding concepts, applying knowledge, monitoring progress). Her research provides support for a metacognitive model, at least in relation to application transfer, and also supports the idea in the studies above, that integrating metacognition coaching with subject-matter instruction (in the Gourgey study, reading and mathematics) is likely to be of more benefit than trying to coach metacognitive competence in a programme that is separate from other parts of the students' curricula.

The findings of the first two key studies discussed in Section 3, which imply that the increases in self-regulation transferred beyond the context in which it was developed, support the overall impression from the literature reviewed that transfer is connected with the ability to self-regulate knowledge and thinking.

Dispositional model

An attempt to explain problems of generalisation or transfer has been to add a ‘dispositional’ component to the traditional skills conception of critical thinking (Perkins, Jay and Tishman 1993). Thus, lack of transfer is explained in terms of insufficient disposition to make the effort to think well. Kuhn (1999) argues that the disposition construct leaves much of the variance unaccounted for. She argues that people make the effort to think carefully because they are convinced of the value of doing so (but cf Baron 1995: in some cases, individuals may value not thinking even-handedly about an issue). Few interventions have built in components designed to enhance students’ understanding of the value of careful thinking.

Controversies: knowledge that is limited, non-existent or highly contested, and questions that arise for further research

Basic models of thinking

The various types of intervention included in this report can be located in two fundamental views of thinking that come from cognitive psychology and which are outlined briefly below. Future research might include a review of empirical research on these two views. If such research were to indicate that the way people think is closer to one view than the other, there would be justification for designing and evaluating interventions that are informed by that view of thinking—since, plainly, interventions are unlikely to work if they are too inconsistent with available evidence on human cognition.

The discrete programmes for teaching general thinking skills reviewed in Appendix 2 rest on one of the two fundamental views. These studies incorporate the central idea of translatable mental processes, which can be located in a long-predominant view in psychological literature that people are endowed with a general set of reasoning abilities that they bring to bear on any cognitive task, whatever its specific content. Included in this view is the assumption that once such processes are learned, they will be usable again in other content areas. Measures to promote transferable ‘key’ and ‘core’ skills in curricula in the FE and HE sectors also draw on this view. It is a view that has been strongly challenged by empirical evidence.

This model is contested by a growing number of researchers whose evidence has led them to conclude that the mind is not, to any substantial extent, an all-purpose problem solver (Hirschfeld and Gelman 1994). Although this evidence is robust, like the model outlined in the previous paragraph, it also leaves some significant questions as yet unanswered. These researchers would argue that if students are asked to perform, and are assessed on, tasks that require disciplined enquiry and transformation of knowledge, their thinking will come to resemble that of experts in their field; and that if they need to think in another field, their thinking will develop through similar enquiry in that field. Programmes classified in this report as designed to incorporate thinking skills throughout the existing curriculum accommodate this view quite well as do programmes in which the main purpose is to improve students’ ability to think with specific subject knowledge. However, in the selected interventions classified in this latter category, there was no clear commitment to either of the two models outlined in the previous two paragraphs.
Discussion of this section in relation to the research questions

The research questions outlined in Section 1 will be discussed with reference to the three types of programme described in the research specification and used to classify the studies in this report. (Italics are used in the text below in referring to the different programmes.) The programmes were as follows.

- **Discrete programmes for teaching general thinking skills** (programmes separate from existing components of a curriculum).
- **Programmes in which the main purpose is to improve students’ ability to think with specific subject knowledge.**
- **Programmes designed to incorporate thinking skills throughout the existing curriculum.**

Implicit in all three types of programme are assumptions from at least four of the models cited earlier in this section:

- a cognitive skills model
- a general principles model
- a metacognition/ self-regulation model
- a cognitive information-processing model (schema model).

Although assumptions in all these models have been challenged in the literature (eg Haskell 2001), there is extensive, widely accepted empirical research that supports the idea that if students are coached in some of the mental processes described in each model, and have opportunities to practise the abilities extensively on whatever they are studying, they can achieve at least application transfer (described above in the discussion of ‘definitions of transfer’). Thus, students who were helped to practise a form of thinking that was considered useful in a particular subject seemed to transfer such thinking to other tasks within the domain. However, in the studies that met the criteria for inclusion in this report, only two studies provided convincing empirical evidence to support the view that thinking developed in one subject or domain is transferable to another one; and in both cases, the instruction was targeted on developing metacognition and self-regulation of thinking (Butler 1998; Masui and De Corte 1999). In other studies, evidence is thin and rarely goes beyond self-reports of feeling more motivated or confident, even in discrete programmes whose raison d’être is to teach for across-the-board context transfer.

Thus, the evidence from the studies reviewed implies that pedagogies intended to bring about transfer should draw on all four models listed at the beginning of this section. Since most of the studies included in this report combine ideas from the cognitive skills model, the general principles model and the schema models in their pedagogies, it is not possible to attribute improvements in students’ thinking to ideas from any one of these models. All that can be said is that ideas from these three models, in combination, informed effective pedagogies. However, in a few studies included in this report, the pedagogy rested only on the idea of developing metacognition and self-regulation of thinking (the two key studies – Butler 1998, Masui and De Corte 1999; and Kincannon, Gleber and Kim 1999), thereby enabling improvements to be attributed to teaching metacognitive and self-regulation skills.

Very few interventions in the post-16 sector took the form of discrete programmes. The findings from the discrete programmes included in Appendix 2 tend to support a view found in the wider literature that knowledge about the benefits of discrete programmes for teaching general thinking skills (programmes separate from existing components of a curriculum) remains highly contested. No discrete intervention in the post-16 sector that met the criteria for inclusion in this report produced firm evidence that indicated learning gains were transferred to any situation beyond the programme in which the thinking was practised. Although being able to apply thinking taught to tasks within the discrete programme fits the term application transfer, the transfer is not to the students’ normal course tasks, as it is in the studies classified as programmes in which the main purpose is to improve students’ ability to think with specific subject knowledge, but to tasks made up for the purposes of the discrete intervention.

It seems reasonable to propose that, in judging the relative merits and disadvantages of different approaches, evidence of transfer is one appropriate criterion. In the case of discrete programmes, if context transfer cannot be demonstrated, the students are no better at performing course tasks. On the other hand, even if transfer outside the domain is not an aim in programmes in which the main purpose is to improve students’ ability to think with specific subject knowledge, arguably such programmes are of some practical benefit, since students are better able to meet learning outcomes in their course. For example, in the studies included in Appendix 2, there was sound evidence that learners were better able to engage in complex tasks such as problem solving in mathematics or physical sciences, literary analysis, or asking useful questions about marketing and advertising content.
In many of the studies of this type, the research seems to have been driven by a pragmatic goal of accelerating students’ progress towards thinking like more expert people in the domain (e.g., developing ‘scientific thinking’ was often mentioned as an aim). The evidence points to learners being better able to complete the tasks described as problems in the learning outcomes for the course within which the intervention took place. In one of the studies included in this category (Blagg, Lewis and Ballinger 1994) the claims go further than this, but the supporting evidence is weak. There were strong claims in the Blagg, Lewis and Ballinger study that the programme was successful in promoting context transfer. However, the data presented is not sufficient to support this claim about transfer outside the domain in which the thinking was practised. For example, learners were able to transfer the ability to discuss and identify layout problems in one picture of an office layout to pictures that differed in various ways. However, there was no evidence that they performed better on learning outcomes in the course that required identification of features of layout or anything else. No evidence was offered as to whether students were any more aware in the workplace of matters depicted in their training materials. Nor was there any evidence that learners were able to transfer whatever general ability is assumed to underlie training tasks to tasks that differed from those in the training materials.

In programmes that were designed to incorporate thinking skills throughout the existing curriculum, the claim that the sets of processes taught were both useful and translatable across the curriculum in which they were exercised. The evidence for the ‘translatable’ claim was that the learners seemed to deploy these processes to good effect in many different tasks within their curricula. Thus, in the few studies of this type that met criteria for inclusion in the report, there is evidence of at least application transfer and context transfer in the sense that the students used the targeted forms of thinking in most areas of their curriculum. What is not clear is whether the learners were able to transfer their thinking to contexts beyond their existing curricula.

From the research reports of programmes in which the main purpose was to improve students’ ability to think with specific subject knowledge, and from some studies designed to incorporate thinking skills throughout the existing curriculum, it is possible to say that some knowledge is extensive and widely accepted in terms of its practical relevance. That is not to say that its philosophical foundations have not been challenged, but simply that there seems to be extensive and sound empirical evidence that certain approaches work in terms of application transfer; and, in the case of the Masui and De Corte (1999) intervention, metacognitive approaches have considerable promise in promoting transfer from one domain to another. The information below about pedagogical conditions for promoting transfer is also supported by studies included in the category of those whose purpose is to identify curricula and teaching associated with developments of thinking in one or more than one domain.

The interventions from which the more convincing empirical evidence emerged had some of the following features.

- The students were encouraged to acquire a large primary knowledge base in the area in which transfer is required (this was particularly evident in science areas, e.g., Chapman 2001).
- The students were encouraged to acquire some level of knowledge base in subjects outside the primary areas (e.g., the TALESSI Project – Jones and Merritt 1999; see also Section 3).
- The students were encouraged to work at understanding what transfer of learning is and how it works.
- The thinking goals were made explicit to students from the outset.
- A ‘spirit of transfer’ was fostered.
- The students were encouraged to develop an orientation to think in transfer terms.
- Cultures of transfer or support systems were created (e.g., see Section 3 for information on the TALESSI Project website).
- Students engaged in hours of conscious practice.
- Time was allowed for the learning to incubate.

Such studies tended not to rely on any one model of transfer, but drew on three or four of the models listed in this section.

An example of a study that illustrates some of the above features, and was typical of the better-designed interventions, was Chapman’s (2001) 2-year project on molecular cell biology. In terms of application transfer, the data suggests that this was a successful intervention. The data also indicates conditions that facilitate this result: to maximise its effectiveness, the goals of such a course must be made explicit to students from the outset, especially as they relate to the amount and type of work required for success in the course. Implementation included a focus on significant concepts that might be regarded as promoting the acquisition of a large primary knowledge base in the area in which transfer is required. It is well documented in the literature on expertise that the possession of such a knowledge base seems to play a central role in expert problem solving (Chi, Glaser and Farr 1988).

Few interventions were designed to encourage students to acquire some level of knowledge base in subjects outside the primary areas as well as a large primary knowledge base. The outstanding exception is the TALESSI Project (Jones and Merritt 1999; see Section 3). This study also strongly encouraged students to understand what transfer of learning is and how it works, and to acquire a ‘spirit of transfer’.
In the light of the empirical evidence that is discussed in this section, and in the light of the discussion of knowledge that is highly contested, a reasonable conclusion is that future research on transfer should proceed within two of the types of programme that were the focus of this report.

- Programmes in which the main purpose is to improve students' ability to think with specific subject knowledge.
- Programmes designed to incorporate thinking skills throughout the existing curriculum.

The content of this section suggests that in future research, teachers should be encouraged to describe transfer more precisely and state explicitly the sort of transfer they want to achieve, drawing on the descriptions offered here. Although there was not sufficient evidence to suggest that one model of the mechanisms underlying transfer should inform future research, rather than another, the available evidence supports the idea that pedagogies should include provision for developing self-regulation/metacognitive abilities.
Introduction

It is commonly believed that some form of peer-based learning enhances students’ ability to think well (Kuhn 1991; Salomon and Perkins 1998; Perkins 1999). Not surprisingly, most approaches to teaching thinking skills in the studies that emerged from the searches (described in Section 2) incorporate some form of peer-based learning. Therefore, the research question about the relative merits and disadvantages of different approaches involves evaluating evidence about the efficacy of different forms of peer interaction. In many of the studies reviewed, the authors claim that there is evidence to suggest that interactions with technology offer new possibilities for interdependent, collaborative learning. This section begins by setting out the research questions to be addressed, followed by a brief consideration of distinctions that have been made between forms of peer-based learning, an acknowledgement that the use of the term ‘thinking’ in the sample interventions is problematic, and consideration of claims made about the potential of ICT to support measures to enhance students’ thinking through some form of interaction. The ICT studies are reported in detail to allow readers to evaluate such claims. What unites the ICT and other studies in Appendix 2 is that both types of intervention can be located in constructivist accounts of learning. Studies concerning ICT are included in this section because of the growing interest in its use to support peer learning. However, some of the studies discussed also provide evidence of ICT’s role in promoting self-regulated learning.

This section considers the research questions posed about areas in which knowledge is extensive or widely accepted; areas where knowledge is limited, non-existent, or highly contested; and questions that arise for further research – considered first in relation to knowledge of face-to-face peer interaction, and then in relation to technology-supported interaction. This section takes a pedagogical focus and addresses the question as to which models of teaching thinking skills are well suited to post-16 learners. Throughout the section, sample studies from Appendix 2 are cited in pursuing the research questions.

The overall theme of this section is that there is extensive and widely accepted evidence that gains in student thinking seem to be connected with approaches that deploy forms of peer-based learning, but that knowledge is limited as to how any specific aspect of such approaches influences performance on any particular outcomes in post-16 curricula. The evidence cited here is interpreted as support for a view that future research might focus on exploring how ICT and face-to-face interaction might be combined in models of teaching thinking skills that are well suited to post-16 learners. It is suggested that future research is required to investigate the effects of variables that, typically, have been confounded in most studies.

The following research questions are addressed in this section.

- Which models of teaching thinking skills are well suited to post-16 learners, and why?
- What are the relative merits and disadvantages of different approaches to teaching thinking skills?
- In which areas is there knowledge that is extensive or widely accepted?
- In which areas is knowledge limited, non-existent, or highly contested, and what questions arise for further research?

Distinctions that have been made between forms of peer-based learning

Foot and Howe (1998) distinguish three different forms of peer-based learning. The first is cooperative learning, in which a superordinate goal is subdivided among members of a team, and different individuals work on different sub-goals, finally pooling the results into a composite product. This form of peer-based learning is common in the post-school sector. Small groups might gather, organise and interpret information on an issue and present it to a larger group of peers. The second is peer tutoring, in which one learner acts as tutor on a topic, while the other acts as tutee; these roles may alternate within a pair in ‘reciprocal peer tutoring’. The third form of peer-based learning is termed peer interaction – a situation in which the learners jointly learn material; for example, jointly constructing concepts or jointly solving a problem in science learning.

In most of the studies that emerged from searches made during the project, this third form of collaboration – peer interaction – was used as a means of enhancing students’ thinking, often along with other measures. For example, undergraduate peer interaction was combined with tutor modelling and questioning by Chapman (2001) to promote thinking about science concepts. In the MacPherson (1999) study, undergraduates in a supervisory management programme collaborated in peer assessment exercises. In a few studies (eg Hanson and Wolfskill 2000), all three forms of collaboration were built into a ‘new model for instruction’ for post-school chemistry education. A central feature of the programme design was ‘process workshops’ during which there were frequent opportunities for students to engage in these three forms of collaboration; the opportunities for collaboration were designed to promote targeted aspects of thinking that the researchers judged to be important in chemistry education.
What interaction was intended to develop in the interventions reviewed in the report? As noted in Section 4, thinking is a problematic concept that was loosely defined in most of the interventions that emerged from the searches. In the interventions, peer interaction was used to promote thinking in most of the senses set out in Section 4, including the enhancement of metacognitive or self-regulation skills. In the ICT studies included in this section, the term critical thinking is often used to mean translatable mental processes in the sense outlined in Section 4.

Technology and the development of thinking

New technologies have already become an integral part of everyday life. Several studies selected for analysis in this project suggest that technology has the potential to transform many aspects of how learning occurs and how people interact (21st Century Literacy Summit 2002). The amount of information that is available to individuals continues to increase dramatically and this creates the need to develop skills to access and process information. The thinking skills literature makes many references to the need to encourage young people to think critically in order to prepare them for the challenges of the information society. For example, McKnight (2000) argues that greater accessibility to information via technology means that there is a need to develop critical thinking. She suggests that without the ability to think critically, people will fall prey to modern communication media, which presents a world where the pre-packaging of intellectual positions and views is so ingenious that thinking seems unnecessary. The argument is that technological developments demand new skills in order to synthesise, interpret and apply the information available. In other words, technology is often used as an argument for the inclusion of critical thinking in educational programmes. Frear and Hirschbuhl (1999) also claim that new technology is leading to greater emphasis on the development of thinking skills. According to them, schools are now using interactive computer-based multimedia as a tool to develop the thinking skills needed to assimilate and transform large quantities of information into solutions for today's fast-changing society. The Cognition and Technology Group at Vanderbilt University (CTGV 1996) believe that this implies a shift in the primary goals of education, based on the assumption that all students, not just a select few, must be prepared to think, learn and reason on their own. This follows Resnick's view (1987) that the new challenge for education is to develop programmes that assume that all individuals, not just an elite, can become competent thinkers.

On the one hand, technology is contributing to the increased need to develop critical thinking. On the other hand, it has been argued in the studies reviewed for this project that it also provides a way of developing thinking (eg Mooney, Fewtrell and Bligh 1999 on cognitive process modelling: computer tools for creative thinking and managing learning; McKnight 2000 on teaching critical thinking through online discussions). McGuinness (1999) points out that there is now growing research literature on the impact of computer-mediated learning in classrooms and beyond. The research suggests that interactions with technology provide opportunities for learners to engage actively in the learning process and develop their thinking skills. In many of the studies reviewed, the authors claim that there is evidence to suggest that technology offers new possibilities for interdependent, collaborative and self-regulated learning, and that these approaches are consistent with those recommended in thinking skills programmes.

Knowledge that is extensive or widely accepted; areas where knowledge is limited, non-existent or highly contested; and questions that arise for further research

Extensive or widely accepted knowledge about the use of face-to-face interaction in approaches to developing thinking

Salomon and Perkins (1998) locate advocacy of peer interaction in constructivist accounts of learning. They acknowledge that many questions remain to be researched about this theoretical perspective. Nevertheless, it is a landscape that seems to make sense to many people, in that almost all the interventions reviewed here have an instructional design that is consistent at least with what Von Glaserfield (1998) calls ‘weak’ or ‘trivial’ versions of constructivism. Von Glaserfield asserts that knowledge is not passively received from the world, from others or from authoritative sources, but actively built up by the cognising subject; and that the function of cognition is adaptive and serves the organisation of the experiential world, not the discovery of ontological reality. Those who accept both of Von Glaserfield’s principles are called radical constructivists, while those who accept only the first are seen as trivial or weak constructivists.
Almost all the studies reviewed for this report included student tasks that encouraged them to construct, test and justify knowledge through some form of peer interaction; and in all cases, positive results of some kind are reported. For example, Patronis, Potari and Spiliotopolou (1999) undertook an ethnographic study of 14-year-old school students debating a socio-scientific issue (the design of a road in their area). In Guest's (2000) study, undergraduates with non-standard entrance qualifications prepared together for, and participated in, informed debates.

Among the most rigorous research reported in Appendix 2 is Kuhn, Shaw and Felton’s (1997) intervention with US community college students, which was informed by theoretical frameworks about critical thinking/argumentative reasoning. (For an explanation of what such terms were used to mean in the selected studies, see Section 4.) The aims of this study were to explore the impact of repeated engagement in peer discussion on a topic (in this case, capital punishment) on argumentative reasoning about that topic. Reasoning was practised on content that is typical in college curricula, such as social studies and communication.

In the main study, the participants each interacted with different partners across five sessions spaced at weekly intervals, thus exposing each individual to the views of several other individuals. Participants were instructed to reach agreement within each session and, if they could not reach agreement, to try to identify where they differed. Evaluation was based on rigorous analysis of appropriate data. Participants were asked, before and after the test, to set out in writing ‘a brief argument that explains, justifies and supports your view about capital punishment’ (Kuhn, Shaw and Felton 1997, 290).

Anderson et al.’s (2001) experimental study with students in Scottish FE colleges was informed by Kuhn’s (1991) notion of critical thinking and by Piaget’s theory, which emphasised that socio-cognitive conflict was a spur to individual cognitive change (termed equilibration, ie the reconciliation of conflict between pre-existing and newly experienced beliefs). Practice on two related aspects of thinking – justification and evidence evaluation – was closely integrated into the students’ work on the ‘additional assessment’ project, a 3000–4000-word report which was required to achieve accreditation in the Scottish Vocational Qualification (SVQ) in Social Care or Health Care at Level 3. This project requires students to integrate content from all the modules in their curriculum, and one day each week is set aside for students to work on this project.

Over a period of 3 months, the authors implemented a 10-session teaching intervention with 84 students. The evaluation was based on videos of student interaction and on their written work for accreditation, and on a test for far transfer (see Section 5 for an explanation of this term). The intervention used strategies which, according to many writers (eg Butler 1998), have been associated with the development of thinking, positive motivation and independent learning. These strategies included: modelling thinking about the nature of evidence-based justification; engaging students in ‘talking about’ their thinking; and critiquing each other’s drafts of project outlines and plans in terms of their use of justification.

The students’ subsequent written projects were content-analysed in terms of their use of justification, and the results showed that participants engaged in justification of their arguments to a significantly greater degree than did a control group. Analysis of the students’ dialogues with each other indicated that the number of unjustified statements declined significantly as the intervention proceeded, and justification with anecdote rose significantly over time, suggesting that the intervention had had a positive (but weak) impact upon the students’ use of justification. There were significant positive correlations between some of the dialogue variables (particularly ‘justifies with anecdote’) and levels of justification in the written work, suggesting that the dialogues had had an impact on the written work. The study did demonstrate a long-term retention effect, in that materials written several months after the intervention had ceased nevertheless included features that had been stressed during the intervention. One interpretation of the results is that the effects were weaker than they might have been had there been sufficient time in the students’ curriculum to achieve a deep enough understanding of the knowledge about which they were expected to think. The authors’ experience was that arrangements to infuse similar aspects of thinking across the curriculum would have required institutional support that was not forthcoming at the time of their study.

Hanson and Wolfskill’s (2000) intervention illustrates another way in which peer interaction was used to enhance students’ thinking. They describe the implementation and evaluation of a process-workshop classroom for chemistry undergraduates at the State University of New York at Stony Brook. A process workshop is defined by the authors as a classroom environment where students are learning a discipline by working in self-managed teams on activities that involve information processing, guided discovery exercises, thinking and problem solving, and include reflection on learning and assessment of performance. The interactions involve teamwork, communication, management and assessment.
The main aim of the research was to develop a new model for classroom instruction in response to a range of issues which included: the perceived ineffectiveness of sessions in which tutors answered questions and worked problems for the students and at which student attendance was low; negative perceptions and attitudes regarding chemistry and science displayed by many students; and lack of any connection to the real world in the types of experience offered to students (eg there was little provision for teamwork and application of concepts).

Hanson and Wolfskill posit that introducing process workshops can provide a mechanism by which a lecture-based course can evolve into a more interactive, learner-centred, process-oriented format. The premise is that if students are actively engaged in learning and have the opportunity to exercise process skills in key areas, then they will grow intellectually and become better learners, thinkers and problem solvers, and will improve their examination grades and be more successful in the real world.

The research takes the form of a case study which lasts for one semester and which involves a full cohort of approximately 1300 chemistry students. The case study provides a rich account of the learning, teaching and assessment processes used within the process workshop under the following headings: the process-workshop classroom; use of learning teams; guided discovery and exercises; problem solving; reporting; assessment; and the role of the instructor.

This research has significance for thinking skills and pedagogy in post-16 learning contexts because it provides a very clear articulation of learning, teaching and assessment processes that are very well grounded within a constructivist tradition. It is possible that the instructional design might work well in other subjects.

Since peer interaction was used in most approaches that reported learning gains of some kind, there seems to be extensive, widely accepted knowledge that students can be helped to think about what they are studying through instruction that is designed in ways that require students to interrogate informed sources and to debate with each other their different interpretations and conclusions.

Areas where knowledge is limited, non-existent or highly contested about the use of face-to-face interaction in approaches to developing thinking, and questions that arise for further research

A short answer to the research question is that little is known about how any specific aspect of peer interaction within approaches to teaching thinking influences performance on particular course and other tasks. Reasons for exercising caution in interpreting available research and questions that arise for further research are considered in the remainder of this section.

In drawing any conclusions about how peer interaction influences thinking, there are two grounds for exercising caution (Anderson and Soden 2002). One reason, explained in Section 4, is that there is no strong consensus about what counts as good thinking or about the way that domain knowledge might interact with ‘translatable mental processes’ to produce thinking, or indeed whether such processes exist at all. A second reason is that some studies involved confounds of key variables. Anderson et al. (2001; see also Appendix 2) confounded peer interaction, direct instruction about the nature of and evaluation of evidence, and questioning students about the evidence they gathered. Typical of many interventions that emerged from the searches, this study was designed to find out if, and to what extent, it was possible to enhance students’ thinking about their coursework through several measures, rather than to apportion the relative contributions of any one measure. Thus, in many interventions, the relative contribution of these separate measures remains uncertain. Since Anderson et al. also provided models for the students on how to support arguments with evidence and posed questions intended to help students to identify flaws in evidence they gathered, it is not possible to say much about the extent to which the students’ greater propensity to provide evidence in their written work was attributable to peer interaction or to tutor modelling and questioning. Researchers who use peer interaction independently of direct instruction and questioning to some extent get round this difficulty of confounding the effects of those variables (eg Kuhn, Shaw and Felton’s 1997 intervention with US community college students).

Nevertheless, it can still be difficult to isolate the precise effect of peer interaction. For example, Kuhn, Shaw and Felton’s (1997) study which involved peer interaction sessions spread over a period of several weeks is open to the objection that individual post-task private reflection, and even some kind of individual post-task implicit learning (eg see Berry and Dienes 1993), could have been influential. According to theories about implicit learning, students can learn without any awareness that they are thinking about some previous learning. The Schwarz, Neuman and Blezuner (2000) study is open to similar objections that individual post-task reflection or implicit learning contributed to the student gains.
Another uncertainty arises from the fact that most interventions that met the criterion relating to relevance to teaching were not designed to compare peer interaction with individual student effort on thinking tasks. This comparison tends to be done in laboratory work where it is far easier to control variables. In the field of formal reasoning, Mosherman and Geil (1998, cited in Anderson and Soden 2002) used an experimental design to demonstrate that peer interaction in a propositional reasoning problem resulted in greatly superior performance compared with individual reasoning. It is difficult to find replications of this result outside experimental situations, partly because of difficulties in controlling variables. Few studies that met the criteria for inclusion in the report used an experimental design, and few provided an analysis of dialogue that enabled judgements to be made about its possible role in enhancing thinking. Although it might be argued that dialogue analysis involves spurious attempts at objectivity, there are weaknesses too in the many studies that claim that peer interaction made a difference in the absence of any direct data about the nature of student dialogue.

Considerable uncertainty as to which features of peer interaction promote thinking arises from research designs that did not include any data on peer dialogue. It might be supposed that science students would benefit more from peer interaction in which they were guided towards asking each other the sort of questions which, according to Newton, Driver and Osborne (1999), promote scientific thinking. Evidence as to what students say during classroom interaction in the post-school sector is scant. The majority of studies that met the criteria for inclusion in the report had no such data, and in those that did include peer dialogue data, there are questions important to both researchers and practitioners that cannot be answered from available data. The following paragraphs consider what sort of information might be derived through fuller use of dialogue analysis and outline other questions that could be addressed by using such analysis.

In some interventions, the researchers measured aspects of peer dialogue and the frequency of different types of dialogue. Schwarz et al. (2003) gathered evidence that indicated that individuals appropriated reasons from peers within their discussions and abandoned reasons as a result of their discussions; additionally, there was evidence within the dialogues that the arguments and reasons given by peers and by the texts provided during Phase 2 were also prompting the generation of novel (previously unexpressed) items of knowledge by participants during the group discussion phase. Analysis of such matters can provide practitioners with information that enables them to assess whether students need help in engaging in dialogue that is likely to take their thinking forward. Little emerges from studies about the effects of other variables such as differing durations and spacing of practice, and differences in the structuring of the peer interaction tasks. These factors vary from one study to another. There is hardly any evidence on questions such as a minimum time that might have to be spent on peer interaction practice to reap student gains – whether gains level off after limited practice, whether practice should be spread across programmes, and whether structuring peer interaction in some ways rather than others produces greater student gains. Yet answers to these questions have significant practical implications.

Some interventions that emerged from the searches apparently had a sound instructional design, but did not go far enough in their evaluation to address many of the uncertainties outlined above. One typical study - Dyas and Bradley (1999) – developed 29 seminars for geography undergraduates, grouped around themes. The themes include introducing group-working skills, critical thinking and discussion and group presentations. Each seminar session consists of three parts: student preparation, the seminar (tutor contact) and student follow-up work. The programme introduces the ideas of self-assessment and reflection. The geographical content reflects the subject areas that were commonly cited in a questionnaire to HE geography departments about their first-year teaching. However, Dyas and Bradley say that the content of each session is considered less rigid than the skills being delivered, and that the materials are structured to allow for easy adaptation to an alternative topic or even, as they suggest, to another subject area. They claim that many of the skills are generic.

The paper explains that an evaluation strategy was planned from the start of the project, encompassing evaluation of individual seminar materials, the overall programme and the impact of the project on student learning. The authors claim that the response to the seminar materials was very favourable, but they provide little evidence to support this claim. Little comment is made in the paper about the impact on student learning or on the transferability of the programme to other disciplines. Dyas and Bradley (1999) simply conclude the paper by saying that an external evaluator was appointed to evaluate the programme as a whole and that research into the impact of the project on student learning has been initiated. No details are provided concerning the identity of the evaluator or when the report will be published.
MacPherson (1999) used an approach that involved tutors in teaching about thinking in general, and then in modelling its application to the analysis of journal literature and to the evaluation of oral reviews of that literature. A full cohort of 68 second-year students then participated in a series of seminars in which they practised the skills taught by giving oral presentations of literature reviews and assessing each other's presentations. Various deficiencies in the research design have led to only tentative conclusions being reached by the author on the relationship between thinking instruction and students' performances on the reviews. The results indicate that the teaching of thinking may have improved students' ability to peer assess (which was found to improve with practice) and to produce a good literature review.

Evidence about the efficacy of peer interactions could be investigated more thoroughly through a research design that enables correlations to be calculated between dialogue variables, such as students' discussion of evidence, and the discussion of evidence in the students' subsequent written work (eg Anderson et al. 2001). Such correlations might suggest the strength of the effects of peer interaction on students' reasoning performance.

An example of an approach to finding out how students reason is provided by Resnick et al. (1993), who examined shared reasoning in conversation. Groups of three undergraduates (constructed so that both possible positions on the issue at stake were represented) discussed the issue of nuclear power. Resnick et al.'s analysis of fragments of the resulting dialogue suggested that post-school students have developed a repertoire of reasoning behaviours that could be used for the development of argumentative reasoning in relation to their coursework. Resnick et al.'s data showed that sophisticated, coherent argument structures emerged within the conversations, and that these structures emerged interactively: participants listened carefully to each other and constructed their arguments in relation to what interlocutors said, building complex argument and attack structures. This technique might be useful for gathering data in the vocational education sector to establish student strengths that could be extended through peer interaction.

The use of technology in approaches to developing thinking

The term 'technology' does not refer to one simple type of technology. It is a broad term often used to refer to a range of electronic materials and/or methods for learning. For example, the use of technology may relate to the use of a computer, video material, the internet or a range of multimedia. The computer can be used as a tutor, as a means of promoting the development of thinking via different electronic 'mind tools' or as a support for dialogue between learners and/or between teachers and learners. (No studies were selected that use the computer only as an electronic tutor to provide feedback.) The different types of technology have different uses and fulfil different learning goals (Livingston 2001). It is important to point out that the studies reviewed suggest that technology does not in itself guarantee effective learning (Bransford, Brown and Cocking 1999). To understand the role of technology in the development of thinking, it is necessary to consider the type of technology being used, how it is being used and the theory of learning underpinning its use.

A study conducted by Mooney, Fewtrel and Bligh (1999) provides an example of the use of technology to support learning; it also, to some extent, attempts to build deeper understanding of ideas through participation. The study uses a suite of computer-based learning programmes called Mind Tools. The suite comprises three programmes – Brainstorm, Creative Mind and Action Planner. The authors claim that a 'cognitive process model' underpins the learning programme that it provides an environment to support learning as the active construction of meaning. The model used is divided into three phases: descriptive, analytical and pragmatic. The claim is that the programme encourages mental activities such as categorisation, structuring, association, synthesis, reflection and planning, and that it makes use of a range of strategies to promote deep processing of information.

The application of the Mind Tools is discussed by Mooney, Fewtrel and Bligh (1999) in relation to undergraduate medical education. The programme design is content-specific, in that it is designed to help the students learn about a specific area of medicine (eg anatomy of the heart). The Mind Tools were piloted with 51 undergraduate medical students. The tools were used as a ‘trigger’ (eg in medical education, a clinical scenario) to activate learners’ prior knowledge and stimulate brainstorming and group discussion. Ideas were shared and clarified and specific tasks for each member of the group were identified (eg to find out about the anatomy of the heart). The students then had to report back at another meeting. The reporting-back process provided an opportunity to exchange information and reflect on initial ideas.
In this study, the computer is being used as a tool to assist the brainstorming of ideas, to encourage group discussion and to record new learning. Technology is being used as a stimulus to encourage the exploration of knowledge and understanding of the workings of the heart. The computer is prompting learning and the software is designed to record the brainstorming process and the outcome of group discussions. It is encouraging the students to make their thinking processes explicit. From the authors’ description of the programme, it would appear that the Mind Tools could encourage self-directed learning and, to a limited extent, group learning. However, the pilot study appeared only to evaluate the ease of use of the computer programme, rather than assessing the cognitive benefits in areas such as problem solving and deeper processing of information. This use of technology may serve as a useful motivator in the post-16 learning environment, as it could offer a different approach from more traditional learning stimuli and provide an opportunity for students to engage actively in the thinking process. It is unfortunate that the impact of the Mind Tools on learning was not more rigorously investigated. Further research is needed to identify the impact that the use of technology has on thinking, compared with more traditional approaches.

A study by Frear and Hirschbuhl (1999) explored the use of interactive multimedia to promote thinking. They examined the effects of an interactive multimedia approach compared to a more traditional approach to environmental science. These authors cite Schwier and Misanchuk (1993), who believe that the advantage of interactive multimedia instruction is the creation of meaning developed by the learner’s interaction with the new information in the programme. However, Frear and Hirschbuhl point out that there is little empirical evidence regarding the use of interactive multimedia instructional technologies in higher education; and there is a lack of research regarding the effects of a self-paced interactive multimedia computer simulation on students’ learning, motivation and attitude.

Frear and Hirschbuhl undertook to address this research gap by conducting a study to examine the impact on students’ grades and higher-level thinking skills when interactive multimedia simulations of ‘real world’ situations were incorporated into one section of an environmental geology course. A quasi-experiment was conducted, with a control group of 113 students who received the traditional lecturing method of instruction, and a treatment group of 39 students. In the treatment group, interactive multimedia replaced the traditional instruction. Multimedia was defined as computer-based technology integrating some of the following: text, graphics, animation, sound and video. Frear and Hirschbuhl claimed to find a significant reasoning gain in the treatment group and suggested that the increase was so significant that it was hard to argue that uncontrollable variables (such as classes meeting at different times of the day or different days of the week, being taught by different instructors, grading standards or student attendance) could account for all of the variance. They believe that the study validates the effectiveness of the use of interactive multimedia field-trip simulations for an environmental geology course.

However, the impact of the novelty of the approach was not discussed by Frear and Hirschbuhl. The students may have been motivated to engage more with the technology because it was new and different. There may have been an initial burst of enthusiasm resulting in a temporary improvement in achievement that may ultimately be followed by a drop in achievement. The long-term effect may be different, highlighting the need for further study in this area. The opportunities that technology affords to provide simulated experience of ‘real world’ activities also needs further investigation. It is a constant challenge for teachers and tutors in the post-16 sector to create interesting and relevant learning environments that encourage the active involvement of students. Vosniadou, Ioannides and Papademetriou (2001) emphasise the importance of making classroom activities more meaningful by situating them in authentic contexts. Simulated contexts may provide the students with new and more motivating learning experiences that help them to a better understanding of workplaces, but at present, the evidence to support the benefits of simulations is limited.
Research has been conducted by Mayer (1999) in order to determine the conditions under which multimedia presentations lead to problem-solving transfer. He reviewed more than 40 studies and reported that there is some encouraging evidence to suggest that multimedia learning environments can promote constructivist learning. Mayer defines multimedia learning environments as those in which instructional material (such as scientific or mathematical explanation) is presented in multiple forms of representation, including visual (such as animation or illustration) and verbal (such as narration or text). He believes that constructivist learning occurs when learners seek to make sense of the material presented by constructing a coherent mental representation, and that problem-solving transfer occurs when a student is able to use what was learned to solve problems that are different from those presented during instruction.

Mayer makes the important point that not all multimedia presentations lead to constructivist learning. He says that it is necessary to design the presentation in ways that promote constructivist cognitive activity in the learner. According to Mayer, a fundamental premise underlying the use of multimedia is that learners understand explanations better when they receive words and corresponding pictures, rather than words alone (Mayer’s Multimedia Principle). The rationale for this is that learners are better able to make connections between words and pictures if they are physically presented.

A series of nine studies was conducted by Mayer and a team of researchers in order to test the multimedia principle. The studies undertook to examine different aspects of multimedia presentation and the effect that it had on learners – for example, connections between animations and narrations and between visual and verbal representations. Learners were assessed on tests of problem-solving transfer and gain scores were computed. Mayer concludes that this research pinpointed some conditions under which multimedia learning can lead to substantial improvements in problem-solving transfer. He claims that students are better able to make sense of a scientific or mathematical explanation when able to hold relevant visual and verbal representation in working memory at the same time. He suggests that this finding is consistent with a cognitive model of learning in which the learner actively seeks to build connections between visual and verbal representations through selecting, organising and integrating processes.

Areas where knowledge about the use of technology in approaches to developing thinking is limited, non-existent or highly contested, and questions that arise for further research are limited in several ways. First, constructivist learning was evaluated only indirectly through transfer tests. Second, the studies identified several major variables affecting multimedia learning, but additional work is needed to clarify the ways in which these variables might interact. For example, Mayer (1999) points out that multimedia effects may depend on individual differences in the learner. Third, the research was conducted in a laboratory setting and this enabled Mayer and his colleagues to control important sets of variables, but the disadvantage of this is that many issues relevant to real classrooms and post-16 culture, in particular, are not dealt with, thereby limiting the applicability of the findings to classroom settings. Further research is needed to understand the effects of technology on student learning and educational practice.

A concept that the Cognition and Technology Group at Vanderbilt University (CTGV 1996) believe will be increasingly important for future thinking about technology is the concept of learning communities. In classrooms organised into learning communities, students are provided with opportunities to plan and organise their own research and to work collaboratively to achieve important goals (Brown and Campione 1994). This is in line with research which suggests that thinking is both individual and social (based on Vygotsky 1978). It is also consistent with Vygotsky's notion of the zone of proximal development (ZPD). Through dialogue with others, a learner progresses with concepts and moves outside the ZPD. The expectation is that learners will not only contribute through dialogue, but will reflect on the learning that takes place. Technology offers the possibility of dialogue with experts and with other learners, and it makes the idea of classrooms as learning communities more powerful as it enables them to become part of larger electronic learning communities.

The studies selected in this project that propose electronic learning communities to develop thinking appear to be grounded in constructivist and participation theories. The participative model encourages learners in a collaborative learning environment to take ownership of their own learning through active participation, learn effectively from others, and collaborate to increase understanding about existing knowledge and construct new knowledge. The learners are also encouraged to move from a model of dependence on teacher input to one of initiating and leading discussions.
McKnight’s (2000) study provides an example of the use of technology to emphasise the social aspects of learning in the development of critical thinking. She suggests that online discussion and collaboration can support critical enquiry and that online communication offers the potential for collaboration, as well as increased participation in the learning process, reflection, peer tutoring, monitoring of student learning as it is taking place, and extension of classroom learning. McKnight provides the following examples of social and participative learning activities: the use of online ‘chat lines’ to generate ideas and an electronic bulletin board to provide coaching discussions to take students’ ideas to deeper levels.

However, McKnight (2000) suggests that it is unlikely that students will succeed in substantive, reflective exchanges online if they have not learned to carry on similar conversations elsewhere. The author points out that it cannot be assumed that the students have sufficient critical thinking skills to advance online discussion, or that tutors have enough practice in monitoring discussions or skills in creating productive communities of online learners. McKnight suggests that both students and tutors need support and training. She cites Sugar and Bonk (1998), who suggest that there is no guarantee that peer collaboration and interaction will trigger critical reflection or enhance interpersonal understanding if there is no process designed to cultivate these skills. McKnight believes that it is first necessary to conduct some off-line activities that will give students a better understanding of the collaborative learning and communication process.

These are important messages for the post-16 learning environment. Technology is unlikely to encourage and develop collaborative thinking if the students have had no previous experience in collaboration off-line. This is in line with Fisher (1995), who suggests that young people need to be taught to work collaboratively. He points out that the skills and behaviour that make learning in groups effective have to be learnt. This begs the question: what skills are needed to facilitate online collaborative learning?

McKnight (2000) attempts to answer the question by referring to the characteristics of a well-functioning group and identifying a range of strategies that she believes are required to support group interaction and collaborative learning. She draws attention to the diversity of the student body and emphasises that it is insufficient to provide students with the means to communicate online, and not support them with the skilful and active participation of facilitators. For example, facilitators should ask probing questions to engage students in a line of questioning and help them to continue to drive an idea forward. She suggests that the teaching staff must model questioning techniques that enhance social interaction and dialogue.

This study is useful in highlighting the point that online collaborative discussions will not automatically promote the development of critical thinking skills if students are not provided with appropriate support from their tutors and given the opportunity to practise thinking skills in other contexts. McKnight concludes by saying that unless the pedagogical role of university faculties includes modelling, coaching, questioning, reflection and task structuring, it will be difficult in online discussions to escape the superficiality of classroom talk. This clearly involves staff development issues for those working in the post-16 sector. Not only do the students require support to develop the skills and behaviour to participate in online collaborative learning communities, but it is suggested that the staff also need to develop new teaching approaches in order to support and mediate learning in the new electronic environments.

Similarly, CTGV (1996) emphasise that technology implementations that are based on constructivist and participative theories cannot simply be assimilated into traditional classroom practices based on transmission models of instruction. They highlight the need for teachers to change in the process of learning to work in a technologically rich classroom environment. However, McKnight (2000) is sceptical about whether some tutors can change their teaching strategies to use online communication tools effectively.

The sample ICT studies (see Appendix 2) suggest other uncertainties. CTGV (1996) suggest that visions of technology look very different depending on the tacit or explicit theories of learning that guide their design and implementation. The group point out that changes in theories of learning affect how technology is used, but technology also makes new kinds of interaction possible and hence affects theories of learning, citing Salomon (1993). Similarly, changes in technology affect educational policy and vice versa. Sheingold (1991, cited in CTGV 1996) argues that technology, educational policy and learning theory need to be considered simultaneously. This simultaneous treatment creates a challenge for any research study that sets out to investigate technology and education, as it will be necessary to give consideration to learning theory, educational practice and technology as well as the interaction between the three. The studies examined in this project indicate that few have considered the findings from all three perspectives.

The analysis of the studies demonstrates that different views on learning theory underpin the way that technology is used to develop thinking. The studies examined appear to fall into two main categories: those that use technology to support learning by the active construction of meaning; and those that make use of it to support the building of a deeper understanding through participation, engagement and collaboration. The studies in both categories are based on a constructivist model of learning.
There is limited evidence to support the claims made for technology's contribution to critical thinking in any of the senses discussed in Section 4. Further research is needed to assist post-16 teachers to make decisions about the relative merits and disadvantages of online discussions for the development of thinking skills.

A review (Riel and Levin 1990) of six different electronic communities, which included teacher and student networks and a group of university researchers, looked at how successful these communities were in relation to their size and location, how they organised themselves, what opportunities and obligations for response were built into the network, and how they evaluated their work. Across the six groups, three factors were associated with successful network-based communities: an emphasis on group rather than one-to-one communication; well-articulated goals or tasks; and explicit efforts to facilitate group interaction and establish new social norms. According to Bransford, Brown and Cocking (1999), more needs to be known about the key components that make these electronic communities successful. What has not been fully understood is that computer-based technologies can be powerful pedagogical tools – not just rich sources of information, but also extensions of human capabilities and contexts for social interactions supporting learning. Many issues arise in considering how to educate teachers to use new technologies effectively. What do they need to know about learning processes? About technology? What kinds of training are most effective?

Which models of teaching thinking skills are well suited to post-16 learners, and why?

A summing up of the studies selected for this report resonates with commentaries by other writers (eg Salomon and Perkins 1998; Brophy 2002) who note that available research suggests that relationships between peer interaction and increased ability to engage more fully in some aspects of thinking are complex. Brophy's discussion of the ‘affordances and constraints’ of social constructivist teaching helps to raise awareness of the complexity of the role of peer interaction in learning.

All of the studies reviewed in this report rest on constructivist accounts of learning. Perkins (1999) points out that constructivist learning experiences exert high cognitive demands and that not all learners respond to the challenge. Constructivist techniques also often take more time than do traditional educational practices. Consequently, enthusiasm for peer interaction as a means of promoting learning arguably should be, and has been, tempered with some degree of caution (eg Crook 1998). Nevertheless, there seems to be enough evidence to support the view that some forms of peer interaction should be at the heart of models for teaching in the post-16 sector. Resnick et al.'s research (1993; reported above) implies that peer interaction might be a powerful way by which adults learn to reason.

An overall conclusion from the studies selected for this report supports the idea that progress in research requires the sort of synergy described by Salomon and Perkins (1998). They believe that progress in taking forward research in this area involves synergy between two conceptions of learning which are often treated independently of each other. First, there is a conception of individual learning, emphasising the acquisition of knowledge and cognitive skills as transferable commodities (eg Anderson, Reder and Simon 1996). Second, there is the socio-cultural conception of learning as a collective participatory process of active knowledge construction, emphasising context, interaction and situatedness (eg Cole and Engstrom 1993). They suggest that such a synergy might lead to a culture change. They argue that such change requires a recognition by collectives that their learning should be directed towards learning to learn from and with others; learning to draw the most from cultural artifacts other than books; learning to mediate others, not only for their sake but for what that will teach oneself; and learning to contribute to the learning of the collective. According to Salomon and Perkins, conditions that seem to increase the chances of achieving these benefits include the provision by peers of informative feedback on each other's thinking, of highly personalised and situationally contingent guidance and challenge and the elicitation from each other of responses in the form of explanations, suggestions, reflections and considerations.

All the studies reviewed used learning activities which are derivable from social constructivist accounts of learning (eg through learners discussing, debating, hypothesising, investigating, taking viewpoints). Perkins' (1999) analysis implies that educational activities derivable from constructivism make particular sense when the educational goals to be achieved include conceptually difficult knowledge that comes from a differently constructed social perspective, as was the case in many of the studies reviewed (eg students become aware of how historical ‘truth’ varies across different interest groups). Psychological research shows that active engagement in learning may lead to better retention, understanding and active use of knowledge (Wilson 1996; Wiske 1998; Reigeluth 1999). Therefore, engaging students in reasoning is likely to serve two educational goals: enhancing the learning of conceptually difficult knowledge and improving students' ability to reason and to generalise that reasoning.
These conclusions resonate with those in the body of literature on learning and teaching in post-school education (Ramsden 1992; Biggs 1999; Prosser and Trigwell 1999). Plainly, thinking is central to the educational goals described by such writers – becoming able to engage in self-directed transformations in one's understandings of aspects of the world and becoming able to evaluate evidence relevant to claims so that sound conclusions can be drawn about them (Bonnett 1995; Gardner and Johnson 1996; Langer 1997; Hyland and Johnson 1998). Although Sternberg (1987) spelled out ideas for developing students' thinking along these lines, very few of his ideas seem to have been embedded in educational practice.

If students are to learn to think critically in school or post-school courses, several matters require urgent attention. If, as Kuhn (1999) suggests, researchers have not yet enabled teachers and students to know precisely what is meant by the term critical thinking, it is very difficult for students to know how they might demonstrate such thinking in their coursework. Biggs (1996) points to difficulties in realising certain educational goals because the whole system is not compatible with those aims. Assessment systems, in particular, require attention: if teachers are to take thinking seriously, competence in its use has to attract serious credit in assessment systems. Educators have to avoid setting tasks which fail to challenge students' thinking: Bloomer's research (1998) questions the value of tasks set for students in the British vocational education sector, noting that they were often trivial. As Lonka and Ahola (1995) point out, to embed the practices described in this section in mainstream education requires a radical shift away from prioritising transmission of content as a curriculum goal. Such a shift would entail an equally radical change in teachers' conceptions of learning and teaching. (See Kember 1997 for a discussion of relationships between such conceptions, educational practices and learning outcomes.)

None of the studies demonstrated generalisation of the effects of peer interaction beyond the domain within which the peer interaction took place, although only one study explicitly tested for such transfer. Kuhn (1999) points out that gains reported in interventions most often do not generalise beyond the immediate instructional context. Generalisation is very much a contested issue (see eg Salomon and Perkins 1989; Detterman and Sternberg 1993; Perkins and Grotzer 1997).
Section 7
Assessment

This section will explore important issues concerning the conduct of evaluations of thinking skills interventions. It will then examine the related topic of how growth in students’ thinking can be assessed in ways that are appropriate for post-16 learners, drawing on the evidence from studies which have met the project team’s selection criteria.

Important issues concerning the conduct of evaluations of thinking skills interventions

Since assessment of student learning is a key facet of an effective evaluation strategy, issues concerning testing and assessment practices are discussed below, alongside other relevant evaluation considerations.

In programmes for which the main purpose is to improve students’ ability to think with specific subject knowledge, or to incorporate thinking skills throughout the existing curriculum, assessing application transfer should be a key aspect of the evaluation, whereas in discrete programmes which are separate from existing components of a curriculum, assessing context transfer should be a key aspect of the evaluation.

Within a major review of thinking skills programmes in the US, Resnick (1987) identified a range of evaluation issues which were common to many thinking skills interventions in schools and post-16 academic settings, some of which are summarised below.

Testing practices

Many national and state tests in US schools were not adequately sensitive to detect the effects of thinking skills interventions, and their widespread use made it difficult for such reforms to survive. Even course grades generally provided only an indirect measure of student achievement, or thinking demonstrated by some individuals, and to the long-term use of the programme to attest to its popularity. Students of using the abilities in question beyond the confines of the programme, but there is no direct evidence that transfer of learning has occurred.

It can be difficult to unpick the effects of particular interventions from other effects

Sometimes a strategy, skill or teaching method is embedded within a fairly extensive programme. For example, reading comprehension strategies (such as skimming, self-testing, summarising) may be taught within an overall programme designed to help students to manage their time, control anxiety and mood, and apply deliberate learning strategies. Resnick (1987, 25) commented favourably on one evaluator’s strategy, combining global evaluation with more detailed analysis, which was designed to overcome this difficulty:

This mixture of global evaluation with detailed analyses of the effects of specific component strategies, pursued in a cumulative fashion and extended so that long-term effects and transfer can be evaluated, is precisely what we need to establish which elements of complex programs are important to their overall effects.

It can be difficult to understand the effects of particular interventions

The effects of an intervention cannot always be explained, since not everything may be known about the underlying learning mechanisms. This makes it difficult to determine in advance the essential components of a training approach.

Other researchers have highlighted a range of obstacles and challenges faced by programme designers when attempting to assess gains in thinking skills or to evaluate the effects of thinking skills interventions. The use of testing is a recurrent theme. Nisbet (1990) has argued that tests which emphasise the reproduction of factual information can suppress efforts to teach problem solving and critical reasoning, since examinations may have a strong influence on what is taught, how it is taught, and how students set about their learning. Popham (2001) is highly critical of standardised national and state tests which are in current, widespread use in US schools, arguing that their use leads to: misdirected pressure on educators to boost test scores rather than to focus on what students really need to know or learn; the incorrect identification of schools as ‘inferior’; curricular reductionism; ‘drill and kill’; and attempts by teachers to artificially inflate test scores. Such circumstances are clearly not conducive to the creation of ‘thinking classrooms’, and could prevent any reforms from taking hold. (Neill 2001 expresses similar views to Popham’s - see Appendix 2.)
Flavell (1976, 234) highlighted trying to get beneath the surface to find out what is ‘running through the child’s mind as he or she wends his or her way through the task’ as a particular area of difficulty. Some studies (e.g. Schoenfeld 1985) have used an experimental setting involving verbal protocols, where individuals/pairs report out loud what they are thinking as they work on problems. However, the setting can place students under considerable pressure, which in turn affects their behaviour. Schoenfeld (1985, 280) used an example to illustrate this, describing students’ reactions while solving a novel mathematical problem out loud:

The cells problem was outside the range of the students’ experience, and they found it disturbing. They read the problem statement and were stuck. They had not worked problems like this in a formal setting (if ever), and they had no clear idea how to approach it. Knowing that one or more mathematics professors would be listening to the tapes of their work, the students felt under great pressure to produce something substantial for the record. It goes without saying that the ‘something’ they produced should be mathematical. So the students working alone responded to the pressure by doing the only formal mathematics related to the problem statement they could come up with under the circumstances...

He pointed out that an ostensibly objective evaluation of the students’ responses would, in this case, have resulted in conclusions that didn’t make sense, and that this is illustrative of the kind of subtle difficulties inherent in analysis of problem-solving processes. A further disadvantage of using verbal protocols is that, although the technique does yield a very large amount of rich data, the process of gathering and analysing the data tends to be very time-consuming and labour-intensive (Green 1995). The data that can be gathered is likely therefore to be restricted to only a few students working a few problems in an artificial situation.

Schoenfeld (1985, 283) used the example above to make a more general point that:

... any particular approach to studying intellectual behavior is likely to illuminate some aspects of that behavior, to obscure other aspects of it, and to distort some beyond recognition. Of necessity the same phenomenon must be investigated with a variety of methodologies, and from a variety of perspectives.

Baron (1987) listed four dimensions to aid the planning of a carefully controlled, broadly conceived, and well-documented evaluation study of thinking skills in the classroom: formative/summative, product/process, qualitative/quantitative, and experimental/quasi-experimental. No matter the scale, a sound evaluation should represent a concerted attempt to understand both whether there were any meaningful changes in the students’ thinking skills and dispositions, and how these changes came about. She recommended to teacher evaluators that they should: develop jointly with their students a set of criteria for effective thinking to be applied in the classroom; use, as it were, a wide-angle and telephoto lens; evaluate continually; look for sustained effects; look for transfer; look for side-effects; look for metacognition; use a variety of approaches – discussions, writing, tests, performance tasks, unobtrusive measures which do not interfere with students’ learning and do not require additional instruction time; and interpret results. She recommended that programme developers should also consider the reliability, validity and sensitivity of available test measures and whether the information deriving from such measures is in a useful form for programme improvement (echoing Resnick’s concern), and attempt to evaluate appropriate attitudes and dispositions.

Baron (1987) focused on what should be done, but it is clear, from Resnick (1987) and other analyses, that much of this was not being done in evaluation studies of thinking skills interventions. Given the comprehensive nature of the advice, the relatively uncharted (at that time) territory that it encompassed and the exigencies of teaching and research, perhaps this is hardly surprising. Nisbet and Davies (1990, 60) pointed to some of the general deficiencies and problems:

The evaluations that have been reported tend to be small-scale, involving disappointingly small numbers or using only a limited measure of effectiveness. Inevitably, evaluations are short-term, since there is insufficient time to follow up any group for long-term effects. It is also difficult to decide what should be taken as firm evidence of success, or to distinguish between the merits of the materials and the methods adopted in using them, or to take account of the quality of the teaching.

These general deficiencies and problems are still much in evidence among the recent empirical studies reviewed by the project team. There are several instances of very short interventions (even amounting to one teaching episode) or interventions involving few students. There is reliance on the participants’ self-reports as evidence to evaluate the intervention, with no attempt being made to assess the actual gains in students’ thinking skills as demonstrated through their performances. For example, McGuinness (1999, 21) comments about her own project in Northern Ireland, entitled Activating Children's Thinking Skills (ACTS):
... teachers were very satisfied overall with the ACTS methodology. They quickly adapted the method to their own teaching style and needs ... Even within a short time they could see benefits for the children’s thinking ... Notwithstanding these positive comments, the limitations of this type of evaluation should not be forgotten. The data are teachers’ impressions and opinions and are not related to learning outcomes in the classroom. Comparisons were not made with alternative methodologies and the evaluations were collected immediately at the end of the training days (when spirits were high)...

In some cases, there is no indication that an evaluation has been carried out or is planned. The durability of any effects on students’ thinking skills is rarely explored [a clear exception to this is the Cognitive Acceleration through Science Education (CASE) evaluations; see McGuinness 1999], and investigation of transfer of learning (when this is done) is invariably in a ‘forward reaching’ direction, with little discussion of students’ prior learning and experiences and how these may have influenced the outcomes. Although some studies are ostensibly focused upon developing a particular form of thinking – for example, critical thinking – there may be little discussion of the thinking skill in question or any attempt to define it. Therefore one would doubt that the researchers have given much thought as to how evidence of the skill can be clearly proven in students’ performances. In some reports of studies, the materials and teaching methods are barely touched upon and the quality of the assessment instruments is not mentioned.

Some studies have used a quasi-experimental design. One example is the evaluation conducted by Blagg, Lewis and Ballinger (1994) on the Thinking Skills at Work (TSAW) modules. Following a 3-month feasibility study and a 9-month development phase, 14 controlled studies were conducted over a year in varied post-16 settings. In each study, the experimental and control group were assessed before and after the intervention on a wide range of measures. In her review of this study, McGuinness (1999) reports that trainees became more able to recognise and understand complex problems; more inclined to plan, check and review; more interpersonally skilled; and more self-confident. Trainers became more positive about their job role and more optimistic about the trainees’ abilities.

By focusing on learning and teaching in progress, some recent evaluations (eg Kirkwood 2000, 2001) have sought to capture students’ emerging understanding and competence as they grapple with applying particular thinking skills or strategies to subject matter over a reasonably extended period. Through detailed, ongoing analysis, one can establish that the requisite learning opportunities are being provided, and one can seek to put in place a range of valid and reliable measures that reflect the many facets of students’ learning (Harlen 1994).

Such approaches can avoid complete reliance on end measures of attainment, or on pre- and post-test comparisons, since two practical difficulties associated with testing as a means of evaluating new materials or innovative approaches are that (a) it is often difficult to design tests which encompass all of the intended learning; and (b) some aspects of learning are difficult to test by conventional means (eg different ways of thinking and solving problems; attitudes and perceptions). One must also be aware of the other significant influences on students’ intellectual development over the duration of any study, such as their increasing maturity, the formal and informal curriculum, and their everyday lives and relationships. The greater reliance on formative processes of assessment and evaluation enables a more nuanced judgement to be reached about the influence of the learning environment and learning activities on the development of each student’s thinking and learning.

It should be noted, however, that the issue of whether evaluation design should strive for what some educational researchers regard as the ‘gold standard’ of scientific research (using randomised controlled experiments; see eg Slaven 2003), or whether it should employ methods more suited to gathering formative data such as case study and action research, is highly contested. It is not the purpose of this review to present or weigh up the arguments for and against these approaches.

How growth in students’ thinking can be assessed

Formative assessment

Around a decade ago, Broadfoot (1994) noted a clear shift in emphasis in the UK from summative assessment (assessment of learning) to formative assessment (assessment for learning). Marzano (2003) cites a substantial body of research evidence which indicates that academic achievement is considerably higher in classes where effective formative feedback is provided to students than in classes where it is not. This evidence clearly has significance for post-16 students who are learning to think with specific subject knowledge, or learning to apply thinking skills throughout their curriculum. To be effective, the feedback must be systematic, timely and specific to the content being learned, since otherwise the results may underestimate the true learning of the students. Since state tests in the US use very general performance categories that provide little feedback on specific knowledge and skills, they should not be relied upon to provide useful formative feedback.
In relation to formative assessment, Simmons (1994) advises making the standards of good work clear to students by using various benchmarks of good performance, and by students taking time and expending effort to reflect on and improve their work rather than receiving the teacher’s evaluation passively - the key components of this approach being shared and public criteria, feedback and frequent reflection throughout the learning process. Pollard (2002) refers extensively to the findings of an influential review of assessment for learning conducted by Black and William (1998). Feedback should focus on the particular qualities of the work with advice on how to improve, and should avoid comparisons with other students, which could reduce students’ self-esteem and motivation for successful learning. Students need time to put into practice the suggestions for improvement: therefore the timing of the feedback is crucial. Students should be trained in self-assessment, thinking about their own performance in relation to clearly stated objectives (echoing Simmons’ advice). Classroom practices which enable students to demonstrate their understanding allow teachers to develop real insights into students’ thinking, but devising suitable questions can be difficult: therefore Pollard advises that whenever possible, teachers should work together to collect and share good questions.

Methods of assessing thinking skills developed for learners in school

Seven chapters of the third edition of Developing minds (Costa 2001) are devoted to the topic of assessing growth in thinking skills. The chapters focus on current assessment practices in the US, ranging from large-scale summative measures (standardised national and state tests) to small-scale, teacher-devised formative measures. While for the most part, the discussion focuses on assessment practices in schools, nevertheless it is possible to make the link to post-16 educational settings. For example, there is a strong focus in some chapters on performance assessments, in which students have to apply knowledge and skills in context, solve problems and engage in a number of other kinds of higher-order cognitive activity. Such assessments are highly appropriate in vocational as well as academic settings as a means to assess growth in thinking skills.

Testing practices

Asp (in Costa 2001) analyses whether current national and state tests in the US measure thinking in a meaningful way. He reports that since the mid-1990s, all the major test producers have revised their tests and reporting procedures to incorporate higher-order thinking. The most significant change has been the incorporation of performance (constructed response) items requiring students to, for example, compare and contrast, predict, or explain how their solution to a problem was arrived at. Asp (2001) points out that there are, however, some practical constraints which affect the ability of standardised tests to assess growth in student thinking.

The most open-ended and authentic tasks are the most time-consuming to administer and score, and when states have tried to use more classroom-oriented measures, they have had to narrow the parameters of what can be included in portfolios in order to assist the interpretation of the results. A related difficulty is the narrow scope of performance measures and the technical problems associated with generalising students’ scores on one task to other tasks in the same domain. It therefore takes several performance episodes to get a stable score, thus adding to the high cost in comparison to administering more traditional multiple-choice or short-answer tests. Despite these constraints, Asp calls for the continued use of performance assessments within national and state tests, the use of new technologies to increase the authenticity of assessments by contextualising them (eg through video or use of the internet), the ‘designing-in’ of thinking, by specifically identifying what it ‘looks like’ to engage in various kinds of higher-order cognitive activity and then developing items that adequately measure the full scope of that domain. It is argued that this would lead to more focused, in-depth assessments that would provide a much more accurate measure of thinking.

Specially designed tests to assess higher-order cognitive skills

In the context of discussing how to prepare students to become critical thinking and science literature citizens, Zoller (2000) argues that how teachers design, administer and grade examinations communicates very clearly to the students both the course philosophy and what the teacher considers to be important. Therefore examinations should not only be in consonance with the teaching and instructional goals; they should also contribute meaningfully towards those goals. New approaches to testing and assessment are called for in order to promote higher-order cognitive skills learning. In one such approach, the core element is a pre-arranged class session in which the teacher is examined orally by the students. Each student is required to formulate two or three relevant and meaningful questions, one of which is posed to the teacher and from the other(s), the teacher selects two to five questions to serve as a student-designed take-home examination.
Classroom-based assessment techniques

Five chapters of the third edition of Developing minds (Costa 2001) focus on techniques which are recommended to teachers as being appropriate to assess growth in students’ thinking. These chapters do not present any empirical findings arising from evaluations, although one cannot infer from this that no evaluations have been done. Nevertheless, it is important for the reader to bear in mind that some of these techniques may not have been thoroughly tested in the classroom. The techniques involve: the application of a comprehensive framework for assessing what are termed discrete cognitive operations, thinking tasks and habits of mind (Costa and Kallick 2001); the use of a specific format for assessing thinking skills (Beyer 2001); and the use of performance assessments (Burke 2001), open-ended assessments (Stone 2001) and multiple-rating items (Fisher 2001). Also relevant to this discussion of classroom-based assessment techniques is an empirical study conducted by Zohar, Schwartzer and Tamir (1998), which examined the formative methods used routinely by biology teachers in Israel to assess thinking and enquiry skills.

Costa and Kallick (2001) discuss how to build a system for assessing thinking. They argue that we cannot assess growth in thinking abilities (process-oriented outcomes) exclusively through product-oriented strategies, and set out strategies that teachers can use to provide rich information on the development of their students’ thinking. They discuss cognitive operations such as recalling, comparing and classifying which may need to be taught directly and then assessed (the outcome of such assessments can help teachers to design better teaching interventions). Generally, specific thinking skills are embedded within a larger context in response to some stimulus (a thinking task), examples of which are creative problem solving and decision making. These require the application of clusters of discrete cognitive operations over time and their assessment generally requires demonstration and performance. Beyond this, individuals must recognise opportunities to use these skills and be inclined to employ them through developing habits of mind such as persistence, precision and accuracy, listening with understanding and empathy.

The implication is that assessment strategies must be designed to gather data about increasingly and spontaneously applying habits of mind over time and in a rich variety of contexts. Therefore, overall, a balance of assessment strategies is required. Checklists, rubrics, portfolios, performances, anecdotal records maintained by the teacher, interviews, journals and logs can all be used to assess habits of mind. Student self-assessment and peer assessment are integral to the successful use of the majority of these tools. Costa and Kallick (2001) note that building a system for measuring thinking will require considerable work. The specific aspects will need to be defined, the best methods of collecting evidence will need to be determined, and evidence will have to be collected over time.

Beyer (2001) focuses on a specific format for assessing thinking skills. The format consists of six tasks all dealing with the same thinking skill. The first two tasks assess basic knowledge of the skill – its meaning ('Which of the following best defines classifying?') and how you can recognise when someone is doing it ('Which one of these shows information that has been or is being classified?'). The next three tasks assess student expertise in executing or performing the skill. The final task assesses students’ metacognitive understanding of how they execute the skill. The assessment provides specific direct evidence of what the student knows and can do to execute the skill, and allows the teacher to judge the degree of proficiency exhibited by the performance and to identify any dysfunctional, irrelevant or erroneous moves, enabling remediation to take place. When administered repeatedly over the duration of a course, changes in proficiency in applying the thinking skill can be revealed. The skill, it is suggested, should be applied to a substantive learning task, thus providing students with a purpose for applying the skill which should motivate them to expend more effort, since they will sense that the task is not simply an ‘exercise’.

Burke (2001) focuses on performance assessments. Their strength, according to the author, is that they provide a mechanism whereby teachers can cover the curriculum, monitor students’ progress towards standards, and engage students in meaningful learning experiences that promote deep understanding. A performance task, according to Burke, represents a realistic problem scenario that requires students to apply their content knowledge and their thinking skills. It enables students to see the connections among subject areas and to recognise the importance of integrating skills to achieve success. Burke argues that the task of developing and assessing performance tasks can be made more focused by the application of criteria. Burke cites Popham’s (1999) seven factors to consider when evaluating performance-test tasks.
Generalisability
Is there a high likelihood that the students’ performances on the task will generalise to comparable tasks?

Authenticity
Is the task similar to what students might encounter in the real world?

Multiple foci
Does the task measure multiple instructional outcomes?

Teachability
Is the task one that students can become more proficient in as a consequence of instruction?

Fairness
Does the task avoid bias based on such personal characteristics as a student’s gender, ethnicity, or socio-economic status?

Feasibility
Is the task realistically possible to implement in relation to cost, space, time and equipment requirements?

Scorability
Is the task likely to elicit student responses that can be reliably and accurately evaluated?

Of these factors, Popham (1999) considers generalisability to be the most important, since students engage in fewer performance tasks than conventional tests; therefore the selected tasks should optimise the likelihood of accurately generalising the students’ capabilities.

Rubrics can be used to assess the quality of student performances. They include the specific criteria that should be components of the performance and describe the level of proficiency necessary to score at each level. They make the judgement of the performance more objective and the grading process more consistent and fair. Students who are involved in developing the rubric internalise the criteria for high-quality work and feel more confident about what they are supposed to do, so that ultimately students should become independent learners and critical self-evaluators. This advice concerning the involvement of students in assessing their own performance is consonant with the evidence emerging from research on formative assessment.

Stone (2001) draws an analogy with how an industrial technology teacher would assess students – ‘The tools, although introduced and practised singularly, are meant to be used in conjunction with each other to produce a more complex project.’ – to point out that students who are never asked to ‘build’ anything from the mathematics, science or history that they learn are being short-changed by the education system. Also, he argues that since in real life very few important tasks are limited to a single subject, most good assessment should allow students to pull together learning from multiple subjects. It is important to be able to perform tasks in new and different situations, not just learning situations.

Stone recommends open-ended assessments that can capture creative thinking. He states that recall is good (and teachers can assess this using traditional methods), but the possession of knowledge should lead to something. He outlines some available resources, recognising that teachers do not always have the energy to develop creative ways to assess thinking, and discusses the need for the curriculum to be pruned to release time to go deeper and to take pressure off students. He recommends that teachers should set realistic deadlines; encourage students to weigh up a number of possible approaches to the task; give students a choice of assessments using a rubric that focuses more on the thinking and research involved than the content; and teach students to assess their own thinking.

Fisher (2001) argues that if teachers are going to assess student thinking in their own discipline, their expertise both in the discipline and in what would count as ‘good thinking’ is the guarantee of their good judgement. He then focuses on the assessment of critical thinking skills. He stresses that it is important to ask the right kind of question, one that engages students in the kind of thinking involved (and not, for example, in recalling arguments). This leads to the need to provide the right kind of stimulus material or experiences to provide adequate scope for the thinking being assessed. When grading, teachers would take account of the age of the students and how much practice they have had at similar tasks. Teachers can increase their confidence in their judgements by developing model answers or preparing schemes that show what is expected, and discussing these with a colleague who knows what the students have been taught in relation to both subject matter and thinking skills. Fisher then discusses and exemplifies the construction of multiple-rating items. An item concerned with a student’s ability to evaluate arguments might begin with the stem: ‘Assume each of the following statements is true and assess the extent to which it strengthens or weakens the above argument…’. These multiple-rating items, it is claimed, offer several advantages over other options.
An empirical study by Schwartz, Tamir and Zohar (1998) was conducted in biology classrooms in junior and senior high school in Israel (see Appendix 2). Its main purpose was to address the nature and quantity of higher-order thinking activities in classes when teachers were not explicitly ‘teaching for thinking’, but rather were acting and behaving routinely. This involved an analysis of teachers’ questions, posed during class, in homework assignments and in tests. In order to identify the cognitive level of questions, an adaptation of Bloom’s taxonomy (1956) was used. The main findings were that only a small proportion of teachers’ questions in class required students to think; whereas in tests, there was a decrease (since a previous study in 1977) in knowledge recall and open-ended questions, but an increase in objective questions tapping higher-order thinking. The authors conclude that, although there are many enquiry items in the Israeli matriculation examination, enquiry has not yet become a routine component of biology lessons. While this study does not propose or evaluate innovative methods for assessing thinking, nevertheless it is clearly useful to gain a measure of the extent to which teachers use formative techniques – questioning, homework and routine tests – to engage their students in higher-order thinking. This could serve as a baseline measure within an evaluation of a thinking skills intervention.

Methods of assessing thinking skills developed for post-16 learners

Although a range of assessment approaches was used within the post-16 studies reviewed by the project team, frequently there was little emphasis on the assessment dimension in the reporting of the studies. Five studies which do focus well on the assessment dimension are discussed below, although only three report on evaluation outcomes. The studies involve college or university courses on social theory (Silver and Perez 1998), chemistry (Deese et al. 2000; Hanson and Wolfskill 2000), medicine (Schuwirth et al. 1999) and informal logic (Ikuenobe 2001). A sixth study discusses a systematic mapping of thinking skills within geography fieldwork (Foskett 2000), which would enable tutors to assess thinking skills.

Silver and Perez (1998) report on a study designed to teach social theory through students’ participant observation. Students on the Chicago field studies programme at Northwestern University take field notes about their observations while on work placement and meet regularly with tutors to explore substantive topics. They receive written comments on their notes which encourage them to question common-sense explanations for the behaviours they observe. Silver and Perez require that students construct an argumentative paper of 25–35 pages that integrates their field data with three theoretical perspectives. Although weekly improvements in note-taking indicate that students are developing a critical stance towards their data, this final paper provides further evidence that they are thinking theoretically about their placement sites. Rather than merely testing students on their knowledge of theoretical perspectives, Silver and Perez argue that it is necessary to require students to assimilate readings, lectures, and discussions with their own theoretical knowledge.

Deese et al. (2000) report on a study which was designed to evaluate the effectiveness of demonstration assessments (which involve students in viewing a short demonstration, recording their observations and explaining what they observe) within the teaching of general chemistry at undergraduate level. In particular, the study sought to determine if such assessments promote critical thinking and deeper conceptual understanding of important chemistry principles. A general rubric is presented to students before each assessment and a task-specific rubric is applied to score written student responses and to promote class discussion immediately after student papers are collected. A two-group differential design was used in which first-year engineering students in two different chemistry classes (52 and 61 students respectively) were compared (see Appendix 2 for more information on the evaluation design).

It was found that in both groups, attitudes towards science were stable and positive; however, the intervention promoted better conceptual understanding of the course material. The use of a general rubric before each assessment prepared students to use a pattern of thinking to address the analysis of a situation and the drawing of appropriate inferences based on their understanding of chemistry concepts. The discussion of a task-specific rubric immediately following each assessment enabled students to compare their answers with the model of expert thinking provided by the instructor, thus developing their understanding of how chemists think and enabling them to emulate these thought processes. The authors conclude that demonstration assessments offer an option useful in developing as well as assessing conceptual understanding. This is attributed to three important features of the assessments:

- they focus student attention on what is to be learned
- they encourage deep elaboration of concepts in the students’ own words
- they give students the opportunity to develop a metacognitive self-awareness of the thinking process.
In Hanson and Wolfskill's (2000) implementation and evaluation of a process-workshop classroom for chemistry undergraduates (the fourth key study presented in Section 3), students are engaged actively in learning a discipline and in developing what are termed ‘essential skills’ by working in self-managed teams on activities that involve guided discovery, critical thinking, problem solving, reflection on learning and assessment of performance. The authors claim that performance skills in these areas, just like skills in laboratory work and athletics, can be developed, strengthened, and enhanced through practice, and that these skills are highly valued by employers.

Ongoing assessment involved techniques to help students think critically about their performance. At various stages of an activity, students would be asked to identify strengths and areas for improvement in their performance, along with strategies for achieving these improvements. The need to vary the questions weekly was stressed, since otherwise the questions would elicit the same response with little cognitive processing. A written report was submitted by each student team to provide the results and summary of their work during each workshop. This counted towards the summative grade, together with their individual performance in examinations. Positive findings were reported on examination performance and other measures (see Section 3). Thus, process workshops would appear to offer a promising route to developing the sort of skills that many employers claim to value, including the ability to self-assess.

Schuwirth et al. (1999) discuss the writing of short case-based tests in medical education with reference to various strategies and pitfalls. A case-based question consists of two obvious parts: the case in which the situation is described or information is presented; and the question which poses the problem to be solved. The authors argue that the more different cases that can be presented and the more different questions that can be asked (addressing key elements of the problem-solving process, although these key elements are not unpacked), the higher will be the generalisability. A set of 14 strategies is presented for writing good cases and questions, each with clear exemplification. These include: use representations of real patients; provide sufficient realistic clinical and contextual information; provide information that is not pre-interpreted (ie ‘raw’); avoid problems or possibilities that do not exist in real practice; focus on essential problems only; let the content of the question determine the format; and have your material reviewed by others. Unfortunately, the article does not evaluate the approach through any empirical test.

Ikuenobe (2001) describes a theoretical framework for teaching and assessing critical thinking abilities as outcomes in an informal logic course. The framework proposed by Ikuenobe is general, flexible and adaptable to suit different pedagogical needs. How the requisite outcomes are achieved depends on the teacher’s approach and the assessment tools used. He suggests that critical thinking may be broken down into five abilities that students must acquire, demonstrate and apply as critical thinkers. He believes that these abilities can be articulated as outcomes to be achieved by students.

His paper explains a developmental model with five different levels. In levels 1 to 4, students learn the principles of reasoning as objective principles that transcend disciplines. At level 5, critical thinking abilities are specifically contextualised to various disciplines, context and subject matter. Ikuenobe discusses methods to assess students’ abilities in relation to desired outcomes identified at each level of his model, and how students can learn from the process of assessment. He emphasises the importance of a person’s disposition to use thinking, since otherwise even the best instruction may not succeed. Self-reflection, he argues, provides motivation for students to keep track of how they use the skills they have learned. He sets out general criteria at each level that can be applied to a range of student performances, as illustrated by the examples below.

- **Level 1**
  Students understand the concepts of argument, premise, conclusion, statement (proposition) and sentence, and they are able to articulate what these concepts mean.

- **Level 2**
  Students understand, and are able to articulate or explain the concepts of inference and evidence in relation to premises and conclusions.

He argues that instructors have to be willing to devise techniques and reflect on their modes of assessment to determine which fare best and which will better achieve the outcomes in a given circumstance. It is unfortunate that no mention is made of testing his model with a cohort of students and evaluating its success against other methods of teaching and assessing thinking skills.
Foskett (2000) presents an argument for incorporating a thinking skills approach into geography fieldwork. The article uses an example of a student fieldwork exercise on visitor management at a popular historic monument, which is mapped onto Sternberg’s (1985) triarchic classification (knowledge components, performance components, metacomponents) together with a consideration of transfer. Transfer is viewed as either ‘lateral’ – the ideas and skills are used in a different but no more challenging or complex situation; and ‘vertical’ – the element of challenge or complexity is present. If fieldwork can support transfer, then, it is argued, its role in enhancing student performance across the curriculum may be important. A framework which is designed to enable geography teachers to identify the opportunities for developing thinking skills already present in fieldwork activities (an auditing approach) is presented and discussed. The idea is that the thinking skills can then be made more explicit to both teachers and students. Unfortunately, no evaluation data is presented. Nevertheless, this systematic auditing approach could be applied more widely across a range of post-16 educational contexts.

Conclusions

How to evaluate thinking skills interventions well is clearly a topic that urgently needs more attention paid to it, in order to make it possible to build a more coherent, robust and comprehensive knowledge of ‘what works’ in teaching thinking. Teaching teams, researchers and research sponsors must become more convinced of the value of devoting more resources towards developing robust evaluation designs and conducting sound evaluations.

How best to assess growth in student learning appears to be an aspect of the design of thinking skills interventions that is frequently under-examined. It is assumed that the use of self-reports by the participants, standardised tests or end-of-semester examinations and standard assignments are ‘fit for purpose’ to assess thinking skills. In contrast, where there is thoughtful discussion of assessment techniques which are deemed by their proponents to be well suited to the task of assessing thinking skills, the evidence of these tools in use is often not presented in articles. Although the techniques may be soundly based upon established theories and principles, according to Slaven (2003), this makes them only promising, not proven. In relation to post-16 education, few recent studies were located which had assessment as their theme. Future research needs to focus on how formative tools can be used to develop and assess students’ thinking abilities. Caution should surround the development of any summative testing instruments designed for widespread use in post-16 settings in the UK, if one takes seriously the concerns expressed by Popham (2001) and others.

Some of the systems, methods and tools for conducting classroom-based assessment of thinking in schools could be adapted for use with post-16 learners and then carefully evaluated. There is also the potential for cross-fertilisation of ideas on assessing thinking from post-16 to pre-16 settings, such as the use of case-based tests (in business education, for example) and demonstration assessments.

Promising methods of assessing growth in student thinking within post-16 education would seem to encompass some or all of the following characteristics, according to the evidence discussed in this section:

- **Effective formative feedback**
  To be effective, feedback must be systematic, specific to the aspects being learned, timed to ensure that the student can put into practice the suggestions for improvement, and personal to the student, avoiding comparisons with other students.

- **The use of shared and public criteria**
  Students’ attention needs to be focused on what is to be learned and the standards of good work need to be made clear to them by using various benchmarks of good performance (e.g., rubrics).

- **Students are supported to develop a metacognitive self-awareness of the thinking process**
  Through self-assessment and peer assessment, students learn to assess their own thinking and take time and expend effort to reflect on and improve their work, rather than receiving the teacher’s evaluation passively.

- **Assessments are more focused and in-depth**
  This enables teachers to develop real insights into students’ thinking, prompts students to demonstrate their assimilation of ideas and understanding, and therefore permits more accurate assessment to be done.

- **Assessments contribute meaningfully towards teaching and instructional goals**
  Assessments focus on process-oriented outcomes as well as product-oriented outcomes, on the types of thinking that it is important to develop for lifelong learning and employment, and on students’ dispositions to use the thinking abilities that they possess.

- **Assessment opportunities provide meaningful and varied contexts to enable students to apply a range of thinking skills to substantive learning tasks**
  This provides students with a purpose for applying the skills which should motivate them to expend more effort, enables students to see the connections among subject matters, and provides opportunities for students to experience a real sense of accomplishment.

- **Teachers possess a range of expertise relevant to assessing growth in student thinking**
  This would include knowing what would count as ‘good thinking’ within the discipline or situation and being able to specify clearly the aspects to be assessed, determining the right kind of stimulus to provide adequate scope for the thinking being assessed, determining how the evidence is to be judged, and providing effective feedback to students.
Introduction

Many of the studies selected in this research project (see examples throughout this section) provide an indication of a range of conditions that the authors suggest are central to the successful implementation of thinking interventions. Some studies (also discussed here) take a negative perspective and highlight the barriers that have to be overcome in order for the interventions to be effective. A systematic categorisation was carried out of the conditions and barriers identified in the wide range of studies analysed. The aim of this mapping of the conditions for successful implementation of thinking interventions is to add to the research in this field: by identifying conditions that appear consistently across studies; by questioning the claims made for the link between the conditions and successful implementation; and by highlighting any conditions that lack substantive evidence and require further research. Browne and Freeman (2000) suggest that no single condition will by itself encourage critical thinking. They propose that a variety of conditions reinforce one another and therefore only as a package will they lead to success. This suggests that much more needs to be known about how different conditions identified in the studies interact with one another to result in the successful implementation of thinking interventions. Zohar, Degani and Vaaknin (2001) also suggest that there is a pressing need for deeper investigation into the conditions necessary for success in teaching thinking.

For the purpose of clarity, the various conditions for success are discussed separately in this section. However, bearing in mind Browne and Freeman’s point that attention to only one of the conditions identified is unlikely in itself to lead to success, there is inevitable overlap in the discussion. It is suggested that a combination of conditions will have to be in place for success to occur.

The conditions have been grouped around a number of key themes, namely:

- teacher/lecturer readiness
- student readiness
- learning environment
- course design and content
- post-16 culture.

This section does not discuss explicitly the conditions in relation to discrete approaches to teaching thinking, programmes related to one subject domain, or approaches relevant to more than one subject domain. A more general approach to conditions for success in thinking interventions is taken.

The following research questions are addressed.

- Which models of teaching thinking skills are appropriate for post-16 learners?
- In which areas is there knowledge that is extensive or widely accepted?
- In which areas is knowledge limited, non-existent or highly contested, and what questions arise for further research?

Teacher/lecturer readiness

A key condition of success is teacher readiness to implement a thinking intervention. According to Hargreaves (1992), cited by Leat (1999), the teacher is the ultimate key to educational change and improvement. Leat suggests that individual teachers face some difficult challenges in introducing thinking skills programmes. He says that they require a conceptualisation of teaching and of their subject(s) that accommodates an emphasis on developing learning skills, reasoning patterns and transfer. They have to be determined enough to overcome any resistance from their pupils and they need to establish a classroom discourse which encourages pupils to initiate, speculate and accept that there is not only one right answer. Teachers need to be able to maintain this style when there may be pressures to be more didactic, and they need to be able to defend and justify their approach in the face of scepticism, indifference and ignorance. It is unlikely that all teachers will feel ready to embrace these challenges for a variety of reasons.

Zohar, Degani and Vaaknin (2001) suggest that teachers’ theories and beliefs about how pupils learn best have strong implications for the way they prioritise teaching. They claim that numerous previous studies have shown that teachers often see their role as transmitting knowledge and covering the curriculum, rather than guiding students in thinking and constructing their own meaning of what they learn. Soden and Pithers (2001a) conducted an evaluation of a 10-week UK intervention which was designed to embrace domain-specific thinking skills in an accounting module at an FE college. The results suggest that effective development of thinking skills through vocational education depends on changes in the conceptions of lecturers and other stakeholders of the purpose of vocational education. Such a cultural change seems to be important if lecturers are to move from teaching routine procedures to using their subject as a vehicle for developing a thinking workforce.
According to learning theories that were embraced until about 25 years ago, learning was seen as linear and sequential and thus described hierarchically (Zohar, Degani and Vaaknin 2001). Learning objectives were sequenced to progress from simple, lower-order cognitive tasks to more complex, higher-order ones. Zohar, Degani and Vaaknin suggest that if this theory of learning was adhered to, then low-achieving students may chronically experience lower-order instructional emphasis because educators see these students as ‘stuck’ in the early phases of the learning process. They argue that the perceptions of many teachers regarding low-achieving students and the instruction of higher-order thinking may hinder successful implementation of programmes designed to teach thinking.

More recent learning theories view the learning process from a different perspective – understanding is seen as evolving while learners engage in thinking and inquiry in contexts that make sense to them. Jarvis and Twyford (2000) explain that according to constructivist theory, learning is an active, continuous process whereby the learner takes information from the environment and constructs personal interpretations and meanings based on prior knowledge and experience. Zohar, Degani and Vaaknin emphasise that a restructuring of teachers’ beliefs will require a deep change in their views about the nature of teaching and learning, and that there is a need to help teachers reconstruct their instructional model from a transmission-of-knowledge model to a constructivist one.

According to Resnick and Resnick (1992), cited in Zohar, Degani and Vaaknin (2001), the traditional view that the basics can be taught as routine skills, with thinking and reasoning to follow later, can no longer guide educational practice. As a result, thinking is no longer viewed as an optional activity that learners may or may not get to at the final stages of learning. Instead, thinking is applied to all learning and all learners.

In contrast to these views, Leming (1998) claims that school-aged students are developmentally incapable of the cognitive tasks required by a curriculum intended to develop higher-order thinking. To support this claim, Leming draws on the reflective judgement model of King and Kitchener (1994). This model describes the development of epistemic assumptions and how those assumptions act as ‘meaning perspectives’ that radically affect the way individuals understand and subsequently solve problems. Seven developmental stages are described in the model. Each stage consists of a set of assumptions about what can be known and how certain one can be about knowing.

Leming says that research spanning 15 years, that used longitudinal data as well as cross-sectional studies, has offered strong support for the existence of stages of epistemic development that are identifiable and age-related and that change in predictable ways over time. King and Kitchener (1994) suggest that high-school seniors are at stage 3 in epistemic development; college juniors reason at the 3.75 level; and advanced doctoral students reason at stage 6. According to them, before the age of 24, few individuals use a stage higher than stage 4. Therefore, based on their stage of epistemic development, high-school students are incapable of reflective thinking. Leming poses the question – what are the consequences of attempting to teach students to think in a manner that they are incapable of? His answer is that in addition to teachers not being able to achieve their stated goals, such attempts may lead to a lack of student interest and motivation.

Leming (1998) draws on his own experiences as a high-school teacher and his observations of an issues-focused college classroom in an attempt to add weight to his argument. He says that students grow frustrated with the instructor and sceptical that anything can be rationally known. He claims that developmental mismatch is likely to result in unintended and undesirable consequences for teachers and students, and that expecting students to demonstrate thought patterns that adults have spent decades developing is unrealistic.

Leming believes that what it means to teach students to think critically needs careful re-examination. He does not suggest that the teaching of thinking should be discontinued, but that teachers should scale back their expectations. He says that it is necessary to build up a store of information that will provide ‘datum of reflection’ for emerging reflective thought. Leming suggests that although it is debatable whether the traditional study of subject matter (he refers to social studies) will result in detectable changes in student thoughtfulness, he believes it is clear that a rich store of information is an essential precursor to the act of thoughtfulness.

Leming’s view presents an interesting critique of the teaching of thinking skills and calls into question the effectiveness of teaching thinking skills if students are not at an appropriate developmental stage to be able to cope with the tasks. To take up this position requires one to accept the findings of the seven developmental stages of the reflective judgement model. Set in the context of all the studies that were analysed for this research project, there were more studies defending constructivist theories of learning and the view that all students can, with appropriate support, develop thinking skills. Nevertheless, the alternative views indicate that ideas about how people learn are contested. This highlights the need for further research to investigate students’ ability to engage in thinking processes in relation to developmental stages.
In the studies that accepted that the development of thinking is underpinned by constructivist theories of learning, the authors emphasised the need for teachers and students to re-conceptualise their roles. For example, the Cognition Technology Group at Vanderbilt University (CTGV 1996) emphasised that constructivist-oriented classrooms require new roles for teachers and students. Teachers must be able to accept the role of learner and facilitator rather than expert and transmitter of knowledge. These changes in identity are not easy to make. Many of the notions of the role of the teacher and the role of the student are deeply embedded, and the culture of schools, colleges and universities often works against new roles being adopted.

This difficulty in making changes to teaching and learning processes was discussed in a number of studies. According to Shell (2001), a survey of deans and directors of nursing programmes (O’Sullivan et al. 1997) found that 20% of the respondents reported difficulty in developing methods to teach critical thinking and found resistance to these changes. Shell states that these findings were supported by a Delphi survey of nursing faculty conducted by the National League for Nursing in 1999. It said that 40% of the respondents reported that teaching critical thinking was the area in which they felt least prepared. Reports on teaching for critical thinking by non-nursing college staff (Hass and Keeley 1998; Sears and Parsons 1991; Onosko 1991) quoted by Shell (2001) also reveal several barriers to the effective teaching of critical thinking skills. One barrier is the lack of exposure to critical thinking skills that staff members themselves had as students.

According to Marantz and Warren (1998), teachers must be thinkers themselves if the vision is to be realised of enhancing students’ thinking, and teachers should also ‘think out loud’. Beyer (1998) suggests that if teachers are proficient at executing a thinking skill and can verbalise clearly how they do it, they can model it for their students. This is in line with Pithers and Soden’s (1999) views. They argue that it is important to plan development programmes to enhance the level of teachers’ own critical thinking. They attempted to find a starting point by assessing some critical thinking skills in a population of 256 Scottish and Australian vocational educators who were enrolled in university teacher education programmes. Their results add to the evidence suggesting that development of the teachers’ own critical thinking skills is a necessary condition to enable them to help students engage in thinking processes.

Hardman and Leat (1998) suggest that many teachers continue to teach their pupils in the same way as they themselves were taught. Their findings suggest that when student teachers begin their pre-service courses, they have definite ideas or images about teaching and learning which have developed from their own educational experience and which shape their perceptions of teaching and developing classroom practice, thereby merely reinforcing the status quo. Shell (2001) also reports that the teacher role model for most of the staff in a survey that she conducted was the ‘traditional lecturer and dispenser of information’. She says that the perceived need to focus teaching on content competes with teaching of critical thinking skills.

Shell believes that assumptions held by teachers about their role act as barriers to teaching critical thinking. She says that rather than engaging in a collaborative relationship, which she believes is required for the promotion of critical thinking skills, the teacher and the learner take up opposite roles (expert and novice). Leat (1999) believes there is a need to alter long-standing images of what teaching is and prior perceptions of models of teaching which do not equate with thinking skills programmes. According to Leat, an understanding of children’s learning hardly featured in many prior models of teaching, and established patterns of behaviour can be very hard to change.

Leat (1999) cites a report from a teacher who found his experiences of using thinking skills principles de-skilling. Baumfield and Oberski (1998) also suggest that it can be threatening for an experienced teacher to feel ‘de-skilled’ when attempting to teach thinking. They suggest that the teachers need confidence in the merits of the programme and in their ability to deliver. They point out that specific programmes designed to teach thinking skills, such as the Somerset Thinking Skills Course (Blagg, Ballinger and Gardner 1988) may stifle teachers’ creativity.

Baumfield and Oberski (1998) conducted a case study in one school, trying out three thinking skills programmes: the Somerset Thinking Skills Course, the Instrumental Enrichment programme (Feuerstein et al. 1988) and Philosophy for Children (Lipman, Sharp and Oscanyon 1980). None of the programmes prohibits the use of other teaching material or of expanding on a topic; however, the teachers stuck carefully to the teaching material provided. Baumfield and Oberski suggest that this is probably an indication of a lack of confidence, stemming from the demands of trying out a new idea and the insecurity of not having a solid body of content to deliver. They found that a lack of tangible outcomes from the learning and teaching process was a source of insecurity for the staff. Baumfield and Oberski also found that staff were more likely to engage fully with the group work when they felt that the structures for discussion were explicit in the design of a programme. Closer analysis of the nature of group work in thinking skills programmes and the teacher dispositions necessary for the successful facilitation of discussion is needed so that appropriate training can be provided.
From their study, Baumfield and Oberski (1998) suggest that very little is known about the motivation of teachers who become involved in thinking skills programmes. They refer to lone enthusiasts working in isolation and say that thinking skills programmes may never attract whole-school support. Undoubtedly this causes difficulty in sustaining a thinking skills programme and embedding it in the culture of the school. Further case study research in the post-16 sector that focuses on understanding teachers’ motivation to embark on thinking skills programmes may help to provide a depth of understanding about the necessary conditions for teacher readiness.

Like Shell (2001), Leat (1999) suggests that thinking skills programmes place demands on teachers to develop new teaching strategies and may threaten the identity of teachers who wish to hold fast to the notion of ‘teacher-expert’. Leat, like many other proponents of thinking skills programmes, says that they depend on cooperative group work, in which understanding is constructed through discussion. However, he suggests that the reality of classroom practice is that the necessary conditions for cooperation are not in evidence in all circumstances. He draws attention to typical discourse patterns in the classroom and suggests that they are one of the key features that affect teacher and pupil willingness and capacity to engage in new activities. He says that the established discourse pattern is one where the teacher initiates (I), usually via a question, pupils respond (R) and the teacher provides feedback (F). He believes that one key condition for the successful teaching of thinking skills is a change in this I-R-F pattern, in order to allow pupils to initiate the questions. Conscious efforts by teachers to reduce the number of questions they ask and to encourage students to ask more would appear to be one way to initiate change in the classroom climate.

Browne and Freeman (2000) single out tutors in higher education for criticism. They say that the tutors often have one clear model of their instructional role. They are the experts about a body of knowledge; the students are seeking that knowledge. Thus, the one with the knowledge speaks: the ones seeking the knowledge listen. This fails to provide the critical thinking learner with the opportunity to practise using the knowledge under the guidance of a skilled mentor. However, Browne and Freeman say that the tutor can provide a special kind of mentorship by modelling and by providing assignments that require critical thinking, Kelly (1999) says that teachers need to be encouraged to use active listening to hear what students are saying when they work together, and that teaching should be directed towards clarifying students’ own thinking. Prior (2000) asks the question: to what extent do we as teachers give an impression that we have the answers? She says that teachers should recognise that students sometimes need to struggle with material, concepts and theories in order to gain critical thinking skills. This implies that teachers need both to understand the process of critical thinking and be willing to address the power inherent within their role; and, in so doing, constructively decline to give answers or rescue students from what is a necessary struggle if critical thinking is to develop. In this scenario, greater responsibility is given to the students to ask the questions and engage actively in their own learning process. This requires a major change in classroom discourse patterns and in the roles of the teacher and students. In these circumstances, the accent is on the teacher as a facilitator of classroom discussion.

Blagg, Lewis and Ballinger (1994) explain that effective use of the thinking skills materials depends on a facilitative approach, with the trainers acting as mediators and the learners maintaining maximum responsibility for both the problem-posing and the problem-solving process. However, the role of facilitator is not straightforward. Mezirow (1990), quoted in Kienzler (2001), says that the educator does not act as a passive facilitator of learning, but as an empathic provocateur, gently creating dilemmas by encouraging learners to face up to: contradictions between what they believe and what they do; disjuncture between espoused theory and actual practice; and discrepancies between a specific way of seeing, thinking, feeling and acting and other perspectives that may prove more inclusive, differentiating, and integrative of experience.

The difficulty of the change of role for some teachers from one of transmitter of subject knowledge to facilitator should not be underestimated. Teachers may feel more inclined to support and initiate thinking activities that they believe will lead to improving their students’ thinking in their own subject area than in programmes that take a more general view of developing thinking. Teachers who see themselves first and foremost as subject specialists, who lead students towards the fulfilment of a set of outcomes related to subject knowledge and understanding, may not readily embrace more general thinking skills programmes that are designed to encourage transfer to other subject domains.
It is likely that not all teachers would share Halpern's (1998) view that the goal of instruction designed to help students become better thinkers is transferability to ‘real world,’ out-of-classroom situations. Teachers need to be clear at the outset what they are trying to achieve through a thinking intervention. The results of a study by Lawson et al. (2000) support a view expressed in the literature on thinking that clarity on the part of teachers as to what is involved in thinking and what aspects they are targeting in any unit of teaching may be a necessary condition for effective ‘teaching thinking’ programmes (see Section 4). Baumfield and Oberski (1998) suggest that thinking skills programmes may encourage teachers to reflect on the purpose of education and their role as a teacher. One condition for the successful implementation of thinking interventions may be greater teacher reflection about the purpose of their work with students and how it relates more generally to their students’ educational development.

New and more demanding activities that ask pupils to take more responsibility and make decisions are far more problematic for the teacher to organise and control. Many teachers who feel secure in the pedagogical content knowledge associated with their subject may feel unprepared for the demands imposed by the greater emphasis on the learning process. Leat (1999) suggests that to introduce a major innovation into the classroom risks disruption to the flow of activities and jeopardises the chances of order. He believes that the whole process of change is emotionally charged and that some teachers will experience greater difficulty than others in embracing change.

Leat raises a number of interesting points that are all relevant to understanding the conditions related to teacher readiness to implement thinking interventions. One must consider the whole learning and teaching environment and the range of factors that will have an impact on new learning and teaching strategies and ultimately determine their success or failure. Clearly a better understanding of the staff development needs of teachers is required if the necessary conditions to teach thinking are going to be put in place.

### Student readiness

A key condition of success proposed is student readiness for a thinking skills approach. Shell (2001) conducted a survey with 175 nurse educators from the Tennessee public university system who attempted to implement a thinking skills approach in their teaching. The major barrier perceived by the respondents related to student characteristics that indicated a lack of readiness for a thinking approach to their studies. The responses included comments concerning lack of student motivation, student resistance to active learning, students’ expectation of a lecture format, and students’ concerns about getting good grades versus learning. According to Shell, this finding is consistent with the other reports on student resistance to innovative teaching methods (Rieser and Dick 1990; Onosko 1991; Hannafin and Savenye 1993; Yildirim 1994 – all quoted in Shell 2001).

Prior (2000) points out that students’ conceptions of what learning means have implications for anyone attempting to change a learning environment’s focus. Her study with students completing an HNC Social Care award found that they were generally not prepared to accept responsibility for sourcing information in relation to topics or issues to be discussed. The students did not seem to value each other’s contributions or feedback and expressed a desire for lectures with overheads. Prior says that the new thinking approaches appeared to leave them feeling anxious and unmotivated and they did not experience analysing material, generating questions and following up their ideas as reward enough to boost confidence.

One key difficulty identified in Prior’s findings was that the students reported not feeling confident that they were carrying out activities in the right way. Peer feedback through group discussion did not appear to satisfy the students. According to Prior, the students still sought feedback from their tutor. However, she made the interesting point that the students may have been seeking approval rather than just support for their learning. This raises an issue concerning the impact of learner confidence on learning and the amount of praise appropriate for some learners’ development. Hubermas (1993), quoted in Halliday and Soden (1998), suggests that if challenges arising from exposure to new ideas become frightening, then changes in approaches to learning are unlikely to occur. Halliday and Soden suggest that there is a fine dividing line between challenging students and causing fear that would be counterproductive.
The implication from Prior's findings (2000) is that the development of critical thinking skills seems unlikely unless the self-esteem and confidence needs of students are addressed. Students who have low self-esteem, which manifests itself in behaviour that dominates or consistently seeks the attention of a facilitator, may cause disruption to the group learning environment. Prior's findings suggest that understanding the affective dimension to learning is an important condition for the successful implementation of thinking approaches. This is in line with Goleman's view (1996) that when it comes to shaping decisions and actions, emotions count every bit as much as thought.

Jarvinen and Twyford (2000) also suggest that personal interests and needs that arise from the learner have a great influence on the learning process. Similarly, Keeley et al. (1995, cited in Browne and Freeman 2000) say that an aptitude for critical evaluation is dependent on motivation on the part of the learner. McCombs (1996) argues that learners of all ages are naturally quite adept at being self-motivated and at directing and managing their own learning on tasks that they perceive as interesting, fun and personally meaningful, or relevant in some way. She cites examples of learning in informal environments as evidence to support her argument. This implies that learning activities may prove to be more successful at capturing students' attention if they are perceived to be relevant and meaningful to the students' lives. It is acknowledged that this is not always possible or desirable. McCombs points out that the need to motivate students arises in situations where they:

- are asked to learn something that does not particularly interest them
- have little or no control or choice
- lack the personal skills or resources needed to be successful
- lack adequate external support and resources, including adult help, respect and encouragement.

In these circumstances, the teacher must give consideration to the students' attitudes and dispositions in order to engage them successfully in thinking interventions.

Halpern (1998) proposes a fourpart empirically based model for teaching thinking skills. The first part of the model highlights the need to be aware of and give attention to learners' attitudes and dispositions. The model includes:

1. a dispositional or attitudinal component to prepare learners for effortful cognitive work
2. instruction in and practice with critical thinking skills
3. training in the structural aspects of problems and arguments to facilitate transfer across all contexts
4. a metacognitive component used to direct and assess thinking.

Halpern's argument (1998) in relation to the first part of the model centres on her belief that critical thinking is more than the successful use of a particular skill in an appropriate context. She argues that it is also an attitude or disposition to recognise when a skill is needed and the willingness to apply it. Halpern stresses that it is important to separate the disposition or willingness to think critically from the ability to think critically. As she points out, some people may have the ability to think critically, but choose not to put in the effort to do so. She explains that there are large differences among cognitive tasks in the effort that is required in learning and thinking. She emphasises that critical thinking requires the conscious exertion of mental effort and that learners need to understand and be prepared for this effort so that they do not abandon the process too soon. Halpern suggests that good instructional programmes will help learners to decide when to make the mental investment in critical thinking and when a problem or argument is not worth the effort. For example, it is worthwhile generating alternatives and calculating probabilities in a diagnosis of cancer. However, extended effort is not worthwhile if the decision involves the selection of the flavour of ice cream.

Halpern identifies the following dispositions or attitudes:

- willingness to engage in and persist in a complex task
- habitual use of plans and the suppression of impulsive activity
- flexibility or open-mindedness
- willingness to abandon non-productive strategies in an attempt to self-correct
- awareness of the social realities that need to be overcome so that thoughts can become actions.
Perkins (2001) argues that a dispositional perspective on thinking provides a richer view of what good thinking demands and it is therefore a useful instrument for examining the social side of thinking. He suggests that within a dispositional perspective, sensitivity, inclination and ability form three distinct components.

In relation to the social distribution of thinking, Perkins observes that when people work well together they pool their abilities, provide critical checks on one another's thinking, and engage more in metacognition through articulating their thoughts in order to communicate, thus making their patterns of thinking more salient and subject to examination. Diverse views can stimulate exploratory thinking and competing views can stimulate a search for evidence, thus making a positive impact on inclination. When working together, any individual may detect a situation that calls for the attention of the group, and people are likely to be sensitive to different things, thus expanding the overall alertness of the group.

Perkins observes that the social setting may either cultivate or inhibit thinking. Thinking is cultivated through social interaction, which builds sensitivity (through becoming familiar with the contexts in which patterns of thinking are used), inclination (through forming rationales and habits of use), and ability (through developing facility with the use of patterns of thinking). Language and literacy are powerful resources for supporting the development of thinking; for example, specific words carry within them patterns of thinking – such as ‘claim’ which calls for evidence – and writing ideas down enables them to be examined, critiqued and revised. Students' commitment to learning that can be encouraged within families, communities and schools is another important social force fostering the development of thinking. Social inhibitors of thinking include doctrine, authoritarianism and prejudice, which ‘tell us not to notice exceptions or anomalies and, if we do, not to think about them seriously’; and relativism which ‘tells us not to worry about differences and try to puzzle out what's right’ (Perkins 2001, 161). These affect sensitivity and inclination – the kinds of situation that are detected as worth thinking about and the readiness to invest in thinking about them. Accordingly, such inhibitors have no place in the thinking classroom, except as problems worthy of examination in themselves.

A dispositional perspective on thinking leads towards the realisation that, while abilities can be taught, sensitivities and inclinations are not so readily installed; it is more a matter of enculturation. This analysis leads towards the following strategies being proposed to develop thinking dispositions in students:

- intense and frequent thoughtful interaction around intellectually challenging matters with students thinking and learning together
- students being coached on how to think and work well together
- peer support, taking various forms
- the language of thinking being used; for example, words such as ‘evidence’, ‘theory’ or ‘model’ in the science classroom
- students being encouraged to accept responsibility for and develop commitment to learning
- avoiding the social antagonists of thinking, such as doctrines about what you must believe and think
- in the micro-culture of school, home, the workplace and other settings, key figures supporting patterns of thinking by what they model and reward.

Zoller (2000) also suggests a model that emphasises personal involvement, responsibility and motivation. Its main features are:

- a holistic, systematic, interdisciplinary approach as the guiding construct
- an independent, enquiry-based approach rather than passive knowledge acquisition
- personal involvement and responsible action on the part of the learner
- motivation and self-confidence to act accordingly and take responsibility

In relation to how teachers can work to enhance individual student motivation, Marzano (2003) proposes providing students with tasks and activities that are inherently engaging, and providing opportunities for students to construct and work on long-term projects of their own design. Both of these ideas are in keeping with Zoller's (2000) proposals. In addition, Marzano emphasises the importance of teachers providing students with feedback on the knowledge they have gained – to enable all students to experience success; and of teaching students about the dynamics of motivation and how these dynamics affect them.

It is suggested that within the post-16 sector, understanding the dispositions and attitudes of the learners is a key condition for success when implementing a thinking approach. However, there is a lack of hard evidence concerning ways to foster positive attitudes to learning in the post-16 sector that would serve to guide teachers and lecturers.
It has been noted in the previous sub-section that some teachers are resistant to change in teaching and learning approaches. There is also evidence to suggest that this is the case for students. According to Silver and Perez (1998), students are resistant to changes in learning approaches which demand their active involvement in discussion, because it requires them to challenge assumptions or misconceptions that they take for granted about familiar issues. They suggest, citing Lofland (1996), that students often possess political and emotional ties to issues and resist analysing them in new ways. This resistance lends credibility to ‘traditional’ teaching in which instructors lecture from assigned texts and the students remain passive.

Several of the studies reviewed provide evidence of student evaluations which indicate that the students did not respond favourably to new teaching and learning approaches. Everett and Zinser (1998) carried out a quasi-experimental study of the Broad Analytical Expository Report (BAER) approach to critical thinking, which was introduced in business courses. They provided some case study evidence suggesting that critical thinking tends to lower student evaluations of teaching. Their findings showed substantial increases in cognitive and report-writing ability, but lower student evaluations as the approach became more rigorous. In the economics class, some students reported that they had learned little or nothing of value.

The findings indicate that the more rigorous the BAER approach, the more negative the evaluations. The conclusion the authors came to is that the BAER approach results in active student learning which produces higher cognitive levels and critical thinking outputs, but the students dislike and resist the approach. They suggest, citing Marshall and Tucker (1992) and Brock (1993), that many students see little need to invest in the additional time required to develop critical thinking, because most employers use the college degree as a screening device and do not ask about skill development or even courses taken. This is an interesting finding, given that one of the reasons put forward for implementing thinking skills is the perceived demand by employers that their employees should be able to think critically.

Similar to Everett and Zinser (1998), Shell's (2001) findings indicate that nurse educators saw their students’ attitudes, abilities and beliefs as the greatest barriers to implementing critical thinking teaching strategies and were fearful of negative student evaluations. The findings suggest that the lecturers were concerned about the effectiveness of teaching methods that run counter to student desires and expectations, and find it difficult to penetrate the actual, or perceived, student resistance to active teaching methods.

A case study of practice in an FE college conducted by Soden and Pithers (2001b) found that both lecturers and students preferred approaches to teaching and learning that were incompatible with developing thinking skills. The authors interpreted the significant discrepancies they reported between preferred practices and those described in research literature for developing thinking in terms of a model proposed by Kember (1997). This model posits that student ‘presage’ factors interact with other factors, including institutional influences, to influence lecturer and student practices. ‘Presage’ factors include knowledge and dispositions that students bring to the course, what they want from the course and what they are able and willing to do to achieve what they want. According to Soden and Pithers, institutional factors seemed to interact with students’ expectations to influence lecturers to give priority to ways of working which were most likely to produce success in year-end examinations.

These studies (Everett and Zinser 1998; Shell 2001; Soden and Pithers 2001b) highlight the power of student evaluations on the lecturers’ choices concerning teaching approaches. However, it is necessary to be clear whether the student evaluations were really critical of thinking skill approaches or if they were critical of personal teaching characteristics. New topics and alternative course structures may reduce clarity. Lecturers who lack experience or confidence in teaching thinking, or who do not wholeheartedly see the value of thinking skills approaches are unlikely to be effective in their teaching of thinking. Student evaluations of thinking skills may be quite different with a lecturer who embraces a thinking approach confidently.

Everett and Zinser (1998) conclude that while they believe that they can produce excellent student critical thinking learning outputs in one course, the potential negative impact on long-term interest and on enrolments exacts too high a price. They suggest that the BAER approach should be moderated to allow students to build up skills and orientations gradually through several courses; and that administrators should encourage faculty and students to use active critical thinking approaches by communicating to faculty and students a commitment to, and reasons for, the approach. These recommendations point not only to staff and student readiness, but also to institutional readiness and support. This demonstrates the need to consider the overlap between conditions for successful implementation of thinking interventions.
In a number of studies, the importance of training students as well as teachers for thinking skills approaches emerged. Leat (1999, 391) suggests that students need to be trained to approach learning in a different way in order for thinking approaches to be successful. He provides evidence to support this claim with a teacher’s comment: ‘The activities, although often apparently straightforward, usually require a certain way of thinking and depth of thought which pupils are simply not accustomed to. It is therefore necessary to ‘train’ children to learn in a different way...’.

Prior (2000), drawing on research by McGuinness (1990) and Blagg, Lewis and Ballinger (1994), suggests that responsibility has to be taken to ensure that students are properly equipped to undertake learning through a thinking intervention. She says that the research suggests that in order to give maximum benefit to students, the underlying cognitive processes that enable learning have to be made explicit. According to Halpern (1998), when one is teaching for thinking, the goal is to have students not only understand and successfully use the particular skill or strategy being taught, but also be able to recognise where that particular skill might be appropriate in a novel situation. She believes that in order to teach for transfer, the students must be made aware of the structural aspects of problems and arguments so that they are able to identify retrieval cues (see Section 5).

McKnight (2000) highlights the need for student ‘readiness skills’ in any thinking intervention. McKnight’s study concerning the potential that online communication offers for collaboration as well as increased participation in the learning process, reflection, peer tutoring and monitoring of student learning is discussed in Section 6. She points out that it cannot be assumed that the students have sufficient critical thinking skills to advance online discussion, or that tutors have enough practice in monitoring discussions or skills in creating productive communities of online learners. She believes that it is necessary to conduct some off-line activities that will give students a better understanding of the collaborative learning and communication process first. McKnight suggests that both students and tutors need support and training. This suggests that a careful mapping of training needs in the post-16 sector, construction of appropriate training and support mechanisms and a subsequent evaluation of their effectiveness are required.

Beyer (1998) also believes that it is necessary to make seemingly invisible thinking processes visible and explicit. He draws on Papert (1980), saying that students benefit immensely from becoming conscious of, and articulating exactly, how they execute a given thinking operation or skill, comparing this with how experts do it, considering where and when it is appropriate to employ the operation and how to make it more efficient, effective and expert. Beyer argues that this requires a continuing, systematic, long-term effort to move students towards achieving and maintaining the highest levels possible of self-directed thinking. However, there is not universal agreement that encouraging students to make their thinking processes explicit is a key component for success when developing thinking. This is an area where the knowledge remains contested by researchers working within the perspective known as ‘situated cognition’. It is clear that further research in this area is needed to clarify the importance of encouraging students to make their thinking explicit.

Learning environment

Changes to the learning environment were frequently referred to as an important condition for the successful implementation of thinking skill interventions. As has been pointed out throughout this report, the majority of the studies suggest that thinking interventions are underpinned by constructivist and participatory theories of learning. Therefore it is proposed that to be effective, the learning environment must provide opportunities for learners to construct their own understandings, engage in active participation and experience a sense of empowerment. According to Kienzler (2001), the core of the teaching process is the arrangement of environments within which students interact and learn how to learn. He says that it makes a great difference whether one permits chance environments to do the work, or designs environments specifically for the purpose of developing students’ thinking. A number of suggestions concerning effective learning environments emerged from the analysis of the studies. For example, they should:

- be based on openness, equality, respect and student empowerment
- be sensitive to the emotional intelligence needs of the group
- enable active participation
- enable teachers and students to articulate and reflect on their thinking processes
- provide students with opportunities to challenge ideas and assumptions
- provide opportunities for the direction of enquiry and debate to originate from the students’ own interests
- provide opportunities for peer collaboration
- provide opportunities for sustained thinking.
Beyer (1998) describes four approaches for improving thinking, and his first point emphasises the importance of planning learning environments to enable students to develop thinking processes. His four approaches are:

- providing thoughtful learning environments
- making thinking visible
- guiding and supporting student thinking
- integrating instruction in thinking with subject matter.

Dealing with the first point, he explains what he believes are two crucial features of learning environments. Students should have repeated opportunities to engage in meaningful thinking beyond the level of recall, and they should be encouraged to engage and remain engaged in such thinking. Beyer emphasises that it is necessary to engage students in productive learning tasks. These, he says, are tasks that require students to produce knowledge new to them, rather than simply to reproduce information or knowledge claims already presented to them in texts, lectures or media.

He separates the four points set out above in order to explain them. However, it is clear in his explanation that they are closely interrelated. This highlights the difficulty in identifying specific conditions that lead to successful thinking interventions. Many of the studies analysed by the research team discussed conditions and made assumptions about their role in effective thinking interventions. However, there is a lack of studies that attempt to evaluate specific conditions or analyse how they work in combination to result in a successful intervention. Further suggestions concerning the learning environment for thinking interventions are discussed below, but there is little evidence that the different conditions have been evaluated in different contexts. For example, will features of the learning environment deemed to be necessary hold the same importance in all circumstances relevant to post-16 education - in schools, in FE colleges, in universities, in informal settings and in the workplace? This is an area of research that needs to be explored.

The notion of enquiry-based classrooms is one feature that arises frequently in the literature, which suggests some agreement about its role in developing students' thinking. The importance of creating learning environments that allow students to ask questions is repeatedly referred to in many studies. For example, Kienzler (2001) emphasises the importance of identifying and questioning assumptions, seeking a multiplicity of voices and alternatives on a subject, making connections and fostering active involvement.

In common with many other researchers, Beyer (1998) suggests that learning assignments should be framed around thoughtful questions. He describes a thoughtful question as one that requires students to go substantially beyond where they are in their thinking. He also suggests that it is necessary to find ways to encourage students to build on their answers in order to sustain continued thinking. Thinking may be extended by the teacher or by other students asking for evidence, more details or underlying assumptions. According to Beyer, thoughtful questions should engage students in defining terms; posing hypotheses; identifying, finding, assessing and manipulating data; making and testing inferences; generating and evaluating conclusions and arguments; and applying concepts, principles and other kinds of knowledge. He also emphasises the positive value of rejected hypotheses and wrong answers in leading students to valid hypotheses and answers.

Questioning and discussion is closely linked to the notion of active participation and peer collaboration. Browne and Freeman (2000) suggest that critical thinking is very much a participative activity and that the primary characteristic of a thinking classroom is a room that is abuzz with questions. They believe that questions are stepping stones to evaluation of reasoning. Shaw (1996) argues that critical thinking requires comprehension and he suggests that questions that unearth the conclusion and reasons in an argument are necessary starting points for the development of thinking.

Creating a classroom that is conducive to student questioning is not an easy task. The focus for teachers shifts from ways to deliver subject matter to passive students to ways to help students take responsibility for their own learning. Teachers themselves need to know when and how to ask questions, and they must know how to encourage students to ask questions of each other. This requires an understanding of the emotional climate and the group dynamics of the student body. This follows Vygotsky (1978, 1986), who emphasised that social interaction and discourse are highly important to students' construction of knowledge. Lipman, Sharp and Oscanyon (1980) also emphasised the importance of establishing the necessary conditions for cooperative learning by seeking to establish a democratic community of enquiry within the class. Jarvinen and Twyford (2000) follow the same line of thinking, saying that knowledge and skills are constructed at the individual level, but at the same time, learning is essentially a socio-cultural phenomenon which is mediated through social interactions among the members of the learning community. Teachers have to create supportive environments that gradually give the students the confidence and the ability to participate in classroom discussion and debate.
Mayer (1986), cited in Browne and Freeman (2000), states that the key to developing critical thinking lies in creating conditions for participation rather than passivity, and in providing opportunities for emotional engagement with the materials. He suggests that teachers must provide learners with frequent opportunities for direct practice of evaluation skills and allow them time to experiment with critical thought. Mayer emphasises the tendency to seek only information that supports views and beliefs already held. He sees this as a sizeable obstacle to developing the critical thinking skills of students. However, he suggests that involvement with course material and the critical thinking skills of students. However, he suggests that involvement with course material and verbal attention to key arguments and issues can enable students to rise above this obstacle.

Gerber, Cavallo and Marek (2001) suggest that enquiry-based teaching approaches should provide direct experiences that induce cognitive conflict and hence encourage learners to develop new knowledge schemes. They say that practical activities and active discourse form the core of such pedagogical practices. In classes taught by enquiry, individuals are actively engaged with others in attempting to understand and interpret phenomena for themselves; and social interaction in groups provides a stimulus of differing perspectives for reflection.

One model of enquiry described by Gerber, Cavallo and Marek (2001) is the learning cycle. This consists of exploration, term introduction and concept application. The exploration engages students in some level of disequilibrium or cognitive conflict as they struggle to make sense of their experiences. In term introduction, the teacher guides students towards compilation and representation of collected data. Through classroom discourse, the students prepare statements that represent their understanding of the concepts. In concept application, the students expand their understandings by using the concept in different contexts. Through application activities, students organise the concepts in relation to what they already know, and relate the concept to ‘real world’ experiences. Throughout the learning cycle, the students work in groups and engage in active discourse with peers and the teacher. The teacher facilitates the learning process by asking probing questions without revealing the concept until the students have constructed their own understanding. Gerber, Cavallo and Marek (2001) believe that the development of reasoning abilities is promoted through students’ experiences, cognitive conflicts and social interactions. They quote Adey and Shayer (1990), who demonstrated that acceleration of cognitive development (reasoning ability) was possible among middle- and high-school students through long-term enquiry interventions.

The theme of cognitive conflict was raised in several studies. Hays (1987), quoted in Kienzler (2001), notes that some researchers assert that conflict is the impetus to intellectual development, and Palmer (1998) suggests that a charged environment, full of a sense of creative tension, contributes to the development of thinking. Similarly, Baron (1985), cited in Browne and Freeman (2000), believes that thinking begins only when a state of doubt about what to do or believe exists, and that all conscious thought has its genesis in uncertainty. He claims that doubt motivates thinking to occur and controversy presents situations in which doubt naturally arises. However, striking the right level of cognitive conflict requires careful consideration. Some students, particularly those who lack confidence, may feel threatened by views that conflict with their own. Prior (2000) suggests in her study that it is important that the direction for enquiry and debate originates from the students’ own interests. Likewise, Silver and Perez (1998) provide an account of their successes in teaching social theory to students engaged in participant observation in an undergraduate sociology course in a Chicago field studies programme. They strove to convince students that their own data should be the focus of seminars and discussion should stem from their views and opinions. However, Brookfield (1987), quoted in Kienzler (2001), suggests that educators who plan courses around learners’ wishes may do them a disservice by implicitly condemning them to remain within their existing paradigms of thought and action.

The idea of developing thinking in relation to ‘real world’ contexts was noted in several studies. For example, Marzano (1998) suggests that thinking and reasoning should be reinforced in the context of authentic tasks within their content areas. Similarly, Halpern (1998) says that questions drawn from ‘real world’ contexts should be used to develop connected knowledge structures. This view is consistent with ‘situated cognition’. Halpern says that ‘real life’ thinking is done in a context. Consequently, she believes that a good learning environment should ensure that thinking skills activities have a believable context. She suggests that the repeated use of ‘authentic’ materials that are similar to ‘real world’ situations is one strategy that is likely to enhance transfer. (Situated cognition is explained in Section 5.) Relating thinking to ‘real world’ situations may also be of greater interest to post-16 students as they are able to ‘see’ the immediate relevance of the learning process. They may be prepared to make the additional effort to engage in thinking processes if they are dealing with what they perceive as a ‘real’ problem relevant to their future employment or life in general.
The research team believes that the role of peer collaboration is central to developing thinking. Consequently, the whole of Section 6 is devoted to it. The arguments for peer collaboration will not be reiterated here. However, one aspect that requires further treatment is the power shift necessary to enable students to feel empowered in the learning process. Kienzler (2001) says that participatory pedagogy is needed to help students feel that they are in sufficient command of the learning process. As discussed in the earlier subsections on ‘teacher/lecturer readiness’ and ‘student readiness’, changes in the actual and perceived views concerning teacher and student roles are necessary. However, students may have difficulty at first in their attempts to experience a sense of empowerment. For example, Fisher (1995) points out that although students often sit in groups, they do not necessarily work in groups. They need assistance in order to develop the cognitive and social skills required to engage in democratic debate. They need to develop skills and behaviours such as listening to and respecting contributions from others, thinking things through before speaking and directing critical feedback to what is said rather than the speaker. It is argued that teachers need more support in order to understand the complexity of creating a learning environment that enables communities of enquiry to flourish.

The need for institutional support in order to implement changes to the learning and teaching process and to curriculum design, content and assessment practices has been mentioned several times in this section and would appear to be an important condition for the success of thinking interventions. The studies that were analysed discussed the role of the institution mainly from a negative perspective. For example, lack of institutional support was frequently reported as a barrier to the development of thinking. No studies were found that examined ways in which institutional support could contribute to the successful implementation of thinking skills.

Leming (1998) argues that the barriers to teaching higher-order thinking lie in the organisational context of schools, not in the assumptions on which the instructional model is based. He cites Onosko (1991), who has identified six barriers related to organisational context: teaching as knowledge transmission; broad superficial coverage of content; teachers’ low expectations of students; large numbers of students in a class; lack of teacher planning time; and a culture of teacher isolation.

As Leming points out, other barriers to the implementation of thinking approaches have been identified, such as student readiness to think. Each barrier, when considered individually, is not easy to overcome. When considered together, they present an enormous hurdle for anyone attempting to introduce a thinking intervention. If the barriers to thinking approaches are to be overcome in the post-16 sector, it appears that radical revision of aims and learning and teaching approaches will be required. If such radical thinking were to be contemplated, it would require wholehearted institutional support.

Course design and content

Within the context of this research project, there were few studies that explored the relationship between curriculum design and content and the successful development of thinking interventions. It is suggested that there is little evidence that curriculum designers generally start from the premise that the development of thinking skills should be central to all student study. It appears that the basis for curricular design is usually the course content that has to be covered. Manzo (1998) claims that it is rare to find a school curriculum guide that makes thinking - especially creative thinking - a major objective. It is proposed that, in order for thinking interventions to be successful, it is necessary to rethink existing course design and content as well as the related assessment procedures.

Shell's study (2001) that explored nurse tutors’ views of the barriers to the development of thinking placed ‘content coverage’ high on the list. The tutors said that the need to cover content was a major barrier to teaching critical thinking. Shell says that the amount of factual information that must be learned and taught in nursing education can be overwhelming for both student and teacher. However, the implication that filling students’ heads with content in the context of a lecture hall will lead to increased knowledge or understanding is flawed. More research is required to investigate effective learning in the long term. An emphasis on content may lead to short-term knowledge of certain facts, but it is unlikely to lead to deep sustained understanding. This also flags up the need to understand what end-of-unit/module examinations are actually testing. The results of a comparison of two groups of students, one taught in a traditional way and the other taught using enquiry-based methods, would be highly dependent on the testing procedure used to judge the quality of learning.
Many of the comments made about curriculum design made reference specifically to the constraints of examinations. According to Soden and Pithers (2001b), both lecturers and students in an FE college preferred approaches to teaching and learning that were incompatible with developing thinking skills. The reason they cited was that institutional factors seemed to interact with students' expectations to influence lecturers to give priority to ways of working which were most likely to produce success in year-end examinations. Soden and Pithers suggest that approaches such as problem-based learning require changes in content, and in how students are assessed, which the lecturers felt unable to negotiate. They concluded that, if universities and colleges want students to develop a wider range of 'generic' abilities, which can be summarised as good thinking, this aim needs to be acknowledged explicitly and appropriate changes made to course design and assessment approaches. The focus will need to shift away from performance criteria and summative assessment practices. An institutional policy on curriculum design could be adopted which accommodates Lonka and Ahola's (1995) findings with post-16 students: that the sort of activities described in the literature and outlined in this report are likely to provide qualitatively better results in the long run.

Some evidence emerged from the studies analysed to suggest that some subjects are more appropriate than others for teaching thinking. If this is the case, it may well have an impact on curriculum design. Hardman and Leat (1998) report on two empirical studies that investigated methods of teaching and learning in the post-16 curriculum in England. They concluded that there were discernable differences in the way different subjects were taught (e.g. English literature and mathematics). They say (1998, 367) that the results from these tests were striking and that highly significant results were obtained:

Some of the most dramatic differences can be seen between English literature and mathematics ... Mathematics teaching at A-level appears to be dominated by teacher 'presentation', 'exercises', 'dictated notes' and 'working previous examination questions'. English literature, by contrast, was more characterised by 'class discussion', 'making own notes' and 'reading'.

Tsui (1999b) conducted a large-scale study to illuminate how different types of course and instructional technique affect college students' growth in critical thinking. Results suggest that taking each of the following courses was positively associated with self-reported growth in critical thinking: writing, interdisciplinary studies, history, science, women's studies, mathematics, foreign languages and ethnic studies. Enrolling in an honours programme was also associated positively with critical thinking. The results suggest that it is possible that certain courses offer concepts that facilitate analysis of issues. Tsui believes that it is both instructional techniques and content that together produced the positive effects. In other words, Tsui's findings imply that teaching approaches are unlikely to compensate for content that is overly descriptive or procedural and lacking in conceptual challenge; and conversely, that challenging content requires supportive classroom experiences. The strongest effects came from writing assignments and instructor feedback on the students' assignments.

This rigorous, large-scale study would be well worth following up with the aim of teasing out characteristics of programme content that seem likely to influence students' critical thinking. Post-16 curriculum developers might then explore the nature of the content and learning outcomes in the programmes in which students reported greater growth in critical thinking, and consider the extent to which such characteristics are typical in the courses they develop. Consideration might be given to the question of whether critical thinking could be enhanced by incorporating such features into courses in which, traditionally, they have not been prominent.

Marzano (1998) explains that in an attempt to provide an empirical approach to the teaching thinking skills debate, researchers at the Mid-continent Regional Educational Laboratory (McREL) in Colorado in the US carried out an analysis of national standards documents in core subject areas. These documents explicitly identify what students should know and be able to do in specific content areas. The project was funded by the US Office of Educational Research and Improvement. Documents were analysed in 12 curricular areas. All were analysed for thinking and reasoning skills that were stated explicitly or implicitly. (For a detailed discussion of the protocols used in the analysis, see Kendall and Marzano 1997.)
The results of the research claimed to identify six general thinking and reasoning skills that were mentioned in the majority of the subject areas. Marzano's report includes details of the extent to which different subject areas place emphasis on these thinking and reasoning skills. The percentage of total references to thinking and reasoning skills attributed to each subject area is listed in the report. The researchers claimed that a pattern emerged which showed that science, history and mathematics had the highest percentage of references to thinking and reasoning and language arts had the least. The researchers suggest that their conclusions can provide general guidance for future curriculum design.

These findings appear to contradict those of Hardman and Leat (1998) outlined above. However, the pronouncements in curricular documents may not match the delivery of the content in the classroom. Marzano conducted a document analysis, whereas Hardman and Leat investigated the teaching and learning methods. This difference in the findings of the two studies highlights the importance of analysing both the curricular documents and the teaching and learning approaches in order to evaluate successes relating to teaching thinking skills.

An important condition that was raised in a number of studies was time. Curricula that are designed around hour-long slots of time are not ideal for the successful implantation of thinking interventions. For example, the teachers in Baumfield and Oberski's (1998) case study reported that it was not easy to establish a community of enquiry in a 50-minute lesson. Teachers need time in order to enable students to engage in sustained thinking. Teachers also need to provide time to allow students to think before accepting their response to questions. Prior (2000) also suggests that it is necessary to prioritise time for reflection and critical analysis. Shell's (2001) study indicates that nurse tutors believed that the second highest barrier to the development of thinking skills was time constraints and included items such as ‘insufficient time to learn new teaching methods’; ‘lack of time for preparing and planning critical thinking activities’; and ‘inadequate time in class’. Pithers and Soden (2000b) conducted a review of evidence drawn from Australia, the UK and the US on what might be done to help students in post-school education to think well. They concluded from their review that curricula would need to be redesigned to reflect the importance of learning to think critically, with appropriate time allowed for activities designed to help students develop forms of meta-knowing, including epistemological understanding.

Kirkwood (2000) argues that infusing problem-solving skills into content instruction is extremely difficult to achieve within content-packed, nationally prescribed syllabuses. Problem solving cannot be done ‘to order’ since fast progress on problems can never be guaranteed unless the problems are very routine. Therefore, students need unhurried opportunities to think and to recover from errors. In the absence of any moves by the syllabus designers to prune the content, teachers are forced to adopt a selective focus on the curriculum in order to make room for problem-solving activity. If doing this could jeopardise students’ examination success, then it is extremely unlikely to happen. The implication is that course planners need to consider the time implications of thinking skill interventions.

**Post-16 culture**

Post-16 learning takes place across a number of sites – schools, FE colleges, universities, informal centres/clubs in the community and in the workplace. Different cultures and views of effective ways of learning are apparent in these different sites. It may be that the conditions for the successful implementation of thinking interventions will differ in the different post-16 learning sites. The criteria used to conduct the literature search mainly resulted in studies carried out in schools and universities, with a small number in further education. There are few studies that examine the different cultural climates in the different learning sites. The discussion below explores some of the issues relevant to post-16 vocational education, but it is acknowledged that this does not take account of the range of learning sites in the post-16 sector. Further research is needed to take account of cultural conditions that may affect the implementation of thinking interventions.

A particular culture has developed in relation to post-16 vocational education and training (VET) as delivered in further education and in the workplace. The lack of research into embedding thinking skills in this context may be in part because, generally, teaching and learning within further education is a less researched area compared with schools and university-based higher education. It may also be because for the past two decades, the post-16 vocational curriculum has been designed using competence-based approaches that require the clear specification of learning outcomes and performance criteria. The focus is on behavioural outcomes more than internal processes, and the development of thinking skills has not been of prime concern. This is not to suggest that growth in thinking skills does not occur, but that courses are seldom designed with it in mind.
Because of this lack of research, the approach taken here is to present a brief overview of post-16 vocational curriculum design and to consider the match between this and the features identified in the literature as being key in the development of thinking.

This research project has not entered into the extensive educational debate surrounding competence-based approaches to education and training, but suffice it to say that the strong behaviourist epistemology of that approach is at odds with the cognitive, constructivist and social constructivist theoretical underpinning of thinking skills development. It is considered here only as an explanation of the dominant approach to teaching and learning within vocational provision in the UK. It has also been a powerful force in education and training development in Australia and New Zealand.

The main qualifications in post-16 VET in England, Wales and Northern Ireland are work-based, occupationally-specific National Vocational Qualifications (NVQs); college- and school-based GCSEs and A-levels in vocational subjects (formerly GNVQs); and First, National and Higher National qualifications. In Scotland, separate, but similar qualifications exist, namely Scottish Vocational Qualifications (SVQs), National and Higher National qualifications.

The NVQ framework was developed following a review in the mid-1980s of vocational qualifications, with a view, among other things, to creating a better qualified workforce and devising vocational qualifications which related more directly and clearly to the competences required and acquired at work (Department of Education and Science/Manpower Services Commission 1986). NVQs are based on ‘national standards’ that have been developed by industry-led bodies for specific occupational sectors. The process of development, called functional analysis, led to very detailed prescriptions of expected performance criteria which people have to demonstrate in order to be considered competent. The qualifications are made up of units, which are groupings of related outcomes and performance criteria. The standards are defined at five levels. At Level 1, it is expected that an individual will require substantial supervision and have little responsibility. The increasing levels assume increasing autonomy and responsibility for one’s own work and that of other people.

In early developments, only that knowledge required to allow for competent performance was considered important and ‘knowledge and understanding’ became defined as ‘underpinning’ (Jessup 1991). As NVQs evolved over time and higher-level NVQs were developed, the place of knowledge and understanding has been discussed, but overall the position remains that knowledge and understanding are not outcomes in their own right, but are seen as supporting performance, which is the outcome. In some circumstances, knowledge may be assessed separately, but only where it cannot be tapped into through specific performance; and in the specification of the unit descriptors, any knowledge required must relate to the expected performance criteria. All knowledge specified as being required to support performance must, however, be assessed in some form or another (Wolf 1995).

In the intervening years, NVQs have been reviewed and revised to answer criticisms of difficult language and to take account of changing work patterns (e.g. Beaumont 1996), but their essence has not changed. Thus the key features of units within NVQs are a set of statements of the national standard, a clear prescription of the contexts in which the candidate must be able to demonstrate that they can perform to the national standard, and a statement of the knowledge required to enable them to perform to the national standard.

Other vocational qualifications such as GNVQs and First, National and Higher National qualifications are designed to provide more general vocational education and training, though still within broad occupational categories. They are delivered in classroom-based environments within schools and colleges. These courses are all modularised or unitised and have expectations expressed as learning outcomes, with supporting content, prescribed approaches to assessment, and detailed criteria as to how performance should be judged. These more general vocational qualifications are more likely to include assessment by extended written assignment than NVQs; and in some cases, at more advanced levels, there may be external assessment. Nonetheless, course descriptors remain highly prescriptive.
While ‘thinking skills’ have been introduced into the National Curriculum in schools in England and Wales, there is no such direct focus in the post-16 vocational curriculum. However, attention has been given to key skills (previously ‘core skills’ in England and Wales and still ‘core skills’ in Scotland). Core skills were developed as part of the Youth Training Schemes (YTS) of the early 1980s on the assumption that there are skills that are ‘core’ – ‘generic’ to both life and work and as such, ‘transferable’ and therefore worth developing. While the concept of transfer is disputed in wider educational arguments (see Section 5), as far as vocational curriculum developers are concerned, transfer is assumed. It is intended that key/core skills should be embedded across the curriculum and unit descriptors usually indicate where there is opportunity for developing key skills and gathering evidence if accreditation of the skills is required. Discrete units also exist for specific development and accreditation purposes.

It might be expected that there is potential for the development of thinking skills within the key/core skills framework and, in particular, in relation to problem solving, but no research into this phenomenon has been identified. It is noted that the descriptors for problem solving at different levels present it as a step-by-step process. For accreditation purposes, candidates are required to present evidence that each step has been completed. Terms like ‘critical’ and ‘evaluate’ are used, but the approach is more identifiable with managerial approaches to problem solving than as contributing to, or forming a subset of, higher-order thinking skills.

Within the literature reviewed, a few studies reported successful interventions in introducing thinking skills to students and lecturers in FE colleges. However, there were limitations because of conditions within the learning environment. Anderson, Soden and Hunter (2001) report on an experiment with students studying for the Scottish Vocational Qualification (SVQ) in Social Care or Health Care at Level 3.

The intervention used strategies that have been associated with the development of critical thinking, positive motivation and independent learning. These strategies included: modelling thinking about the nature of evidence-based justification, engaging students in ‘talking about’ their thinking, critiquing each other’s drafts of project outlines and plans in terms of their use of justification. Students’ written work showed that, compared to a control group, the intervention had a positive (but weak) impact upon the students’ use of justification, which endured over time. It was considered that the results might have been stronger had there been sufficient time in the students’ curriculum to achieve a deep enough understanding of the knowledge they were expected to think about. The authors’ experience was that arrangements to infuse similar aspects of critical thinking across the curriculum would have required institutional support that was not forthcoming at the time of their study.

Soden (1993) reports on a study in which FE lecturers were trained to introduce thinking skills to their students in the course of acquiring vocational knowledge. Lecturers looked for opportunities to incorporate thinking skills into the content of the modules they taught. Results indicated that students in some modules improved their thinking strategies on non-routine tasks compared to control groups. However, barriers to more effective intervention were identified. The intervention was introduced in only one or two modules, as the lecturers for the experimental group only had the students for these modules, and it was not possible for them to teach all the modules. A further impediment identified was the fact that the assessment system typically tested students on routine tasks and provided no incentive for students to engage with the activities in the experimental programme.

Blagg, Lewis and Ballinger (1994) reported on the introduction of Thinking Skills at Work (TSAW) to a range of participants in further education. The project involved the development and controlled evaluation of a range of novel learning materials and accompanying trainer techniques designed to broaden and extend vocational training and promote learner autonomy, flexibility and adaptability. Blagg, Lewis and Ballinger claimed that benefits were identified, though this was based largely on student self-reporting, and therefore the study has some methodological weaknesses. Nonetheless, they did suggest that the benefits varied from study to study, with some of the variation coming from different levels of support and different amounts of time spent on the intervention. It can be assumed that different learning environments had an impact on effectiveness.

Key curricular features in the development of thinking skills include self-directedness and self-awareness, enquiry-based learning, peer interaction and collaboration, teacher modelling of thinking processes and learner verbalisation of internal thought processes. Such approaches all imply giving considerable responsibility and control to the learner, while encouraging both teachers and learners to make explicit the thought processes they are going through to accomplish any given learning task.
To introduce such approaches into the classroom, or another learning context such as the workplace, requires not just willingness on the part of teachers and learners, but also the freedom to determine the learning objectives and to organise the learning environment in ways appropriate to developing the desired thinking skills. This has consequences for deciding what should be assessed and how it should be assessed.

Section 7 highlights approaches which researchers and practitioners have suggested are effective for assessing thinking skills. There is the view that emphasis on assessing reproduction of factual information can suppress efforts to teach problem solving and critical reasoning (Nisbet 1990). Costa and Kallick (2001) argue that thinking abilities (process-oriented outcomes) cannot be assessed exclusively through product-oriented strategies. Key characteristics of approaches to assessing thinking skills and, in particular, growth in the use of such skills, are that knowledge and skills are being applied in realistic or ‘real world’ contexts to solve problems or make decisions. Tasks which require the integration of both skills and knowledge from different subjects are emphasised. Assessment needs to take place over time, and there is some evidence that effective formative feedback leads to greater academic achievement (Marzano 2003). Costa and Kallick (2001) suggest that the development of ‘habits of mind’ should be monitored over time and in a rich variety of contexts. Such approaches to assessment are regarded as time-consuming to develop, administer and score.

In an outcomes-based curriculum, teachers and learners are driven to cover each of the prescribed outcomes, producing both performance and knowledge evidence. The outcomes and performance criteria are mandatory, because they are seen as a prerequisite of competence. Therefore, to be successful, there must be evidence that each has been covered and achieved. Neither teacher nor learner has the freedom to miss out any stage to pursue a more interesting topic or focus on the development of non-prescribed skills. It is easy to imagine that if every performance criterion must be assessed, this could create an assessment-driven environment where teachers constantly teach to meet the requirements of the next assessment. This can lead to a ‘tick the checklist’ approach to assessment.

It is evident that such high levels of prescription of outcomes work against encouraging learning environments that allow learners to define the issues they wish to pursue and how they pursue them. Likewise, prescriptive approaches to assessment, particularly where evidence of each performance criterion has to be identified and recorded, mitigates against, though does not necessarily exclude, developing integrative assessments which take a longer time to complete (see below). The focus on product evidence and observable behaviours is certainly unlikely to encourage systems of assessment designed to track the development of ‘habits of mind’.

Some programmes have integrative units: that is, units which require students to undertake a project drawing on material learned in other units, and often at the same time demonstrate aspects of key core skills. For example, in order to achieve accreditation in the Scottish Vocational Qualification (SVQ) in Social Care or Health Care at Level 3, students are required to undertake a project and submit a 3000–4000-word report. Bloomer (1998) has studied the use of integrative projects and group work in FE courses and his analysis suggests that while the words ‘critical thinking’ and ‘analysis’ are used, in fact, much student activity was being expended on tasks that were often trivial, tightly prescribed, closely supervised and rarely involved critical enquiry.

This analysis suggests that within certain strands of the post-16 vocational curriculum, highly prescriptive outcomes and assessment severely limit both freedom and opportunity to develop learning environments that allow the use of approaches identified as effective in developing and assessing critical and analytical thinking. Therefore a key condition for the successful implementation of thinking interventions will be a shift away from a curriculum context driven by performance criteria.

This has implications for staff. An earlier sub-section addressed the importance of teacher readiness as a condition of the successful implementation of thinking interventions. As the behavioural outcome model for designing the post-16 vocational curriculum has been dominant since the 1980s, FE lecturers and work-based trainers have been accustomed to working with this approach. Many current lecturers and trainers have been trained specifically to deliver an outcomes-based curriculum and work with assessment instruments that focus on observable behaviours or product evidence. This is not to suggest that lecturers would be unwilling or unable to adopt different approaches, but a major investment in staff development would be required.
Summary of conditions for the successful implementation of thinking interventions

A number of conditions for the successful implementation of thinking skills emerged from the analysis of the studies. The discussion of the conditions in this section seems to support Browne and Freeman's point (2000) that the variety of conditions reinforce one another and therefore only as a package will they lead to success. It is argued that much more needs to be understood about the different conditions identified in the studies and how they interact with one another. For example, there is little point in suggesting that teachers/lecturers and students would do well to change their conceptions of learning and teaching unless the environment in which they learn and teach can support different conceptions. Further research is needed in order to understand how the different conditions identified in this section combine to result in successful thinking interventions.

In addition, much more needs to be understood about which conditions lead to success in different post-16 learning contexts. For example, will features of the learning environment deemed to be necessary for thinking interventions hold the same importance in all circumstances relevant to post-16 education - in schools, in FE colleges, in universities, in informal settings and in the workplace? This is an area of research that needs to be explored.
Conclusions and recommendations

Introduction
The purpose of this section is to draw together the discussion in earlier sections about each of the research questions that the project team was asked to address in order to form conclusions and recommendations for future research. The research questions were as follows.

- What are the relative merits and disadvantages of different approaches to teaching thinking skills?
- What is the evidence to support the view that a thinking skill in one subject or domain is transferable to another subject or domain?
- Which models of teaching thinking skills are appropriate for post-16 learners?
- Which methods of assessing thinking skills, and of evaluating thinking skills interventions, may be suited to post-16 learning contexts?
- Is there evidence to suggest that approaches to teaching thinking skills used with pre-16 learners are applicable to post-16 learning contexts?
- In which areas is there knowledge that is extensive or widely accepted?
- In which areas is knowledge limited, non-existent or highly contested? And what questions arise for further research?

The methodology used to address those questions was explained in Section 2. Since the studies selected for review are reported in Appendix 2 or discussed in the previous sections, details are not repeated here. A major theme in this section is that, since it is likely to be difficult to teach what is poorly described, more attention should be given to discussing with teachers what they understand by thinking in post-school education and what it might mean to transfer thinking across contexts. Although the project team would not wish to argue that a common and comprehensive definition of thinking or transfer would ever be feasible, encouraging teachers to develop descriptions that make sense to stakeholders, and that can be located in research literature, is likely to help teachers to understand better what they are to teach, and to enable them to defend to stakeholders their assessment of thinking in student assignments. It is suggested that careful description might help everyone involved in post-16 education to set realistic expectations (Leming 1998).

What are the relative merits and disadvantages of different approaches to teaching thinking skills?

The project team was asked to consider the three types of approach below, all of which have been described in earlier sections.

- Discrete programmes for teaching general thinking skills (programmes separate from existing components of a curriculum).
- Programmes in which the main purpose is to improve students’ ability to think with specific subject knowledge.
- Programmes designed to incorporate thinking skills throughout the existing curriculum.

Very few interventions in the post-16 sector that took the form of discrete programmes (described above) met the criteria for inclusion described in Section 2. Those that did produced some evidence that the students became better able to deploy the thinking skills (eg exploring alternative lines of action) within the confines of the programme, but there was no evidence of transfer to other contexts. The criterion of transfer of learning is an appropriate one for judging such programmes, since their main purpose is to enable students to use the targeted thinking skills in their other course tasks or in other areas of their lives.

By far the largest percentage of the studies were classified as programmes in which the main purpose was to improve students’ ability to think with specific subject knowledge. In almost all reports of such interventions, the researchers presented sound evidence that learners became more competent at cognitively complex course tasks, often described as problems. Typically, students in science and engineering courses were better able to solve problems that required subject-specific knowledge; and in business administration courses, students were better able to handle tasks such as analysing information about advertising and marketing, and using their analysis in composing position papers. If such programmes are judged only on their declared purpose, the evidence produced suggests that they are successful, in that students perform better on a variety of cognitively complex course tasks within their subject area. It is argued in Section 5 that this application of knowledge to complex tasks represents a worthwhile achievement in itself.

In programmes that were designed to incorporate thinking skills throughout the existing curriculum, the claim was that the sets of processes taught were both useful and translatable across the curriculum in which they were exercised. The evidence presented for the ‘translatable’ claim was that the learners deployed these processes to good effect in different parts of a course. Thus, in the few studies of this type that met the criteria for inclusion in Appendix 2, there is evidence of application transfer and context transfer in the sense that the students used forms of thinking to complete tasks in different areas of their course (eg students practised thinking across a nursing studies curriculum).
What is not clear is whether the learners were able to transfer their thinking to contexts beyond their existing curricula. Plainly, one possible merit of this type of programme is that students are supervised across the curriculum in their practice of the targeted thinking skills; whereas in interventions that focus on just one aspect of the students’ course, supervised practice is limited to the targeted class meetings. More general evidence on the effects of practice implies that practice might improve proficiency. However, the data available is not sufficient to draw comparisons between the effectiveness of this type of programme and interventions that focus on one subject in a course, such as biology or thermodynamics. It is possible that students who participate in these subject-specific interventions do practise the forms of thinking they are learning in other classes. There is simply not enough evidence to confirm or refute this possibility.

All three types of programme described above included peer interaction activities, either alone or supported by ICT, as part of the approach to teaching thinking. The project team interpreted the findings from the studies cited in Sections 3–8 as constituting extensive and widely accepted evidence that well-designed peer interaction activities helped to promote students’ thinking within (but rarely beyond) the intervention. Although there was little evidence of transfer beyond the focus of the intervention, there was fairly sound evidence that peer interaction helped students to think more effectively about the curricula they were studying. This was also the case in programmes that were designed to incorporate thinking skills throughout the existing curriculum.

It is suggested that in considering areas where knowledge is limited or contested, further research is required to investigate the effects of variables relating to peer interaction that, typically, have been confounded in most studies. Commentaries by many writers (eg Salomon and Perkins 1998; Brophy 2002) note that the relationships between peer interaction and an increased ability to engage more fully in some aspects of thinking are complex. Brophy’s discussion of the ‘affordances and constraints’ of social constructivist teaching helps to raise awareness of the complexity of the role of peer interaction in learning.

Some successful interventions used interaction to promote metacognitive or self-regulatory competence. The idea that promoting metacognitive or self-regulatory competence is connected with worthwhile gains in performance is supported by a large body of literature noted in the previous sections. Thus, the use of peer interaction to improve metacognitive and self-regulation abilities is a promising area for development.

Recommendations

In the light of the research evidence that two types of programme were successful in producing educationally worthwhile gains in students’ ability to think about certain course tasks, it is recommended that future research should be designed to build on findings from these two types of programme, namely:

- programmes in which the main purpose is to improve students’ ability to think with specific subject knowledge
- programmes designed to incorporate thinking skills throughout the existing curriculum

and that recently established discrete programmes (eg the AS level Critical Thinking programme) should be evaluated rigorously to establish the extent of transfer from the programme to other contexts.

It is also recommended that, in the light of the overall evidence:

- peer interaction should be a component of the above types of programme
- the programme purposes should include the development of students’ metacognitive and self-regulation abilities.

It is recommended that future research should focus particularly on:

- further variables referred to above relating to peer interaction
- conditions required for successful implementation.

In relation to the last point, it was noted that a range of conditions seem to be central to the successful implementation of interventions (eg Zohar, Degani and Vaaknin 2001). Browne and Freeman (2000) suggest that no single condition will by itself encourage thinking. It is recommended that:

- further research is needed in order to understand how the variety of conditions reinforce one another and combine to result in the successful implementation of thinking interventions.

The conditions were grouped around key themes that included:

- teacher/ lecturer readiness
- student readiness
- learning environment and institutional support
- course design and content
- post-16 culture.
Some conditions are likely to be of more importance in different post-16 learning contexts. Course design and context, for example, might constrain teachers/lecturers less in informal learning contexts in the post-16 sector than in formal settings where learning outcomes and content are more tightly prescribed. Similarly, in some universities, such matters are more tightly prescribed than in others. Lecturers in some disciplines might be more aware of forms of thinking than in others, and possibly more ready to enculturate students into ways of thinking. There was evidence that the design of the TALESSI Project (Jones and Merritt 1999; see Section 3 and Appendix 2) was greatly influenced by the lecturers' sound epistemological understanding.

It is recommended that there should be a shift away from a curriculum context in formal post-16 learning settings that is too descriptive to allow scope for students to express their thinking. Reasons for this recommendation are summarised in the following paragraphs.

- Teacher/lecturer readiness possibly includes far greater understanding of theoretical perspectives that inform interventions than is promoted during initial teacher education. Given that almost all the interventions that emerged from searches had an instructional design that was consistent with constructivist accounts of learning, teachers/lecturers need opportunities to pursue their understanding of this perspective.

- Promoting teacher/lecturer readiness requires opportunities for them to identify their own position within constructivism. According to this perspective, such understanding might provoke changes in conceptions of learning and teaching that better support the use of subject matter to promote thinking (Shayer and Adey 2002).

- Encouraging student readiness probably also involves engaging students in activities that help them to clarify their understanding of what constructivism might mean in terms of their own learning.

The behavioural outcome model for designing the post-16 vocational curriculum has been dominant since the 1980s and FE lecturers, work-based trainers and learners have been accustomed to working with this approach. Many current lecturers and trainers have been trained specifically to deliver an outcomes-based curriculum and work with assessment instruments that focus on observable behaviours or product evidence. Thus there is an enculturation that has dominated further education for many years. It is possible that this accounts in part for findings that suggest that neither learners nor teachers/lecturers are clear about the purposes of interaction and ways of achieving such purposes. Arguably, enculturation into ideas about communities of enquiry is required if thinking is to develop.

There is little point in suggesting that teachers/lecturers and students would do well to change their conceptions of learning and teaching unless different conceptions can be supported by course design and content. An important conclusion from the project team's review of sample studies is that their successful implementation depends in large measure on certain features that are not present in curricula in the current VET system. Consequent difficulties for teachers/lecturers in VET in implementing ideas from sample studies were discussed in Section 8. In particular, the strong behaviourist epistemology that informs the design of curricula is at odds with the philosophical, cognitive, constructivist and social constructivist theoretical underpinning of thinking skills development. Bloomer (1998) discussed the influence of behaviourism in his study of the use of integrating projects and group work in FE courses, and his analysis suggests that while the words 'critical thinking' and 'analysis' are used, in fact much student activity was being expended on tasks that were often trivial, tightly prescribed, closely supervised and rarely involved critical enquiry.

Biggs (1996) points out that, if certain educational goals are to be reached, the whole system has to be 'aligned' (ie compatible) with those goals. Assessment systems, in particular, require attention if teachers/lecturers are to take seriously the development of students' thinking. Competence in thinking about tasks has to attract serious credit in assessment systems. Teachers/lecturers should avoid setting tasks which fail to challenge students' thinking: as Lonka and Ahola (1995) point out, to embed the practices described in earlier sections requires a radical shift away from prioritising transmission of content as a curriculum goal.

Although there is much talk of the importance of dispositions (eg Perkins, Jay and Tishman 1993), quite how dispositions consistent with thinking are to be developed is not clear in a post-16 context that does not value thinking. The analysis in Section 8 suggests that within certain strands of the post-16 vocational curriculum, highly prescriptive outcomes and assessment severely limit both freedom and opportunity to develop learning environments that allow the use of approaches that have been identified as effective in developing and assessing thinking.
Almost all of the studies reviewed in our report rest on constructivist accounts of learning that emphasise peer interaction. Perkins (1999) points out that constructivist learning experiences exert high cognitive demands and that not all learners respond to the challenge. Constructivist techniques also often take more time than do traditional educational practices. This requirement might conflict with expectations of employers about the pace of learning. Bloomer's (1998) study implies that the problem with activity methods was not time constraints, but lack of clarity about what they were intended to achieve. The forms of peer interaction he investigated in the FE sector seemed not to afford opportunities to practise thinking in any depth. There is sound evidence from an influential team of researchers (Resnick et al., 1993) which implies that peer interaction might be a powerful way by which adults learn to reason, but only when conditions exist as outlined in Section 8. There seems enough evidence to support the view that some forms of peer interaction should be at the heart of models for teaching in the post-16 sector, but that much more attention should be given to describing what such interaction is to promote.

Perkins’ (1999) analysis implies that educational activities derivable from constructivism make particular sense when the educational goals to be achieved include conceptually difficult knowledge that comes from a differently constructed social perspective. The goals in much of the post-16 sector are not of this nature. The question arises as to whether such goals should be more prevalent in post-16 education.

What is the evidence to support the view that a thinking skill in one subject or domain is transferable to another subject or domain?

Since few studies were designed to provide evidence of transfer from one subject or domain to another, there is too little evidence to provide a definite answer to this question. As noted earlier in this section, the rationale for discrete programmes is that they are designed for context transfer, but there is no convincing evidence that they achieve this purpose.

Recommendations are derivable from laboratory studies, from conceptual research, and from research on transfer within a domain about pedagogical conditions that are likely to facilitate transfer across domains. Recommendations about what sort of learning fosters transfer and how pedagogy might provoke transferability are set out in Section 5. It is important to emphasise that the pedagogical approaches entail many conditions, which are summarised in this section.

The following recommendations have been derived.

- Teachers should be helped to describe what type of transfer their teaching is intended to foster.

A brief definition of transfer can be derived from Haskell's (2001) discussion of transfer in the research literature. His discussion offers a reasonable starting point for teachers’ own descriptions. Thus, a brief definition of transfer of learning is that it occurs when a person uses past learning when learning something new and when past learning is applied to both similar and new situations. Brief descriptions of different types of transfer in Section 5 provide follow-up material for discussion.

- Ambitious claims that have no support in research literature should be avoided in statements of curricular intentions.

Curriculum developers should describe explicitly in curricula the supposed mechanisms by which intentions about transfer are expected to be achieved. It is suggested that the models set out in Section 5 could be used to encourage explicitness about assumptions as to how transfer is supposed to occur. The more useful models for the post-16 sector included:

- a neo-identical elements model
- a general principles model
- a metacognition model
- a cognitive information processing model (schema model).

It is possible to account for the application transfer in studies in Appendix 2 in terms of the above models of transfer.

It might be possible to extend the limited form of transfer demonstrated in some studies by attending to principles for teaching for transfer derivable from research literature (see Section 5).

In the few studies that offered any evidence of transfer from one domain to another, they were informed by a model that rested on assumptions that metacognitive/self-regulation processes help to effect transfer. This model seems to merit future research.

The notion of transfer of learning has been given expression in the VET system through the introduction of key skills (previously ‘core skills’ in England and Wales and still ‘core skills’ in Scotland). The assumption is that there are skills that are ‘core’ – ‘generic’ to both life and work and as such, ‘transferable’ and therefore worth developing. Controversies surrounding this assumption were outlined in Section 5. It is intended that key/core skills should be embedded across the curriculum and unit descriptors usually indicate where there is opportunity for developing key skills and gathering evidence if accreditation of the skills is required. Discrete units also exist for specific development and accreditation purposes. It is recommended that, if students’ thinking is to be developed through discrete units, such units should contain explicit statements about how the thinking is to be transferred to the range of learning contexts experienced by the students on their course.
It might be expected that there is potential for the development of thinking skills within the key/core skills framework, but no research into this phenomenon has been identified. Terms like ‘critical’ and ‘evaluate’ are used, but the approach is more identifiable with managerial approaches than with the literature on teaching thinking.

Which models of teaching thinking skills are appropriate for post-16 learners?

On the basis of the earlier discussion in this section, where the relative merits and disadvantages of different approaches to teaching thinking skills are summarised, the following conclusions can be reached about the appropriateness of different models for teaching thinking.

With respect to the three categories listed below...

- **discrete programmes for teaching general thinking skills (programmes separate from existing components of a curriculum)**
- **programmes in which the main purpose is to improve students’ ability to think with specific subject knowledge**
- **programmes designed to incorporate thinking skills throughout the existing curriculum**

...and in the context of formal learning settings (in the absence of much evidence concerning learning to think within work-based or informal settings), it would seem that the most appropriate models for post-16 learners involve improving students’ ability to think with specific subject knowledge. In the case of successful interventions, students are seen to perform better on a variety of cognitively complex course tasks within their subject area.

There is less evidence in support of models that involve incorporating thinking skills across the students’ curriculum because fewer studies involving post-16 learners have adopted this approach. Nevertheless, such models have the advantage of providing targeted practice and feedback of the thinking skill(s) in question across the curriculum, whereas in interventions that focus on just one aspect of the students’ course, supervised practice is limited to the targeted class meetings.

In order to generate more evidence on the efficacy of models that involve incorporating thinking skills across the curriculum, it is recommended that some future research and development should focus on models that incorporate thinking skills across the curriculum within a range of post-16 educational settings. Such work is already well documented within school settings (eg see Swartz and Parks 1994; McGuinness et al. 1996, 1997; Swartz 2001). However, within modular course designs, the range of possible contexts for infusing thinking skills could be extremely wide, and there would also be a need to coordinate the work of many subject specialist tutors and placement supervisors. How these particular challenges are met at the institutional level would form an important aspect of these investigations. The question as to how students can articulate a specific skill or strategy across a wide range of contexts is especially pertinent – does problem solving proceed in the same way within mathematics as it does within a writing assignment or when working out how to fix a piece of equipment?

Successful instructional strategies

In relation to successful instructional strategies, peer interaction activities, either alone or supported by ICT, formed an integral part of the approach to teaching thinking in the majority of the studies reviewed. Well-designed peer interaction activities helped to promote students’ thinking within (but rarely beyond) the intervention, helping students to think more effectively about the subject matters they were studying. Some successful interventions used interaction to promote metacognitive or self-regulatory competence.

A number of researchers have recently attempted to summarise the evidence from the research literature about teaching thinking. In relation to the question of how to teach thinking effectively, researchers mentioned in this report (eg Beyer 2001) focus on the processes of modelling, metacognitive reflection, coaching, fading and transfer. Important features of effective practice are identified as ‘scaffolded’ and cued instructional support and corrective feedback.

A study by Kirkwood (2000) used a successful combination of direct instruction, modelling, metacognitive reflection and ongoing assessment to infuse higher-order thinking and problem solving into content instruction for 14–16 year olds. This study differed from most of the other studies reviewed in one other significant aspect, since it involved students who were learning independently at their own pace with teacher and peer support, using computers and carefully designed, contextualised written materials. It is therefore recommended that some future research should focus on identifying successful models of developing thinking in situations where learning is self-paced, self-directed and individualised.
In addition to the instructional strategies identified by Beyer (2001), McGuinness (1999) highlights the importance of making thinking explicit in a curriculum, collaborative learning, creating dispositions and habits of good thinking, and generalising the framework beyond a narrow focus on skills (she refers to thinking curricula, thinking classrooms and thinking schools). She notes that the more successful approaches tend to have a strong theoretical underpinning, well-designed and contextualised materials, explicit pedagogy and good teacher support. McGuinness identifies nine core concepts in a framework for developing thinking, most of which have their roots in constructivism. In addition to the strategies listed above, she discusses the need to design learning tasks which are not routine, but have a degree of open-endedness and uncertainty, to permit learners to impose meaning or to make judgements or to produce multiple solutions (these facets are listed by Resnick 1987 in her working definition of higher-order thinking). She highlights the implications not only for students’ thinking, but also for teacher development and teacher thinking and the ethos of schools as learning communities.

Leat (1999) sets out some of the principles of thinking skills programmes (as identified by Baumfield et al. 1995) as a prelude to a discussion as to why thinking skills programmes face an uphill struggle to become embedded in the school curriculum.

- They change the learner – in general, they are constructivist in origin.
- They make students transfer their learning – they usually specify a stage at the end of activities where the teacher supports students to make links between what they have just learned and other contexts, a process known as bridging.
- They promote learning with others – programmes assume cooperative learning where ideas are shared and understanding develops through discussion. Vygotsky’s concept of the zone of proximal development (ZPD) is invoked – students are assisted in their performance by more able peers and adults.
- They encourage students to regulate their behaviour.
- They challenge the learner.
- They are carefully structured to employ measures to ease students into tasks and to establish personal meaning for the learners.
- They develop core concepts and skills such as concept formation, enquiry and reasoning skills, which better equip students to be independent learners.
- They make students think about thinking – not only are students asked for their answers, they are also asked to describe and explain how they have done the task, thus exposing their cognitive processes.

It is evident from these brief summaries that there is a high degree of commonality in the accounts of the research evidence presented by Beyer (2001), McGuinness (1999), and Baumfield et al. (1995; cited by Leat 1999) concerning the characteristics of successful thinking interventions. These characteristics may, however, have been shaped by school learning environments, since much of the research has taken place in schools. There is discussion of the conditions that are likely to be important in post-16 learning contexts earlier in this section. As has frequently been made clear by the research team elsewhere in this report, not all educational researchers or practitioners would agree with the above sets of propositions. Nevertheless, the above characteristics have all been highlighted frequently in the research reviews, reports and articles reviewed for this study.

Relatively unexplored territory

The review by Wilson (2000) on teaching thinking opens by discussing findings from various branches of science on the functioning of the brain. Clearly, new knowledge of how the brain functions will have implications in the future for teaching thinking, but at present, the implications are largely unexplored (Blakemore and Frith 2000). There were few references in any of the studies reviewed by the research team to teaching approaches informed by knowledge of how the brain functions.

An aspect that is not much discussed in the articles and reports featured in this review is the affective dimension of thinking. Those studies that focus on developing and assessing thinking dispositions or ‘habits of mind’ recognise that inclination and sensitivity must be nurtured as well as abilities (using the analysis in Perkins 2001). Since it is universally accepted that higher-order thinking is effortful, and it is also recognised that many learners have become disaffected with studying, therein lies a clear challenge. Another aspect that is often not discussed is how instructional strategies should be differentiated to address the learner’s individual needs.

This discussion on successful instructional strategies and the characteristics of successful models of teaching thinking leads to the following recommendations.

- There is a need for formally evaluated studies of thinking interventions to be conducted in informal and work-based learning settings. These studies should draw on some of the successful characteristics indicated above as the starting point for their instructional design.
- There is a need for thinking interventions to focus more on the links between the affective characteristics of learners, the instructional strategies adopted and educational outcomes of interest.
- There is a need for differentiated instructional strategies to be developed that take account of individual learner characteristics, such as differences in pace of learning.
Which methods of assessing thinking skills and of evaluating thinking skills interventions may be suited to post-16 learning contexts?

In the conclusion of Section 7, the following were identified as key characteristics of promising methods for assessing growth in student thinking within post-16 education (each is elaborated within Section 7):

- effective formative feedback
- the use of shared and public criteria
- students are supported to develop a metacognitive self-awareness of the thinking process
- assessments are more focused and in-depth
- assessments contribute meaningfully to teaching and instructional goals
- assessment opportunities provide meaningful and varied contexts to enable students to apply a range of thinking skills to substantive learning tasks
- teachers possess a range of expertise relevant to assessing growth in student thinking.

For illustrative purposes, there follows below a brief summary of successful assessment approaches within two university studies in which an evaluation was conducted.

- Silver and Perez (1998): students took field notes about their observations while on work placement and met regularly with tutors to explore substantive topics. They received written comments on their notes that encouraged them to question common-sense explanations for the behaviours they observed. Students constructed an argumentative paper that integrated their field data with three theoretical perspectives.

- Deese et al. (2000): demonstration assessments involved students in viewing a short chemistry demonstration, recording their observations and explaining what they observed. The study sought to determine if such assessments promoted critical thinking and deeper conceptual understanding of important chemistry principles. The use of a general rubric before each assessment was seen to prepare students to use a pattern of thinking to address the analysis of a situation and to draw appropriate inferences based on their understanding of chemistry concepts. The discussion of a task-specific rubric immediately following each assessment was seen to enable students to compare their answers with the model of expert thinking provided by the instructor, thus developing their understanding of how chemists think and enabling them to emulate these thought processes.

Across many of the reviews, studies and articles reviewed by the project team, one or more of the following situations pertained.

- The aspect of assessment was barely focused upon (perhaps because it has been assumed that self-reports by the participants, standardised tests or term examinations and standard assignments were ‘fit for purpose’ to assess thinking skills).
- Although the assessment method was soundly based upon established theories and principles and was clearly exemplified, the authors provided no evidence of evaluation.
- The assessment method had been evaluated successfully in schools rather than post-16 educational settings.

Also, a number of helpful articles and reviews (e.g., Black and Wiliam 1998; Pollard 2002; Marzano 2003) focused on using formative techniques to assess any aspects of students’ learning, which might or might not include the development of thinking.

These factors explain the use of the label ‘promising’ above, and lead to the following set of recommendations.

- Further evidence of evaluation of existing methods of assessing thinking for post-16 learners is needed.
- Those methods which have been evaluated successfully in schools should be appraised to determine their suitability for use with post-16 learners in specific learning contexts.
- The above key characteristics should inform the development of new methods of assessing thinking for post-16 learners across varied educational settings.
- Further development and evaluation of formative techniques to assess growth in student thinking should be conducted.
- The aspect of developing teacher expertise should be prioritised, since the teacher’s role is central to the design and successful implementation of classroom-based assessment techniques.

Section 7 also highlighted a range of deficiencies identified by other researchers in the design of evaluations of thinking skills interventions, as follows.

- Formal evaluation of programmes is rarely carried out, only a limited measure of effectiveness is used and there is no direct evidence that transfer has occurred (see Resnick 1987).
- Evaluations tend to be small-scale, involving disappointingly small numbers, and short-term, since there is insufficient time to follow up any group for long-term effects (see Nisbet and Davies 1990).
Problems identified by researchers were as follows:

- deciding what should be taken as firm evidence of success
- unpicking the effects of particular interventions from other effects (combining global evaluation with more detailed analysis was proposed to overcome this problem)
- distinguishing between the merits of the materials and the methods adopted in using them, and taking account of the quality of the teaching
- understanding the effects of particular interventions, since not everything may be known about the underlying learning mechanisms, which makes it difficult to determine in advance the essential components of a teaching approach
- getting beneath the surface to find out what is running through the learner's mind as he or she works on a problem or task
- in evaluation designs where there is reliance on end measures of attainment, or on pre- and post-test comparisons, designing tests which encompass all of the intended learning, and assessing those aspects which are difficult to test by conventional means
- scaling up and transferring the effects to everyday classrooms, since most of the research on the efficacy of teaching thinking has been conducted under optimal conditions.

These general deficiencies and problems are still much in evidence among the recent, empirical studies reviewed by the project team, with some notable exceptions (such as the four key studies discussed in Section 3). Some reports of interventions lacked a clear, explicit focus on the particular type(s) of thinking that the study was intended to develop in learners. Also, in some reports of interventions, the teaching and assessment materials and methods were barely touched upon.

In the light of the discussion on evaluation in Section 7, the following recommendations are made.

- A broadly conceived, well-constructed and well-documented evaluation is an essential component of any thinking skills intervention. Therefore, more training opportunities are needed for researchers and teaching teams to equip them with the necessary knowledge and skills.
- Examples of broadly conceived, well-constructed and well-documented evaluations should be disseminated to researchers and teachers.
- A guide to good practice in evaluation design for thinking skills interventions should be produced.

Is there evidence to suggest that approaches to teaching thinking skills used with pre-16 learners are applicable to post-16 learning contexts?

On the basis of earlier discussion in this report, the following conclusions can be reached.

In McGuinness's (1999) review of general programmes (classified in this review as discrete programmes for teaching general thinking skills), and with particular reference to the UK context, Cognitive Acceleration through Science Education (CASE) is highlighted as providing a very strong model for successful, context-dependent cognitive interventions: characterised by strong theoretical underpinning, well-designed and contextualised materials, explicit pedagogy including the use of bridging to promote transfer, teacher support and programme evaluation. Although CASE is designed for 11–14 year olds, the particular strengths of the programme highlighted by McGuinness could help to inform the design of thinking skills interventions for post-16 learners within any discipline.

McGuinness notes that domain-specific interventions (classified in this review as programmes in which the main purpose is to improve students' ability to think with specific subject knowledge) are particularly evident in the sciences and mathematics and, increasingly, in history and geography. De Corte (1990) has developed the concept of powerful learning environments. Such environments are characterised by a good balance between discovery learning and personal exploration on the one hand, and systematic guidance and instruction on the other. Teaching strategies include modelling, coaching and 'scaffolding', exploration in small groups, and encouraging students to articulate as clearly as possible the procedures they are using. These characteristics and instructional techniques could be translated to a range of post-16 learning settings, including work-based settings.

The discussion of infusion approaches (classified in this review as programmes designed to incorporate thinking skills throughout the existing curriculum) is introduced with reference to the work of Swartz, Parks and Perkins (Swartz and Parks 1994) in the US, which is underpinned by a taxonomy in which logical, critical and creative thinking skills are brought into relation with each other within a problem-solving and decision-making framework. The ACTS project (Activating Children's Thinking Skills) which McGuinness herself directed, adapted this cognitive framework, and began by analysing the Key stage 2 Northern Ireland curriculum to identify contexts for developing different kinds of thinking (McGuinness et al. 1996, 1997).
There is a particular method associated with the approach; for example, the use of thinking diagrams that help to make the steps in the thinking process explicit. Project teachers attended six training days and produced between them over 100 infusion lessons demonstrating 10 different thinking strategies. The evaluation focused on teachers’ impressions and opinions of the impact of ACTS on the students, and not on the learning outcomes, a limitation which McGuinness highlights in her review (1999). A key question to highlight for post-16 learners is whether the incorporation of thinking throughout the existing curriculum can be made to work within modular programmes that offer students a choice of modules to study. Not only is the task of mapping particular thinking skills across the different domains more complex, but also the learning experiences of the students are more variable: when attempting to bridge between one domain and another, which domains are common for all students? This suggests an individualised approach. The language in which this endeavour is couched in the post-16 context is also different - key skills, core skills, generic skills, etc.

The role of ICT in developing thinking is also discussed by McGuinness (1999). She highlights the use of exploratory environments or micro-worlds, multimedia technology, the potential for peer collaboration, and the idea of networking classrooms to create learning communities. However, she cautions that computers alone do not mediate thinking and learning – good software design, an appropriate pedagogy and good infrastructure are crucial. Also, many evaluations are from small-scale studies that were highly supported by research teams or teachers well attuned to the required pedagogy, and therefore transporting the effects to ordinary classrooms may require a new set of considerations. These issues are equally pertinent in post-16 learning environments.

The discussion paper by Wilson (2000), Can thinking skills be taught? has a different thrust from the McGuinness review (1999), but nevertheless ends up in similar territory. There are no new studies encompassed beyond those reviewed by McGuinness. The conclusions are broadly in line with those of McGuinness, although Wilson is more cautious about the evidence on the value of teaching thinking skills, preferring to say that ‘the jury is still out’ on this particular issue. In terms of future directions, Wilson highlights the following issues and questions.

- The need for more evidence of outcomes in order to weigh up whether the use of special programmes or infusion is more effective.
- Whether it will be possible to construct a curriculum with core thinking/problem-solving skills without overloading teachers.
- Which are the most appropriate stages for teachers to introduce metacognitive development?
- The potential of ICT to develop accelerated thinking.
- Is there sufficient availability of high-quality teaching/learning materials on core skills suited to the Scottish curriculum?
- What support do teachers need?

A similar set of issues can be considered in relation to post-16 formal educational settings across the UK. Of the recent empirical studies involving pre-16 learners which met the criteria for this review, all fall within the category of programmes in which the main purpose is to improve students’ ability to think with specific subject knowledge. The implications of these studies for post-16 learners are discussed briefly below.

- Reynolds and Brosnan (2000) report on an experiment conducted with young people of different ages (between 11 and 18) which has the unusual focus of examining the power of speculative thinking as an aid to developing understanding of chemical changes. The experiment may have some relevance to post-16 science teaching, and possibly to other fields in which it is helpful to speculate in order to understand more deeply (social subjects or literature, for example).
- Gerber, Cavallo and Marek (2001) report on a large-scale statistical study to investigate possible differences in school students’ scientific reasoning abilities relative to their informal learning environments (impoverished, enriched) and classroom science instruction (non-enquiry, enquiry). It was found that students with enriched informal learning environments scored significantly higher in tests than students with impoverished informal learning environments. However, it is not clear which aspects of the informal learning environment are most salient to developing scientific reasoning. Also, students taught by enquiry scored significantly higher than students taught by non-enquiry. The informal learning environment and the enquiry method of instruction are useful foci for research with post-16 learners.
A study by Zohar, Schwartz and Tamir (1998), which reports on an empirical investigation conducted in biology classrooms in junior high schools and senior high schools in Israel, addresses the nature and quantity of higher-order thinking activities in classes when teachers are not explicitly ‘teaching for thinking’, but rather are acting and behaving routinely. This study is discussed in Section 7. The study would appear to have considerable relevance for post-16 learners, across all areas of the curriculum, in terms of what it set out to do. For example, this study has identified that enquiry teaching is not taking place in biology classrooms in Israel. This establishes a baseline for improvement, and a rationale for focused curriculum interventions and continuing professional development (CPD) for teachers.

Foskett (2000) presents an argument for incorporating a thinking skills approach into geography fieldwork. This article is discussed in Section 7. It would appear to be very relevant to post-16 geography teaching; the framework and audit approach could be applied to any post-16 context. Of particular interest is the affective-cognitive interaction discussed in the article.

Kirkwood (2000) outlines the successful design, implementation and evaluation of an infusion pedagogy which combines direct teaching on problem-solving strategies, modelling of solution processes, ongoing formative assessment, and developing metacognition through processes of reflection, articulation and exploration. It uses a case study to provide an example of how these approaches can be interwoven within a problem-based learning methodology for teaching computer programming at an introductory level to 14–16 year olds over an 18-month period. A number of implications are drawn from the findings relating to: the lack of connectedness between subject disciplines; the complexity of the ideas contained in some curricula and the implications this has for students and curriculum planning; the importance of good relationships between teachers and students; and the need for teachers to attend to how their students actually tackle their learning and not merely to outcomes. The infusion pedagogy could be applied to other post-16 curricular areas, particularly any in which problem solving features strongly.

In relation to the assessment of thinking skills, a range of articles has been reviewed within Section 7 that discuss approaches to assessing thinking skills and relevant assessment issues in relation to school education. The implications for post-16 educational settings are drawn out in that section (see also the discussion in the previous sub-section here). In particular, it was noted that many of the systems, methods and tools for conducting classroom-based assessment of thinking in schools could be adapted for use with post-16 learners and then carefully evaluated. There is also the potential for cross-fertilisation of ideas on assessing thinking from post-16 to pre-16 settings, such as the use of case-based tests (in business education, for example) and demonstration assessments.

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

In which areas is knowledge limited, non-existent or highly contested, and what questions arise for further research?

Conclusions about the final two research questions are discussed together in this sub-section. In addition, recommendations for further research are included where appropriate.

Our searches suggest that extensive and widely accepted knowledge exists about the efficacy of designing instruction in accordance with general principles derivable from some versions of constructivism (eg see Salomon and Perkins 1998; Brophy 2002). However, little is known about how any specific aspect of peer interaction influences performance on particular tasks.

As noted above, almost all interventions reported included peer interaction. In drawing any conclusions about how peer interaction influences thinking, two grounds for exercising caution are discussed in Section 6 and suggest areas for further research.

Conceptions of thinking
The studies did not all work with similar meanings of thinking, and assumptions about the nature of thinking were rarely articulated. In particular, the relationship between domain knowledge and ‘translatable mental processes’ was rarely explicit. If students are to learn to think critically in school or post-school courses, several matters require urgent attention. If as Kuhn (1999) suggests, researchers have not yet enabled teachers and students to know precisely what is meant by the term ‘critical thinking’, it is very difficult for students to know how they might demonstrate such thinking in their coursework.

Methodological difficulties
Many studies involved confounds of key variables in the measures used to promote thinking, mainly because the studies were designed to find out whether, and to what extent, it was possible to enhance students’ thinking about their coursework through several measures, rather than to apportion the relative contributions of any one measure such as peer interaction, direct instruction about evidence evaluation or guided questions by tutors. Thus, in many interventions, the relative contribution of these measures remains uncertain.

Researchers who used peer interaction independent of direct instruction and questioning to some extent get round the difficulty of confounding the effects of those variables. Nevertheless, it can still be difficult to isolate the precise effect of peer interaction and fundamental objections remain that individual post-task reflection or implicit learning contributed to the student gains.
Another uncertainty arises from the fact that most interventions that met our criterion relating to relevance to teaching were not designed to compare peer interaction with individual student effort on thinking tasks.

Few provided an analysis of dialogue that enabled judgements to be made about its possible role in enhancing thinking. In most studies, correlations were not calculated between dialogue variables, such as students’ discussion of evidence, and the discussion of evidence in the students’ subsequent course tasks.

Section 6 considers what sort of information might be derived through fuller use of dialogue analysis and outlines other questions that could be addressed by using such analysis, including the effects of other variables.

The sample ICT studies suggest other difficulties in drawing firm conclusions. CTGV (1996) suggests that visions of technology look very different depending on the tacit or explicit theories of learning that guide their design and implementation. The group points out that changes in theories of learning affect how technology is used, but technology also makes new kinds of interactions possible and hence affects theories of learning.

- Changes in technology affect educational policy and vice versa. This is an area of research that requires further development in order to understand the interaction between learning theory, education practice and technology.

- To understand the role of technology in the development of thinking, it is necessary to consider the type of technology being used, how it is being used and the theory of learning underpinning its use.

Conclusions from the interventions that emerged from the searches are limited in several other ways.

The studies identified several major variables affecting multimedia learning, but additional work is needed to clarify the ways in which these variables might interact. For example, Mayer (1999) points out that multimedia effects may depend on individual differences in the learner.

The research was conducted in a laboratory setting and this enabled Mayer and his colleagues to control important sets of variables. However, the disadvantage of this is that many issues relevant to real classrooms, and to post-16 culture in particular, are not dealt with and this therefore limits the applicability of the findings to classroom settings. Further research is needed to understand the effects of technology on student learning and educational practice.

Uncertainties about the research questions arise from current limitations in theoretical perspectives informing studies.

Salomon and Perkins (1998) believe that progress in taking forward research in this area involves synergy between two conceptions of learning that are often treated independently of each other. First, there is a conception of individual learning, emphasising the acquisition of knowledge and cognitive skills as transferable commodities (eg Anderson, Reder and Simon 1996). Second, there is the socio-cultural conception of learning as a collective participatory process of active knowledge construction, emphasising context, interaction and situatedness (eg Cole and Engeström 1993).

The studies selected for our report support the conclusion that progress in research requires the sort of synergy described by Salomon and Perkins (1998). They suggest that such a synergy might lead to a culture change. They argue that such change requires a recognition by collectives that their learning should be directed towards: learning to learn from and with others; learning to draw the most from cultural artifacts other than books; learning to mediate others, not only for their sake, but for what that will teach oneself; and learning to contribute to the learning of the collective. According to Salomon and Perkins, conditions that seem to increase the chances of achieving these benefits include the provision by peers of informative feedback on each other’s thinking, of highly personalised and situationally contingent guidance and challenge, and the elicitation from each other of responses in the form of explanations, suggestions, reflections and considerations.

One difficulty in offering recommendations arises from the paucity of evidence as to how far learners develop their ability to think about whatever they are studying during participation in the current NVQ/FE or HE system. It is possible that, during participation in some areas of the curriculum, some students do learn to think more productively about their programme content. Evidence is similarly scant about how different workplace cultures and different jobs within workplaces influence ability to think about tasks.

However, research for the project does suggest that, if curricula are to serve as a vehicle for the development of students’ intellectual ability, course design must be informed by a well-researched taxonomy of thinking (eg see Moseley et al. 2003). Such a starting point is particularly important in planning ‘key skill’ work (eg see Bennett, Dunne and Carre 2000).

Implementation of many of the better ideas that emerged from the interventions reviewed for the project depends on a shared assumption that an important purpose of further and higher education is to enhance students’ intellectual development. Employability and citizenship seem to be well served by a capacity to arrive at reasoned judgements by weighing up evidence in the light of multiple and often conflicting criteria, and by a growing understanding that knowledge is neither entirely objective and certain, nor is it simply a matter of opinion.
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Appendix 1
Search terms

Databases searched
- ERIC (excluding Linguistics and Language Behaviour Abstracts, Social Services Abstracts and Sociological Abstracts) searching for titles and/or descriptors
- PsyclINFO (excluding Geobase and Sports Discuss) searching for titles and/or descriptors
- International ERIC (searching both the British Education Index and the Australian Education Index, using the general ‘search’ option).

All searches limited to 1998 onwards.

Combined search terms

1. thinking or cognition or cognitive or cognitive skills or thinking skills or thinking strategies or thinking dispositions or thinking frames or higher order thinking and
2. Critical thinking or logical thinking or strategic thinking or reasoning or argumentative reasoning or problem solving or informal logic or practical reasoning or everyday reasoning and post-16 or AS level or A level or further education or higher education or university or college or vocational education or workplace learning or work based learning or learning at work or informal education or lifelong learning

3. thinking or cognition or cognitive or cognitive skills or thinking skills or thinking strategies or thinking dispositions or thinking frames or higher order thinking and
5. peer interaction or collaborative learning or collaboration and post-16 or AS level or A level or further education or higher education or university or college or vocational education or workplace learning or work based learning or learning at work or informal education or lifelong learning

6. metacognition or metacognitive skills or metacognitive strategies or self-regulation or self-regulated learning or learning strategies or autonomous learning or independent learning or learning to learn and post-16 or AS level or A level or further education or higher education or university or college or vocational education or workplace learning or work based learning or learning at work or informal education or lifelong learning

10. core skills or key skills or basic skills or transferable skills and post-16 or AS level or A level or further education or higher education or university or college or vocational education or workplace learning or work based learning or learning at work or informal education or lifelong learning
positive thinking or motivation and pedagogy or teaching or teaching approach or infusion or infused and post-16 or AS level or A level or further education or higher education or university or college or vocational education or workplace learning or work based learning or learning at work or informal education or lifelong learning

ICT or computers or technology and post-16 or AS level or A level or further education or higher education or university or college or vocational education or workplace learning or work based learning or learning at work or informal education or lifelong learning

core skills or key skills or basic skills or transferable skills and pedagogy or teaching or teaching approach or infusion or infused and post-16 or AS level or A level or further education or higher education or university or college or vocational education or workplace learning or work based learning or learning at work or informal education or lifelong learning

transfer or generalization or generalizing or generalisation or generalising and pedagogy or teaching or teaching approach or infusion or infused and post-16 or AS level or A level or further education or higher education or university or college or vocational education or workplace learning or work based learning or learning at work or informal education or lifelong learning

review or meta-analysis and post-16 or AS level or A level or further education or higher education or university or college or vocational education or workplace learning or work based learning or learning at work or informal education or lifelong learning.
ERIC only

15 pedagogy or teaching or teaching approach or infusion or infused
and
16 assessment or evaluation
and
post-16 or AS level or A level or further education
or higher education or university or college or vocational
education or workplace learning or work based
learning or learning at work or informal education
or lifelong learning
and
1 thinking or cognition or cognitive or cognitive skills
or thinking skills or thinking strategies or thinking
dispositions or thinking frames or higher order thinking

15 pedagogy or teaching or teaching approach or infusion
or infused
and
16 assessment or evaluation
and
post-16 or AS level or A level or further education
or higher education or university or college or vocational
education or workplace learning or work based
learning or learning at work or informal education
or lifelong learning
and
2 critical thinking or logical thinking or strategic
thinking or reasoning or argumentative reasoning
or problem solving or informal logic or practical
reasoning or everyday reasoning

15 pedagogy or teaching or teaching approach or infusion
or infused
and
16 assessment or evaluation
and
post-16 or AS level or A level or further education
or higher education or university or college or vocational
education or workplace learning or work based
learning or learning at work or informal education
or lifelong learning
and
3 creative thinking or creativity or lateral thinking

15 pedagogy or teaching or teaching approach or infusion
or infused
and
16 assessment or evaluation
and
post-16 or AS level or A level or further education
or higher education or university or college or vocational
education or workplace learning or work based
learning or learning at work or informal education
or lifelong learning
and
4 positive thinking or motivation
1 Review of literature post-16

2 Studies in the post-school sector from 1992:
   2.1 Discrete programmes for teaching general thinking skills (programmes separate from existing components of a curriculum)
   2.2 Programmes in which the main purpose is to improve students’ ability to think with specific subject knowledge
   2.3 Programmes designed to incorporate thinking skills throughout an existing curriculum

3 Studies whose purpose is to identify features of curricula and teaching associated with development of thinking in one or more than one domain

4 Research whose purpose is to examine and synthesise knowledge relevant to pedagogy for teaching thinking

5 Studies describing teachers’ thinking skills or conceptions relevant to teaching thinking skills

6 Studies of transfer of thinking skills from one domain to another

7 Reviews and studies of learning to think conducted in upper primary and secondary education:
   7.1 Reviews of literature
   7.2 Discrete programmes for teaching general thinking skills (programmes separate from existing components of a curriculum)
   7.3 Programmes in which the main purpose is to improve students’ ability to think with specific subject knowledge

Appendix 2
Selection of reviews and studies analysed
1 Review of literature post-16


This review is one of studies informed by theoretical frameworks about critical thinking/argumentative reasoning. The authors note that there is some consensus in the literature around the idea that people are thinking critically when they understand how evidence relevant to claims might be evaluated, and when they can construct arguments for preferred positions and practices, envisage counter-arguments others might offer and can consider how such opposition might be rebutted (Perkins, Allen and Hafner 1983; Kuhn 1991; Bensley 1998). In some parts of the critical thinking literature, these competencies are referred to as argumentative reasoning.

Anderson and Soden use the terms 'argumentative reasoning' and 'critical thinking' more or less synonymously in their review of over 100 studies, which were selected against pre-determined criteria, of helping students (pre-16 in many studies) to engage in such reasoning. Criteria for inclusion included the requirement that the studies were theoretically informed, and that they were evaluated. The review includes studies from Israel, the UK and the US. In the studies reviewed, the aims were to explore the role of peer interaction in enhancing aspects of students' argumentative reasoning – mainly students' ability to mount reasoned, justified arguments, and to detect weaknesses in justification.

The types of study reviewed have been classified as follows, although a few studies fall outside these categories:

- experimental investigations that seek to examine specific questions such as the effect of some aspect of peer interaction on a particular aspect of reasoning
- longer-term interventions that aim to effect enduring change in the learners’ thinking
- discrete programmes for teaching general thinking skills

However, in all three categories it was rare to find attempts to enhance students' thinking skills that did not use content that was related to curricula. For example, when an experimental study was carried out during the social studies class time, argumentative reasoning was practised on topics such as capital punishment and 'green' issues.

Anderson and Soden conclude that, taken together, the studies imply that argumentative reasoning, as defined in these studies, can be improved through peer interaction that is structured in certain ways. Nevertheless, the studies raise a number of research questions that need to be resolved before a more precise estimate of the value of peer interaction can be made.

Some of the studies involved confounds of key variables, such as teacher modelling and peer interaction, making it difficult to apportion the relative contributions of each, and difficult to isolate the effect of peer interaction. The duration of the interventions varied, as well as spacing between sessions and the length of each session. It is therefore possible that all these variables, as well as some kind of individual post-task implicit learning (see eg Berry and Dienes 1993) could have influenced results.

Further exploration is required on:

- the design and sequencing of peer interaction activities themselves
- the relation of the peer interaction exercises to other classroom activities.


The authors described evidence from Australia, the UK and the US on what might be done to help students in post-school education to think well, and considered implications for practice. The theoretical framework informing the studies reviewed was critical thinking/argumentative reasoning (see paragraph 1 in Anderson and Soden review at 1.1).

The main aim of the review was to explore teaching approaches that seem to inhibit or enhance students’ ability to think well.

The review includes extended consideration of Sternberg’s (1987) research from which he argued that there are more ways to fail than to succeed in teaching critical thinking; and that eight teacher ‘fallacies’ contribute very significantly to obstructing the learning of ‘generic critical thinking’. Among the more interesting of the fallacies cited is the idea that there is a ‘correct programme’ for the delivery of critical thinking, regardless of course goals or the culture in which the learners’ thinking is to be situated, and the idea that discussion is a means to an end. According to Sternberg, critical thinking is an end in itself, and a combination of approaches from a wide range is likely to be productive.
The authors concluded that curricula would need to be redesigned to reflect the importance of learning to think critically, with appropriate time allowed for activities designed to help students develop forms of meta-knowing, including epistemological understanding. In other words, researchers would need to be allowed to help define educational objectives rather than merely advising on how to implement objectives determined by others.

1.3
A review of research on critical thinking.

The aims of the study reported in this paper were to review the research on factors that affected the development of critical thinking among college students in the US. In total, 62 studies were identified and reviewed. Sixty-two per cent of the studies were longitudinal in nature, and 13 of the 23 studies that attempted to measure student growth in critical thinking employed a cross-sectional design.

While a large proportion of the findings suggested that students grow in critical thinking while in college, much inconsistency emerged as to the factors that affected this growth. Given that the studies reviewed tended to be homogeneous to the extent that they posed broadly similar research questions and deployed similar research tools, a surprising amount of inconsistency emerged from the study results. A number of studies suggested that college students make the greatest gains in critical thinking during their first year, while courses or programmes specifically designed to improve critical thinking have demonstrated mixed results.

In comparison to courses taught in a more traditional manner, greater gains in critical thinking scores were found for courses with an instructional paradigm emphasising problem solving or critical thinking.

2 Studies in the post-school sector from 1992

2.1 Discrete programmes for teaching general thinking skills (programmes separate from existing components of a curriculum)

McGuinness (1999) points out that such programmes are derivable from mainstream cognitive psychological research, which has suggested that thinking is driven by a general central processor which is used in all tasks. Therefore, it is argued that if students’ general central processing capacities can be enhanced, their thinking in all domains will improve.

In discussing programmes for teaching general thinking skills, which derive their theoretical support from this view of the nature of thinking, McGuinness distinguishes between two kinds of programme. What both types have in common is that they target sets of thinking skills that are deemed to be general, and therefore applicable in any domain. Examples of these so-called general skills include comparing and contrasting things or ideas, and thinking about the relative advantages of different courses of action, taking into account matters such as consequences of actions. What is different about the two variants in this category is the type of content on which these allegedly general thinking skills are practised.

In the discrete type of programme, students often practise the targeted general thinking skills on generally familiar content (eg responses to traffic congestion, buying a car or some consumer issue). Searches revealed only two studies in the post-school sector which could be classified as being of this type and which met criteria for inclusion. In both cases, the activities were not unlike typical classroom work in the subjects that the students were studying. In current research, discrete programmes like the ones described below (2.1.1–2.1.3) are used as pilot studies to identify key variables because the method offers most potential for controlling key variables; follow-up studies often aim at infusing the skills in the earlier study into some of the normal curricula. Programmes which are pure examples of this type are unlikely to attract the institutional support required for their implementation, not only because they do not have sound research support (eg see Kuhn 1999), especially with regard to transfer to the content of the student’s course, but also because neither students nor lecturers are likely to tolerate spending time on activities which have little obvious connection with their course.

In the other type of programme, which also aims at improving general thinking skills, students practise targeted skills within a curricular area, where they are guided towards using the thinking opportunities provided by that domain. For example, catering students might practise general thinking skills on menu planning, construction trade students might practise such skills on differentiating and selecting suitable materials for a task, and science students might practise generating and testing a hypothesis. In the research specification for this report, such interventions are described as programmes designed to teach thinking skills in the context of a specific subject or domain. Therefore, examples of such studies appear in Sub-section 2.2 of this appendix.
2.1.1

The authors’ research with US community college students – reviewed by Anderson and Soden (2002) - was informed by theoretical frameworks about critical thinking/argumentative reasoning (see paragraph 1 in the Anderson and Soden review at 1.1). The aims of this study were to explore the impact of repeated engagement in peer discussion on a topic (in this case, capital punishment) on argumentative reasoning about that topic. The skills were practised on content that is typical in college curricula, such as social studies and communication. However, the study points up the difficulty of classifying interventions into ‘discrete’ and ‘specific subject or domain’ categories, since it could be argued that the skills are specific to social studies and other similar subjects.

In the main study, the participants each interacted with different partners across five sessions spaced at weekly intervals, thus exposing each individual to the views of several other individuals. Participants were instructed to reach agreement within each session and, if they could not reach agreement, to try to identify where they differed.

Evaluation was based on rigorous analysis of appropriate data. Participants were asked, in tests held before and after the intervention, to set out in writing ‘a brief argument that explains, justifies and supports your view about capital punishment’ (1997, 290).

The post-test results indicated that students were giving more two-sided arguments, more comparative arguments, and showing greater awareness of the co-existence of multiple views following the intervention.

Kuhn, Shaw and Felton did not undertake any test of generalisation of the improvement shown in the main study. Neither was the degree of durability of the improvement tested.

The reasoning skills seem to be generalisable to many areas of the curriculum, to the workplace and to being an active citizen.

2.1.2

Located in theoretical frameworks about critical thinking/argumentative reasoning (see paragraph 1 in Anderson and Soden review at 1.1), this was a small-scale study, evaluated by pre-test/post-test analysis of students’ arguments, and intended to improve evidence handling, a central aspect of critical thinking, in Scottish psychology undergraduates. It can be classified as a discrete one-off ‘treatment’ that resembled task-based tutorials in psychology.

During the peer interaction task, students used a workbook which presented items of evidence of different types (anecdotes, generalised claims and research evidence) supplied as justifications within arguments on the same topics used at the pre- and post-test stages. The workbook also ‘scaffolded’ them through a discussion of the strengths and weaknesses of the items of evidence supplied, by asking them to choose, weigh up and rate each item.

Although the short programme was separate from the undergraduates’ curriculum, they practised thinking about psychological knowledge during the peer interaction task. Overall, the undergraduates’ use of evidence did not improve as a function of this brief peer-interaction intervention.

The researchers chose a discrete, one-off intervention for several reasons. First, it offered an opportunity to test the effects of a small combination of variables. Second, since the authors’ experience of teaching undergraduates suggested that it is difficult to persuade students to cooperate with an infusion approach, it is important to know what sort of return can be obtained from brief interventions which replace one or two tutorial periods. A similar short intervention by Perkins, Allen and Hafner (1983) with US high-school students had produced impressive gains, as did Feuerstein’s (1980) Instrumental Enrichment programme, which involved students in separate, workbook-based sessions.

Here, however, the impressive gains in reasoning that Perkins, Allen and Hafner (1983) reported from a short intervention were not replicated. This study seems to add support to the body of research that suggests that short interventions that are not integrated with normal class work are of little value. It seems likely that these undergraduates would have benefited from the sort of infusion approach that is described by McGuinness (1999) and for which support materials for psychology undergraduates have been published (eg see Bensley 1998).

This paper discusses the ways in which critical thinking skills were introduced to students entering higher education via a 'non-standard' entry route, namely an Access course at the University of Luton. Access provision refers to courses provided for students who have previously been excluded from studying at an HE level because they have not achieved the 'standard' entry requirements. The author points out that entry to higher education creates difficulties for these students, who find themselves in unfamiliar learning environments; and for the lecturing staff, who have to cope with students from non-academic backgrounds. Guest suggests that this group of 'non-standard' entry students does not have the necessary critical thinking skills required for higher education or that the students lack confidence in using them.

The approach used at the University of Luton has been to target some of the basic 'study skills', described in the paper as summarising, essay writing, report writing, presentations, revision and examination technique. Guest points out that this list is not exhaustive, but it does aim to cover basic competencies while promoting enquiry and research. He argues that critical analysis and critical thinking are implicit in much of this type of work. His thesis is that thinking skills are developed through practice in reading, listening and analysing as a group – especially when the teacher is part of the process leading to interactive discussion and evaluation.

The aim of the Luton programme was to 'kick-start' the Access students by introducing them to critical thinking skills right at the start of their course. The paper argues that critical thinking can be isolated and developed separately. Guest's premise is that a skills approach could allow 'non-standard' entry students to compete successfully with their peers. The programme at Luton was influenced by methods proposed by Swartz and Parks (1994) and by Fisher (1996).

A Post-Access Critical Thinking (PACT) programme was introduced with the 1994/5 cohort of students. At the start of their course, the students sat a version of the MENO Critical Thinking Assessment (UCLES 1995). The students were invited to evaluate and produce further arguments in response to a passage of approximately 750 words. Marks were awarded for both the amount of evaluation/number of further arguments and the quality of the students' reasoning. The assessment showed that Access students' scores were very low. Some produced no evaluation and few produced any further arguments. The students were then asked to repeat the exercise orally in groups. Guest explains that with no requirement to write answers, the students gained in confidence and were able to 'feed off' each other and provide some good critical evaluation and further arguments. The success of the oral session led to the students being given the opportunity to participate in a debate (on a topic of their own choosing). However, they were restricted by a series of rigorously enforced rules which limited what could be said by whom, forcing the students to research and prepare arguments. A tutor acted as a facilitator, providing help, advice and encouragement.

The results of four students participating in the PACT programme were compared against those of four other post-Access students who did not participate in the programme and against the class average as a whole for five modules. The trend in each of the modules was towards higher-than-average marks for the PACT group and an average, or just below average, mark for the control group. The PACT group also scored better than the average for the class as a whole. According to Guest, the PACT students demonstrated that they were able to use critical analysis in processing information and present reasoned arguments in their academic work. As the author himself points out, the results from such a small sample could not be used to claim that the critical thinking programme alone accounts for the different levels of performance between the PACT group and the control group. It was not clear from the abstract of this study that its findings were based on such a small sample. Further research with a larger sample is required. Nevertheless, the programme does highlight the importance of considering the needs of learners from different backgrounds and exploring new and innovative methods of developing thinking skills.
The University of Luton has continued to experiment with different methods of teaching thinking skills. Following on from the separate thinking skills programme for post-Access students, two programmes have attempted to integrate thinking skills within the curriculum. These programmes were tried with students on a Level 1 Law course and with second-year students in a Supplemental Instruction (SI) module in the same university. The first approach (based on principles used in the post-Access course) was aimed at integrating thinking skills within a law module and involved individuals and groups of students in taking on a specific responsibility such as researching information, designing questionnaires or planning a presentation to a (student) ‘board of directors’. The other approach had been piloted at the University of Missouri – Kansas City (UMKC), and was called a Supplemental Instruction module. For clarity, this is referred to below as the UMKC-style SI approach. Using the UMKC-style SI approach, the second-year students were taught to run sessions for first-year students in which the second-year student ‘leaders’ facilitated the first-year students’ insights into learning.

Results for the Luton group who participated in the UMKC-style SI approach were compared with statistics collated by the University of Missouri – Kansas City (UMKC) from 1980 to 1992. The UMKC results show that consistently higher percentages of students who participated in this approach at UMKC achieved A and B grades, and lower percentages scored D and F grades than UMKC students who did not participate in the SI approach. While data analysis is continuing at Luton, the trend there is towards similar results.

This paper contains many sound, imaginative ideas for working with the typical entrant to FE colleges. Although the activities used are consistent with research on teaching thinking, and there are some references to theoretical and empirical research, the focus is on designing, implementing and evaluating student activities to enhance critical thinking.

2.2 Programmes in which the main purpose is to improve students’ ability to think with specific subject knowledge

As noted in Sub-section 2.1, McGuinness (1999) distinguishes a type of programme in which students practise general thinking skills within a curricular area, where they are guided towards using the thinking opportunities provided by that domain. McGuinness also refers to other types of intervention which are based on the view, arising from evidence from expert and novice research, that good thinking in any domain is driven by well-connected concept structures which are inextricably linked with knowledge of ways of thinking and methods of enquiry in that domain (see also Bonnett 1995). As McGuinness points out, when experts are asked to reason outside their domain, and do not have the benefits of such cognitive structures, their reasoning performance often deteriorates.

Most of the studies reviewed below were designed to incorporate thinking skills that have wide applicability, rather than domain-specific thinking skills. One difficulty in trying to classify studies is that thinking about specific subject matter often involves cognitive operations that have some characteristics of so-called general thinking skills, such as being applicable in many subjects. For example, learning to think in an accounting class involves learning to use classification systems (e.g. sorting financial data into assets and liabilities, capital and revenue expenditure), as does learning to think in biology and in many other domains. Evidence handling can be regarded as domain-specific in a Master of Research model, but the cognitive operations involved plainly have much wider application.

McGuinness (1999) describes courses known as infusion programmes (see Sub-section 2.3) as a middle way which acknowledges the contribution to good thinking made by both discipline-specific methods of enquiry and more general cognitive skills. An infusion method requires that contexts are first identified within the curriculum where particular thinking skills can be developed (e.g. causal reasoning, classification). Then lessons are developed where thinking skills and conceptual understanding are explicitly and simultaneously pursued.

The method in the studies reviewed for this sub-section (2.2) could also be described as a limited form of infusion, since the skill development activities go on throughout a module/unit, although not throughout the students’ entire curriculum, and the skills are potentially transferable to a wide range of tasks. The study reported in 2.2.9 comes nearest to an infusion approach. The exceptions are 2.2.5 and 2.2.6 which target domain-specific skills, but even there it is not difficult to see that there could be outlets for using these skills beyond the domain in which they were learned.

In many of the studies included in this sub-section, the notion of transferability of thinking skills to other domains is implicit. However, there is seldom any attempt to measure the transferability of thinking skills to other domains.

The research seems to have been driven by a pragmatic goal of accelerating students’ progress towards thinking like more expert people in the domain (e.g. ‘scientific thinking’). Rarely is there explicit commitment to a view of the nature of thinking. Thus, there is little mention of the researchers’ views about the extent to which thinking and knowledge are connected, or about the extent to which certain aspects of thinking are independent of content. Typically, there was no specific provision for promoting transfer outside the domain, nor were reasons provided for omitting such provision.
The evidence often is that the participants were better able to complete cognitively complex tasks that were included in learning outcomes for the course within which the intervention took place. Examples of such tasks are solving mathematical, technological and business-type problems, engaging in literary criticism or reading with comprehension.

Whether students could be taught to use the targeted aspect of thinking in these studies (e.g., metacognitive awareness, asking critical questions) in other contexts depends on the extent to which one believes that thinking is context-dependent. For example, some researchers would argue that students who learn to use certain thinking processes in the context of a business administration course might have to learn to use quite different processes when they are studying psychology, because there are quite substantial differences in these two disciplines that lead to differences in ways of thinking with the knowledge. That is not to say that learners who have become aware of their thinking processes will not find it easier to extend their thinking processes, but simply that it might be unsafe to suppose that there is a general set of thinking processes that fit all tasks.

2.2.1
Peer interaction and the learning of critical thinking skills in further education students. Instructional Science, 1, 1–32.

This experimental study with students in Scottish FE colleges was informed by Kuhn’s (1991) notion of critical thinking and by Piaget’s theory that socio-cognitive conflict is a spur to individual cognitive change (termed equilibration, i.e., the reconciliation of conflict between pre-existing and newly experienced beliefs). This study had elements of infusion because the development of critical thinking skills was closely integrated into the students’ work on the ‘additional assessment’ project, a 3000–4000-word report which was required to achieve accreditation in the Scottish Vocational Qualification (SVQ) in Social Care or Health Care at Level 3. The justification and evidence-handling skills introduced were not specific to the social care domain. This project requires students to integrate content from all the modules in their curriculum. However, it was not a full-blown infusion since the thinking skills were infused only during the one day per week when the project work was being done.

Over a period of 3 months, the authors implemented a 10-session teaching intervention with 84 students. The evaluation was based on videos of student interaction and on their written work for accreditation, and a test for ‘far transfer’. The intervention used strategies which, according to many writers (e.g., Butler 1998), have been associated with the development of critical thinking, positive motivation and independent learning. These strategies included modelling thinking about the nature of evidence-based justification, engaging students in ‘talking about’ their thinking, critiquing each other’s drafts of project outlines and plans in terms of their use of justification.

The students’ subsequent written projects were content-analysed in terms of their use of justification, and the results showed that participants engaged in justification of their arguments to a significantly greater degree than did a control group. Analysis of the students’ dialogues with each other indicated that the numbers of unjustified statements declined significantly as the intervention proceeded, and justification with anecdote rose significantly over time, suggesting that the intervention had had a positive (but weak) impact upon the students’ use of justification. There were significant positive correlations between some of the dialogue variables (particularly ‘justifies with anecdote’) and levels of justification in the written work, suggesting that the dialogues had made an impact on the written work.

A psychometric test of general critical thinking skills – the Smith and Whetton Critical Reasoning Test (1992) – showed no evidence of transfer of learning relative to a no-intervention control group. However, the content of this test was somewhat removed from the content of the intervention, and as such it constituted a test of ‘far transfer’. The negative result here is therefore relatively unsurprising, given other negative findings on transfer in the research literature (see, e.g., Detterman and Sternberg 1993). Unfortunately, resource constraints precluded tests of ‘near transfer’. However, the study did demonstrate a long-term retention effect, in that materials written several months after the intervention had ceased nevertheless included features that had been stressed during the intervention. One interpretation of the results is that the effects were weaker than they might have been had there been sufficient time in the students’ curriculum to achieve a deep enough understanding of the knowledge they were expected to think about. The authors’ experience was that arrangements to infuse similar aspects of critical thinking across the curriculum would have required institutional support that was not forthcoming at the time of their study.
The paper reports on the authors' experience of trying out an approach to developing critical thinking which involves enquiring into the potential inconsistencies within apparently common sets of conceptions relating to the nature of learning and its institutional context in higher education. They worked with students on a Master of Research (MRes) degree course, where skills to be developed included teamwork, leadership, communication, initiative, flexibility, creativity, project formulation and management, organisational awareness, presentation and self-development.

Rather than approaching skill development as a process of attaining relevant behavioural competencies, they sought to provoke critical analysis of often unexamined assumptions underlying the practices in which students have become enculturated by the time they become graduates. For example, Socratic dialogue was used in exploring questions such as 'What is the nature of knowledge, learning, research, evidence, etc?' and 'What does it mean to be a lifelong learner?'

Suitably tentative conclusions that students developed self-awareness of their skills and of how they learn are drawn from surveying transcripts from focus group and interview sessions. The authors conclude that this increased self-awareness seems to have led to the development of a more thoughtful, enquiring and open-minded approach, in both professional and personal life.

The article includes a helpful, suitably critical exploration of the nature of thinking. It points out that assessment traditions provide not only an inhibiting factor, but a more active driving force towards kinds of learning which are more readily assessed using clearly defined objective criteria.
Quicke's contribution is a significant one. He suggests that the notion of learning to learn is too narrowly conceived in the key skills; instead, learning to learn needs to be more broadly defined in social psychological, sociological and philosophical terms if it is to take account of all those forces in the environment which facilitate or impede learning. He argues for a 'learning curriculum' based on this broader definition of learning. He supports his position by referring to his own research (Quicke and Winter 1994). Rigorous research of this quality, published in a prestigious journal, deserves to be much more influential in shaping key skills strategy.

Duckett's response (2000) to Quicke concedes that Quicke's argument is valid.

2.2.5

Soden and Pithers discuss the results of a 10-week UK-based intervention designed to enhance domain-specific thinking skills. The participants were 10 FE lecturers and 80 students, who were enrolled on an introductory accounting module (49 students in the experimental group and 31 in the control group). Drawing on cognitive research in knowledge-rich domains which suggests that productive thinking is enhanced by deep understanding of central ideas in a domain, and on McGuinness's (1993) discussion of teaching thinking, the intervention targeted both conceptual understanding and thinking skills specific to accounting. There was no test of transfer to other domains.

The intervention was evaluated by:

- comparing the performance of students in the experimental and control groups on accounting problems of a type they had not encountered before, but which could be solved by extrapolation from the accounting principles they were learning
- asking students to write an explanation for another student of how they might think their way through a given accounting problem.

The students in the experimental group had significantly higher scores on the accounting problems, but the effects were not as strong as those reported in some European studies. None of the students managed to give more than a limited account of the thinking involved in solving the given problem.

The results are interpreted as implying that effective development of thinking skills through vocational education depends on changes in the conceptions of lecturers and other stakeholders as to the purpose of vocational education. Such cultural change seems to be important if lecturers are to move from teaching routine procedures to using their subject as a vehicle for developing a thinking workforce.

2.2.6

Drawing mainly on De Bono's (1967) construct of lateral thinking, the author used problems presented in case study format to enhance HE students' ability to deal with ill-structured problems. The problems required application of specialist engineering as well as other knowledge. While the case studies reviewed are useful enough, the paper is of limited use because discussion is not adequately located within frameworks about teaching thinking.

2.2.7

The 16 participants in this case study were social care students in an FE college. Drawing on some of the literature from the thinking skills movement, the author sought to understand processes involved in developing critical thinking skills which are broadly generalisable to most learning. Methods in common use for engaging students in thinking critically about content (eg questioning assumptions, probing responses, group work) were used over nine meetings in a classroom environment from which features deemed to be oppressive had been removed. What is interesting in this study is not the methods used to develop thinking, but the sociologically informed discussion of the potentially oppressive nature of a classroom environment, ways in which lecturers affect that environment, and the author's view that power relationships in classrooms might well negate pedagogies designed to develop thinking.

A fundamental assumption in the study is that critical thinking skills are not best achieved in oppressive environments and that lecturers often are insufficiently aware of the potential for oppression.

The author reached conclusions that the non-oppressive environment was helpful in developing thinking by reading participants' assignments, reading notes of interviews with nine students and notes of observing participants' classroom activities. The written data was read to extract themes, but not content-analysed.
This paper reports on the efficacy of a module designed to develop 31 students’ critical thinking skills in the context of peer evaluation in a year-long second-year supervisory management unit. The module comprised: a lecture in which a ‘taxonomy of the major cognitive operations’ (Beyer 1987, cited by MacPherson 1999) was presented; modelling of critical thinking in relation to a research article; practice in a series of seminars at which students presented literature reviews and were graded by peers on criteria which captured some aspects of critical thinking.

The definition used of critical thinking is similar to those commonly used in research in this area, but the study is located not in literature on teaching critical thinking (although the learning activities are fairly consistent with those advocated in that literature), but in the peer assessment literature. Of the five research questions, four concern peer assessment and the fifth asks whether critical thinking instruction improves analysis and evaluation.

Statistical analysis of data led to the conclusion that the participants achieved higher average grades on a similar literature-reviewing assignment of 2000 words than students in the previous year who had had no such training. There was a 50% drop in the number of fail grades as compared with the previous year; and 10% of the participants in the critical thinking module gained a distinction, whereas no students had achieved a distinction in the previous year. The author is suitably careful about drawing conclusions from her small sample.

An interesting observation is that it is possible to design quite effective interventions without an in-depth knowledge of the literature on teaching critical thinking. In this case, the author drew on her own knowledge of what it means to be critical in reviewing literature to develop criteria that students could use to notice its presence or absence; and then used a sensible modelling-plus-practice approach to teach students to notice when critical thinking was being demonstrated. Perhaps teachers’ knowledge of what it means to think critically about a particular matter is as important as knowledge of teaching approaches.

The theoretical frameworks which informed the study included research on metacognition (e.g. McGuinness 1993) and Soviet Activity Theory – in particular, Gal’perin’s learning-psychological theory which attempts to translate some aspects of Vygotskian socio-cultural theory into educational practice (for an account of this framework, see Haenen 2001). Thus, the lecturers created opportunities for students to ‘talk about thinking’ and there was considerable emphasis on encouraging students, through modelling and ‘scaffolding’ (Wood and Wood 1996), to generate questions that could form a strategy for tackling vocational tasks.

The research was evaluated by comparing the performance of students in the experimental and control groups on their written descriptions of thinking strategies to reach solutions for problems – devised by expert practitioners – in their own occupational area. Overall, the mean scores achieved by learners in the experimental group were higher than scores achieved by control-group students, but the differences did not reach the chosen level of statistical significance (0.05) for all modules. In addition, lecturers completed a report on their experience of implementing the programme. Overall, lecturers were very positive about their experience, but identified institutional factors as impediments to developing the approach.

It was concluded that the potential of the approach was unlikely to be realised unless colleges committed themselves to an infusion approach which would be implemented in all modules taught by a department, and preferably college-wide. A major impediment identified was the fact that the assessment system typically tested students on routine tasks and provided no incentive for students to engage with the activities in the experimental programme.
Potentially significant information was lost by not having resources to analyse all the available data. The study would have been stronger had it included video analysis of students’ dialogue, similar to those in the Anderson, Soden and Hunter (2001) research. Large sections of the lecturers’ diaries written up during the programme were not analysed.

2.2.10

The authors argue for ‘re-thinking vocational education’ in a way that changes the focus of UK further education from teaching vocational knowledge to helping students to reflect critically on real work they have undertaken. Drawing on the perspective commonly known as situated learning (eg Lave 1996), they argue that vocational knowledge can be learned more easily in a real work situation and that FE lecturers would be better employed using this experience to develop abilities connected with critical thinking. Following Lave, the authors are critical of the idea that thinking practiced in classrooms can be transferred unproblematically beyond it. To illustrate their thesis, they present a case study which reports how they tried out their ideas with 25 adult returnees to formal further education who hoped to achieve a GNVQ in Social Care.

2.2.11

This rigorously evaluated study of US college students was designed to shed light on how to promote the development of their ability to handle a set of questions that must be raised and answered satisfactorily before drawing a firm conclusion about the relative truth or falsity of any particular causal claim. Competence in handling such questions is important for reasoning in everyday life, and crucial if students are to succeed in science-based courses at post-school level, since they are at the heart of scientific reasoning – questions such as ‘What alternative causes are possible, in addition to the proposed cause?’ ‘How can each possibility be tested?’ and ‘How does the evidence, once gathered, match the expectations?’ One of the research questions asked was about the extent to which ability to use such questions plays a role in concept construction – in other words, in learning a knowledge base in science.

During the module, methods commonly used were deployed (lectures, laboratory sessions), but the staff all made a very conscious and concerted effort to make alternative hypothesis testing the central theme of nearly every lecture and virtually all laboratory sessions. Students were given repeated opportunities to practise this form of reasoning with readily observable things (eg levers and pulley) before practising the reasoning on more abstract, less readily observable matters (eg burning chemicals).

Students completed a modified version of Lawson’s Classroom Test of Scientific Reasoning (1978) at the beginning and the end of a biology course. Although the pre-to post-test improvement that occurred was small, the authors point to difficulties reported in the literature of bringing about any improvement on the skills targeted.

Students also completed a transfer task at the end of a biology course. Most of the students who were deemed to possess the targeted skills used them to succeed on the transfer test and on course examinations covering a wide range of theoretical topics.

The authors emphasise that, unless there is much more intervention of this sort, students will not succeed in post-school science-based courses. At the end of this study, students were still confusing significant matters such as evidence and conclusions.

The results support a view expressed in the literature on thinking that clarity on the part of teachers as to what is involved in thinking, and about what aspects they are targeting in any unit of teaching, may be a necessary condition for effective ‘teaching thinking’ programmes.

2.2.12

The study reviewed in this sub-section was not a programme of any kind, but rather a case study which described fits (or otherwise) between:

- practice across three vocational degree courses provided in the FE sector
- practice implied in the body of research on learning to think.
From analyses of questionnaire and interview data, Soden and Pithers established that both lecturers and students preferred approaches to teaching and learning that were incompatible with developing thinking skills. The authors interpreted the significant discrepancies they reported between preferred practices and those described in research literature for developing thinking in terms of a model proposed by Kember (1997). This model posits that student ‘presage’ factors interact with other factors, including institutional ones, to influence lecturer and student practices. ‘Presage’ factors include knowledge and dispositions that students bring to the course, what they want from the course, and what they are able and willing to do to achieve what they want.

Institutional influences seemed to interact with students’ expectations to influence lecturers to give priority to ways of working which were most likely to produce success in year-end examinations. A change to problem-based learning – an approach reputed to encourage a range of ‘generic’ abilities – might have capitalised on the supportive emotional climate and lecturers' willingness to spend huge amounts of time on supporting students, even to the extent of sacrificing activities such as research which might have served their own careers better. However, approaches such as problem-based learning require changes in content and in how students are assessed which these lecturers felt unable to negotiate.

It was concluded that if the university and its partner college want students to develop a wider range of ‘generic’ abilities, which can be summarised as good thinking, this aim needs to be acknowledged explicitly and appropriate changes made to course design. For example, an institutional policy on design might be adopted which accommodates Lonka and Ahola's (1995) findings with post-16 students: that the sort of activities described in the literature outlined in this paper provide qualitatively better results in the long run; but in the shorter term, students will not learn as much content as they usually do in courses which are less enquiry-based.

2.2.13

The Thinking Skills at Work (TSAW) Project was a 2-year Department of Employment initiative arising out of the interest generated by the Somerset Thinking Skills Course (STSC) and previous research into cognitive enhancement. The project involved the development and controlled evaluation of a range of novel learning materials and accompanying trainer techniques designed to broaden and extend vocational training and promote learner autonomy, flexibility and adaptability. The project had three main phases.

1. A 3-month feasibility study to raise awareness and support for phases 2 and 3.
2. Nine months’ developmental work to produce pilot TSAW modules and assessment materials for phase 3.
3. A 1-year research phase to evaluate the activities in a number of controlled studies across a range of education and employment settings.

TSAW modules selectively used STSC ideas and principles, adapted and extended to suit vocational training. Content themes and activities were based on discussion with employers, FE college lecturers and trainers, together with analysis of the relevant occupational standards and vocational qualifications. Four exemplar modules were developed:

- preparing for work (generic)
- administration, business and commerce (occupationally focused)
- catering (occupationally focused)
- engineering (occupationally focused).

The ‘preparing for work’ module used contexts and problems relevant for people preparing for, or returning to, work. The activities were largely pictorial and made minimal use of written instructions and number work, so that trainees with specific learning difficulties were not disadvantaged. The three vocational modules included relevant simulations that rehearsed commonly recurring issues important to many job roles and contexts.

Activities emphasised the need to be thoughtful and the importance of taking time to understand and plan (PLUG – plan, understand, go). Learners were helped to become aware of, and gain control over, important questions and the thought processes involved in understanding, planning, executing and reviewing tasks.

Blagg, Lewis and Ballinger explain that effective use of the materials depended on a facilitative approach, with the trainers acting as mediators and learners maintaining maximum responsibility for both the problem-posing and the problem-solving process.
Fourteen studies were carried out in different vocational areas with: BTEC students in FE colleges; trainees with learning difficulties or disabilities; returners to work; NVQ Level 2 trainees; apprentices and mature employees with major industries. In each study, experimental and control groups were assessed before and after the TSAW intervention on a whole range of measures. Conditions for the various TSAW studies varied from optimal to minimally supportive, with TSAW intervention time ranging from five to 20 hours depending on the study. Some of the studies suffered from high trainee turnover, leading to small sample sizes. In other cases, there were implementation difficulties. Nevertheless, in spite of these methodological difficulties, the claim is that taken together, these studies reveal positive TSAW outcomes for both trainers and trainees across contexts, vocational areas and types of trainee. According to Blagg, Lewis and Ballinger, in 12 of the 14 studies, there were statistically significant findings across the range of experimental variables. They claim that the following specific benefits were identified, but suggest that they varied from study to study:

- ability to recognise and solve complex work-related problems and simulations – becoming more systematic, questioning and detail-conscious
- intellectual effectiveness across a wide range of behavioural indices; for example, showing improved planning, checking and error analysis
- interpersonal effectiveness; for example, showing improved communication and group working skills.

2.2.14

Presented in this paper are the results of a 2-year project to implement recommendations for the reform of college introductory science courses in Berkeley, California. The course on molecular cell biology was designed to 'develop scientific thinking related to the hypothetical-deductive approach' (2001, 1160). Student reactions were studied during this required course for biology majors, in which critical thinking and deep learning were emphasised, in addition to disciplinary content.

Implementation included a focus on significant concepts, specific instruction in ‘scientific thinking and higher-order reasoning, use of assessment that evaluated inductive, deductive and hypothetical reasoning and problem solving ability’ (2001, 1160). Instructors interspersed short periods of questioning and reflection before and after short presentations on major concepts; and in general, implemented approaches known to promote deep learning such as fostering peer interaction, maintaining a logical integrated course and avoiding work overload.

The results showed that development of critical thinking could be integrated successfully with study of the process of science, and that this approach was consistent with content learning. Data from students suggests that, to maximise its effectiveness, the goals of such a course must be made explicit to students from the outset, especially as they relate to the amount and type of work required for success in the course.

The paper contains a useful outline of relevant literature, which includes ways in which critical thinking has been characterised, a classroom illustration of the approach, and sample scientific reasoning questions. Given the methodological rigour of this study, the findings can be regarded as among the more secure in this area. Moreover, they are consistent with results from a growing body of research which suggests that promoting thinking proceeds well when attention is given in curricula to matters such as minimising memorisation of detail and ensuring that students receive substantial credit in assessments for evidence of thinking about content.

2.2.15
If concept mapping is so helpful to learning biology, why aren’t we all doing it? *International Journal of Science Education*, 23(12), 1257–1269.

As the author implies, concept mapping has been extensively advocated as a means of teaching students to think more effectively - not only about biology, but about all aspects of their coursework. The author provides a critical review of the literature often cited to support the use of concept mapping as an instructional strategy to promote thinking about the content of texts. What is particularly useful for readers is the author’s discussion of some of the flaws in this literature.

It is concluded that concept mapping may support learning within an appropriate teaching environment, which the author argues, is one in which the epistemological beliefs of classroom teachers and the underlying philosophy of the curriculum are consistent with the approach. These matters deserve much more attention in research on teaching thinking than is currently given to them.
2.2.16

The second author of this paper has an international reputation in investigating concept mapping. The paper describes the type of extensive training in concept mapping that seems to be associated with gains in ability to think about texts in ways that lead to understanding and retention of ideas. Kinchin (2001) (reviewed at 2.2.15) points to research which concludes that there is inconsistency in results from interventions that have introduced students to concept mapping. In many of these studies, there was very little of the training in concept mapping that has been developed by Dansereau and his colleagues, and often teachers have worked with a diluted and impoverished view of the nature of concept mapping that has amounted to little more than encouraging students to draw lines between any ideas that seem to be connected.

According to Chmielewski and Dansereau, students and teachers need to learn that knowledge maps (k-maps) are spatial/verbal arrays that represent information in the form of node-link diagrams. K-maps make the macrostructure of a body of information more easily available to the learner. Because k-maps emphasise relationships and organisational patterns, training a person in the construction and use of these displays may help them to implicitly structure and encode information in a variety of other presentation formats.

This paper reports on a study designed to investigate transfer of training in the construction and use of knowledge maps to the comprehension of texts. If training in k-mapping results in improved ability to learn without explicit use of the strategy, then this expensive training would be more cost-effective. Participants who received extensive training in the production and processing of k-maps were compared to controls. Differences in ability and motivation were controlled. Participants who received the training recalled significantly more macro- and micro-level ideas. Results indicate that k-map training facilitated recall for ideas; however, students may not have been aware of the advantages they received from the training. Apparently, training in mapping encourages students to use a top-down learning set that facilitates their acquisition of text information.

This paper, together with Kinchin (2001), provides for practitioners an in-depth introduction to concept mapping that might enable them to make informed judgements about the value of this approach in helping students to think about textual information.

2.2.17

This study is typical of the ones in the literature reviewed by Kinchin (2001). Nursing students in six clinical groups each created three concept maps over a semester. Statistically significant differences in conceptual and critical thinking were found between the first and third maps. Given Kinchin’s conclusions about the success of the approach being related to the epistemological beliefs of teachers and the underlying philosophy of the curriculum, it is unsafe to generalise from any one study of this type.

2.2.18

In this methodologically rigorous study, supported by a Social Sciences and Humanities Research Council (SSHRC) of Canada research grant, Butler examined the nature of instruction that can be linked with students’ development of self-regulation in academic domains. Drawing on a range of appropriate literature, she describes self-regulated learning as students’ flexible, ‘planful’ and recursive engagement in a sequence of cognitive activities. According to this model, self-regulated learners start by analysing task requirements, defining performance criteria and setting learning goals; then go on to identify strategic approaches that are likely to accomplish their objectives, which involves selecting, adapting or inventing strategies to match task demands. Self-regulated learners monitor outcomes associated with strategy use and adjust strategies accordingly. The paper includes a model of self-regulation in academic domains, which includes shaping of self-regulated performance by a variety of beliefs and knowledge. The paper considers instructional principles that have been associated with students’ development of self-regulation and reports findings from an intervention based on the instructional principles that the author reviews here.

Butler’s discussion of instructional principles that have been associated with students’ development of self-regulation is a useful resource both for researchers and practitioners. She concludes from a review of the literature that successful instructional models have the following features.
Instruction is:
- long-term
- promotes strategy use in the context of meaningful academic work
- engages students in discussion about learning processes
- explicit and structured
- provides assistance contingent on students’ progress in thinking about tasks
- requires students to apply and adapt thinking strategies across tasks and domains
- helps students to recognise the applicability of strategies across tasks and domains.

According to Butler’s review, this combination of instructional characteristics has been associated with improved task performance, development of metacognitive knowledge about learning processes, construction of positive motivational beliefs, and independent strategy transfer.

Butler points out that students are often explicitly taught (through tutor modelling) strategies for dealing with the academic work that is part of their curriculum, and then practise these strategies on their academic work and adapt them. Butler set out to test her alternative Strategic Content Learning (SCL) approach with a group of students whom she described as ‘actively inefficient’, a description that was recognised by Scottish FE lecturers who read this paper with the authors of this report. The students engaged in discussion with the research assistants about the thinking strategies they were using to complete coursework and were helped to see weaknesses in these strategies and how they might be developed. In the SCL approach, great emphasis is put on helping students to get a sense of what they are trying to achieve, and in guiding students to consider options and make strategic decisions for themselves, without telling them what to do.

The research produced a wealth of quantitative and qualitative evidence which supports her SCL approach as promoting self-regulation in solving mathematical coursework problems, and which characterises mature self-regulated performance in academic work. Although the SCL approach is apparently very sound, its implementation is highly labour-intensive and would require very small classes, or at least classes with trained support workers. Its application might be cost-effective in the early stages of post-school courses, particularly for disadvantaged learners, in that the development of self-regulation might yield high dividends in later study.

2.2.19
Using argumentation to teach literature.
Exercise Exchange, 43(2), 10–11.

The author describes how she used debate with FR Stockton’s The Lady, or the Tiger? to sharpen critical skills in literary interpretation. She posed a series of questions at 5-minute intervals and set up an affirmative and a negative side on which students debated the next day. She suggests also debating on a range of other matters within the domain: for example, debating literary values, an author’s intentions, etc. This is a descriptive study, with no evaluation data other than the author’s notes of her work with her students.

This paper provides useful ideas for enhancing thinking that could be adapted by practitioners to suit a range of arts and social science topics.

2.2.20
Metacognition in basic skills instruction.
Instructional Science, 26(1–2), 81–96.

This article describes self-regulatory processes that promote achievement in the basic skills of reading (clarifying purpose, understanding meanings, drawing inferences, looking for relationships, reformulating text) and mathematical problem solving (clarifying problem goals, understanding concepts, applying knowledge, monitoring progress). Experiences in integrating metacognition with reading and mathematics instruction, and students’ reactions to learning to think metacognitively are highlighted.

The article was published in a journal that has particularly rigorous reviewing procedures. Presentation of research design is clear, and procedures are appropriate to the paper’s research problem. The descriptions it offers are among the best founded in this area. The paper offers ideas for practice in basic skills education that are accessible to teachers and that deal with significant aspects of thinking about texts.

2.2.21
Advertising principles case study.

This article describes how to teach business using critical thinking methods and how to assess elements of critical thinking, including standards for judging it. It illustrates teaching methods, materials and student activities for a course using a critical thinking approach to advertising principles. The methodology allows ‘fuzzy propositions’ (see Bassey 1999), rather than firm conclusions. The propositions provide a very useful starting point for action research by practitioners in this area.

This empirical study focuses on strategies for teaching problem-solving techniques during an engineering design course in the third year of a 4-year degree programme. Forty third-year engineering students at the University of Canterbury, New Zealand studied a new design course entitled ‘Strategies for creative problem solving’, which uses six interactive computer modules together with lectures, laboratory sessions and time spent working in pairs on set problems. The course was intended to introduce basic concepts, give students the experience of applying problem-solving skills, and expand their confidence in analysing and solving new problems independently. The computer modules focused on introducing problem solving, problem-statement definition techniques, brainstorming, analysis of potential problems (avoiding future problems), planning and implementation, and evaluation. Within each area, a wide range of specific strategies was introduced and exemplified.

The focus on creativity was implicit in the approach, but not much discussed in the article. Assessment was by means of computer-generated scores (students could repeat the module as often as they wished to improve their score) and problem-solving assignments. Students also completed a questionnaire. The computer modules were found by the majority of students to provide a new and different environment for learning that provided a useful supplement to the lectures. It was concluded by the authors that problem solving is a skill that can be learned, and that it is a necessary skill to enable students to deal confidently with new situations and problems encountered in their professional careers. Although not rigorously evaluated, the study provides a useful model for teaching problem solving within design disciplines and demonstrates how ICT can be harnessed in this process.


This case study describes a 7-week critical enquiry unit on the 1953 Rosenberg trial within a writing course for second-year college students. The authors use this unit to illustrate the importance of dissonance in promoting learning, and how rhetorical enquiry in Kenneth Burke’s concept of ‘perspective by incongruity’ leads to critical enquiry and deeper understandings about the effects of language. The notion of dissonance has a central role in Piagetian accounts of learning.

Although the data does not support more than ‘fuzzy propositions’, the paper provides a useful resource for teachers in post-school settings in that it reviews literature which offers reasons why reading and writing activities might have a central role in most content areas in pushing students beyond the stage of comprehension and interpretation to a higher level of evaluation or critical consciousness. It is useful too in exploring what it might mean to be ‘critical’.


One of a series of papers arising from the TALESSI (Teaching and Learning at the Environment-Science-Society Interface) Project, this paper discusses the wider strategic framework within which the project operates, and sets out its key aims and its approach to learning and teaching. The greater part of TALESSI’s financial support came from HEFCE’s Fund for the Development of Teaching and Learning (FDTL). The paper includes three appendices that provide operational information.

TALESSI aims to enhance three aspects of environmental learning through active learning:

- interdisciplinarity
- values awareness
- critical thinking.

Characterisations of these three aspects offer clear descriptions that are likely to be helpful to teachers in post-school education. Disciplinary perspectives include those of the natural sciences, the social sciences and the humanities. Included in the characterisation of values awareness (1999, 336) is:

...appreciation of the insights afforded by environmental philosophy and ethics and the ability to recognise values that enter environmental debate via the supposedly ‘value free’ natural and social sciences, and more generally through the learning context of environmental higher education.

Critical thinking is defined as the means to question and reveal the contestable character of ‘knowledge claims’ advanced in relation to many environmental questions, and the means to incorporate this critical awareness into academic writing.
The approach to learning and teaching, which was anchored principally in philosophy and sociology of knowledge, problematised the ‘knowledge claims’ made from within various disciplinary perspectives and the entry of values into environmental debate. The authors report that this approach seemed to be particularly helpful in discussing knowledge that is uncertain and provisional in nature, and where conflicting views are heard, both within academia and beyond.

The aims and approach to learning and teaching are well thought out, and information on a wealth of teaching/learning resources can be found at the TALESSI website (www.greenwich.ac.uk/~bj61/talessi). Evaluative data consists mainly of (highly positive) comments from teachers in higher education who have tried out the TALESSI ideas.

The project’s aims and approach to learning and teaching reflect a view that the development of critical awareness is one of the more important purposes of post-school education. Although the ideas for developing such awareness seem sound, their application in programmes offered in many parts of the FE and HE sectors would seem to entail radical revision of aims and approaches. If such radical thinking were to be contemplated, TALESSI offers a sound starting point.

2.2.25
Beyond the sponge model: encouraging students’ questioning skills in abnormal psychology. Teaching of Psychology, 25(4), 270–274.

The authors argue that educators should provide students with explicit training in asking critical questions, and describe a training strategy taught in two abnormal psychology courses at Bowling Green State University, Ohio. Based on a pre-test and a post-test, results support the promise of using explicit questioning training in promoting the evaluative aspects of critical thinking.

The authors describe teaching procedures that are practicable to use in many programmes that require students to understand and apply a body of knowledge. They used a text that is designed to help students to question the empirical material they study in abnormal psychology (Keeley 1995). Activities for practising various aspects of thinking about psychology or other subjects are readily adaptable to other curricula and can be accessed from texts such as Bensley (1998).

The research design is clearly presented and appropriate to the paper’s research questions. The procedures and measures are clearly enough described to permit replication. Clear definitions and illustrations of four types of question are presented.

Overall, this is a well-conducted study in which the authors define question asking as a component of critical thinking in abnormal psychology, and report an increase in certain types of question, particularly ‘evaluative’ questions, that seems to be connected with their teaching students how to ask questions and giving them ample practice in doing so. As the authors point out, the results should be interpreted with caution because of the absence of a control group. They also point out that they did not gather data on students’ views of the intervention.

Although the article focuses on one aspect of thinking and describes changes in practice that are not major, these changes seem to be important ones, and have the merit of being readily integrated into existing curricula in most post-school programmes.

2.2.26
The effects of metacognitive training on performance and use of metacognitive skills in self-directed learning situations. Proceedings of selected research and development papers presented at the National Convention of the Association for Educational Communications and Technology (AECT), Houston, 10–14 February.

This research examined the effects of teaching metacognitive strategies on performance in a self-directed learning situation. All participants, 60 university students enrolled in a beginners’ photography course for non-art majors, were subject to the same conditions. The ‘treatment’ was embedded instruction and practice in reflection, planning, and evaluation. Metacognitive awareness was measured prior to and after the intervention. The use of metacognitive strategies was measured by a self-reflection survey, following the first and last assignment. These assignments were identical and provided for the assessment of performance.

Results indicated that the intervention had a positive effect on learning. The change in metacognitive awareness led the researchers to conclude that instructional strategies that teach students to practise metacognitive skills while learning course content improve the use and awareness of these skills, as well as performance.

The approaches used in this study are commonly reported in the research literature. The conclusions are supported by student self-report data about their approach to a first course assignment. There is no data on relationships between increases in students’ reported metacognitive awareness and the quality of their photography work during the course. The study adds to a body of research that indicates that students’ metacognitive awareness can be enhanced through embedding metacognitive instruction in subject-matter learning activities.
An advantage of this embedding approach is that the students have opportunities to understand what might be involved in activities described as reflection, planning and evaluation in relation to a particular subject. In the absence of firm evidence of the extent to which such gains transfer to other contexts, a case can be made for including measures to promote such understanding within each subject of the students’ curriculum.

2.2.27

As the title suggests, the main purpose of this study was to test the effect of instruction to improve the proportional, probabilistic and correlational reasoning of undergraduates (in Chicago) who were majoring in the field of education. Fifty students in an experimental group received specifically planned instruction consisting of three 20-minute lectures on each of the three types of reasoning over a 3-week period as part of their educational psychology course.

The findings indicate that deficiencies identified in such reasoning could be addressed successfully with a surprisingly limited classroom intervention. Since this conclusion is derived from a rigorous pre-test/post-test control group design, there are good reasons for believing the findings. The design is clearly presented and appropriate to the paper's research problem. All procedures and measures are clearly and adequately described; the methods of analysis are clearly related to the design and argument and are fully explained.

It is unusual to find support in research literature for the idea that reasoning can be improved through lectures alone. It is possible that the lectures were successful because the students’ proportional, probabilistic and correlational reasoning had been hampered by insufficient understanding of these concepts. The authors make the point that proportional and probabilistic reasoning are prerequisites for correlational reasoning. They urge that curricula tie together the areas of mathematics and science. The study is a useful reminder that apparent deficiencies in reasoning may well stem from conceptual understanding that is insufficient for the reasoning tasks being undertaken.

2.2.28

The authors explain in their paper why they think it is important for chemistry teachers to know about metacognition, and they discuss some instructional tools that have been employed to promote metacognition in science courses. Rickey and Stacy suggest that metacognition is generally thought to be a key to deeper, more durable and more transferable learning. They say that the ongoing debate in conceptual change theory concerns whether students’ naïve science knowledge is coherent and theory-like or fragmented and context-bound. Rickey and Stacy believe that students with high levels of metacognition are more likely to refine naïve ideas in the face of contradictory data. According to them, students’ own monitoring of their developing understanding of new concepts is essential for effective learning.

The authors of the paper suggest that metacognition is a key component of successful chemistry problem solving. The aim of a small study carried out by them was to test this claim. They asked a chemistry graduate student and two undergraduate students to solve some problems and analysed the processes used to arrive at the answers. Rickey and Stacy say that the results show that insufficient metacognition skills caused the graduate student to fail to solve a problem for which she clearly possessed the relevant domain knowledge. The pair of undergraduates working collaboratively solved the problems, apparently using metacognition skills. It is suggested that this implies that promoting metacognition is as important as emphasising the content aspects of chemical problems. Rickey and Stacy conclude from their small study that chemistry teachers need to include instruction in thinking skills in their courses. However, it would be necessary to investigate the problem-solving processes with a larger sample in order to make any firm claims for use of metacognition for effective learning in chemistry.
The paper also discusses some of the authors' thoughts concerning the approaches to teaching thinking skills. They draw on the work of Salomon and Perkins (1989) and Ennis (1989) in their discussion. They suggest that teaching what they call general ‘critical thinking’ skills separately from content knowledge will not be sufficient to enable students to transfer those skills to new situations and types of problem. The authors suggest that each discipline has characteristic ways of reasoning, that some metacognitive strategies are applied differently in different domains, and that many of the most useful metacognitive strategies are domain-specific. Examples of what they mean by a general thinking strategy as opposed to a strategy more specific to chemistry are provided, but there is no evidence to suggest that the authors have themselves tested the different strategies with groups of students. They appear to draw on the literature for their opinions. Their conclusion in this section of the paper is that both general and domain-specific strategies are essential for developing a high-quality understanding of chemistry. They suggest that infusion in subject-matter areas and general teaching of metacognition skills would help students to learn to use their content knowledge more appropriately and flexibly.

Rickey and Stacy's paper also provides a critique of a selection of instructional tools that they say have been used in introductory college science courses to help students become more aware of their own ideas. Their discussion includes concept maps, Concep Tests, Predict-Observe-Explain (POE) tasks and the Model-Observe-Reflect-Explain (MORE) Thinking Frame. They highlight difficulties with the first three tools and suggest that the fourth shows the most promise. Results of a study carried out by Rickey (1999) are cited and the claim is that its results provide a concrete example for chemists of how a metacognitively focused instructional tool can be effectively employed in a general chemistry course. Specific details of the study by Rickey are not provided - for example, the number of students involved in the study. It would be necessary to examine the primary research in order to make any comment on the reliability of Rickey and Stacy's conclusion about the usefulness of the MORE Thinking Frame.

In the final section of the paper, the authors make the point that there is a need for more research into the role of metacognition in understanding chemistry. Although a number of the opinions put forward in this paper are not adequately supported by sound evidence, the authors' views are helpful in raising questions about the different approaches used to teach thinking skills and about some of the instructional tools available. Their conclusion that using a combination of approaches when teaching thinking skills may prove most effective is in line with Sternberg's view (1997) that there is no one correct thinking skills programme and that a choice of approaches should not be restricted to either/ or.

2.2.29

This paper explores the use of case studies in undergraduate biology education. The authors claim that case studies are useful for developing critical reasoning skills and to connect in-class learning with reality outside the classroom. All the case studies described in the paper follow a common format - a problem is described which is based on reality and the student is placed in the role of problem solver. Students may work on cases alone or in groups. Smith and Murphy explain that case studies may also be used as a means of integrating various concepts from lectures and laboratories, in addition to providing the students with opportunities to apply content they have learned to real situations.

The aims of the case studies as described by the authors include increasing students' understanding of materials, improving their reasoning skills and increasing their interest.

The paper provides a brief description of the use of case studies in different biology courses with different year groups. Two short sample case studies are provided in the appendices. The numbers of students involved in the classes are not provided, nor is any mention made of a control group of students. The discussion section in this paper is very short and the conclusions cannot make concrete claims for the use of case studies in the development of critical reasoning skills.

2.2.30

Geography for the New Undergraduate (GNU) is a project based at Liverpool Hope University College and funded by HEFCE. Similar to the programme at the University of Luton described by Guest (2000), the project was based on an existing programme at Liverpool Hope University College, designed largely to assist first-year ‘non-traditional entry’ undergraduates. The project concerned the development of a programme of seminars that allows first-year undergraduate students to develop a range of skills that will enhance their degree studies and future careers. The aim of the seminars is to encourage self-confidence and independence, as well as developing study skills such as written and oral communication, in conjunction with the teaching of geographical content.
The model that has been developed consists of materials required to run the whole programme of seminars and is available to all HE institutions in England and Northern Ireland. The paper provides a table with the entire list of 29 seminars grouped around four themes: introducing group-working skills; study skills; critical thinking and discussion; and group presentations. Each seminar session consists of three parts: student preparation, the seminar (tutor contact), and student follow-up work. According to the authors, the programme emphasises active learning, whereby the students become more responsible for their own learning, and introduces the ideas of self-assessment and reflection.

The geographical content reflects the subject areas that were commonly cited in a questionnaire to HE geography departments about their first-year teaching. However, Dyas and Bradley say that the content of each session is considered less rigid than the skills being delivered, and that the materials are structured to allow for easy adaptation to an alternative topic or, as they suggest, even another subject area. They claim that many of the skills are generic.

The paper explains that an evaluation strategy was planned from the start of the project, encompassing evaluation of individual seminar materials, the overall programme and the impact of the project on student learning. The authors claim that the response to the seminar materials was very favourable, but they provide little evidence to support this claim. Little comment is made in the paper about the impact on student learning or on the transferability of the programme to other disciplines. Dyas and Bradley simply conclude the paper by saying that an external evaluator was appointed to evaluate the programme as a whole and that research has been initiated into the impact of the project on student learning.

Other than the fact that the materials have been produced, the paper tells us little about the strengths/weaknesses of integrating the teaching of critical thinking skills into a geography course or about the suitability of the model outlined to other subject disciplines. It would be interesting to read the external evaluator’s report. However, no details are provided concerning the identity of the evaluator or when the report will be published.

2.2.31

The aim of the study is to describe a theoretical framework for teaching and assessing critical thinking abilities as outcomes in an informal logic course. The theoretical framework neither describes an actual course nor reports on how a course has actually achieved certain outcomes.

Ikuenobe says that informal logic courses have been criticised as not being a plausible way to acquire critical thinking abilities, because they do not apply the abstract principles of reasoning to substantive subject matter (McPeck 1981). According to Ikuenobe, critical thinking involves writing, speaking, understanding, analysing, problem solving, reflecting, synthesising, evaluating, moral and practical reasoning, and decision and judgment making. He points out that it is claimed that teachers of informal logic usually do not pay attention to how the principles of reasoning are applied to the actual processes of reasoning and discourse in various contexts.

Ikuenobe cites McPeck (1981), saying that he has tried to distinguish between the abstract logical principles of reasoning and practical critical thinking abilities. In McPeck’s view, knowledge of a subject matter is required for critical thinking because thinking cannot be done in a vacuum. Ikuenobe suggests that those who distinguish between logic and critical thinking argue that critical thinking is a set of integrative, complex and applicable abilities in the context of a subject matter. Paul (1982), cited in the paper, argues that critical thinking requires reasoning and issues to be seen from a global, contextual, historical world view of multicultural, ethnic, racial, gender and class perspectives. This view is emphasised by Ikuenobe when he says that critical thinking involves making critical connections among conceptual schemes, observed physical objects, statements and the beliefs a person holds. It involves critically examining the nature of conceptual schemes, world views, biases, presuppositions, prejudices, and meta- and background beliefs, and how they shape observation and understanding. The key point appears to be that when teaching thinking skills, it is necessary to find ways to enable students to understand factors that shape their reasoning. Ikuenobe’s paper attempts to show that a connection exists between informal logic and critical thinking: that the logical principles of reasoning are necessary for critical thinking, but they are not sufficient. He argues that a new approach and new thinking in the pedagogy of informal logic is required, as is creativity on the part of the teacher to articulate clear teaching outcomes and criteria for assessing achievements.
The framework proposed by Ikuenobe is general, flexible and adaptable to suit different pedagogical needs. How the requisite outcomes are achieved depends on the teacher's approach and the assessment tools used. Ikuenobe suggests that critical thinking may be broken down into five abilities that students must acquire, demonstrate and apply as critical thinkers. He believes that these abilities can be articulated as outcomes to be achieved by students. His paper explains a developmental model with five different levels. The outcomes at each level are systematically incremental with a succeeding level building on the preceding one. Ikuenobe says that in levels 1 to 4, students learn the principles of reasoning as objective principles which transcend disciplines. As outcomes, the principles are learned as abilities which engender the disposition to apply, transfer and use them across disciplines and contexts. It is argued that to make subject matter a necessary component of critical thinking is to suggest that the requisite abilities and their applicability are not transferable from one context to another. At level 5, critical thinking abilities are specifically contextualised to various disciplines, context and subject matter.

The final part of Ikuenobe's paper focuses on methods to assess students' abilities in relation to desired outcomes identified at each level of his model, and on how students can learn from the process of assessment. Ikuenobe expresses similar views to Halpern (1999) about the importance of a person's disposition to use thinking. It is argued that if there is no willingness to use thinking skills, there will be no thinking. Consequently, learner motivation and students' ability to engage in self-assessment must be considered in any course that aims to teach thinking skills.

This paper adds to the discussion regarding the most effective method to teach thinking skills. A combination of methods appears to be proposed by Ikuenobe, as levels 1 to 4 of his model suggest teaching thinking skills separately and level 5 suggests application of critical thinking in various disciplines and contexts. Ikuenobe's views on assessment of critical thinking also raise some interesting points that require further analysis and discussion. It is unfortunate that no mention is made of testing his model with a cohort of students and evaluating its success against other methods of teaching thinking skills.
It is concluded that demonstration assessments offer an option useful in developing, as well as assessing, conceptual understanding. This is attributed to three important features of the assessments:

- They focus student attention on what is to be learned
- They encourage deep elaboration of concepts in the students’ own words
- They give students the opportunity to develop a metacognitive self-awareness of the thinking process.

This research has significance for thinking skills and pedagogy in post-16 learning contexts because it suggests a form of assessment which may be beneficial to students’ learning and which could be enacted across a range of subject areas. The promotion of critical thinking was not, however, directly assessed and was not brought out as much as it could have been in the analysis and discussion.

2.2.33
Hanson D and Wolfskill T (2000).

This article describes the implementation and evaluation of a process-workshop classroom for chemistry undergraduates at the State University of New York at Stony Brook. A process workshop is defined by the authors (2000, 120) as follows:

... a classroom environment where students are actively engaged in learning a discipline and in developing essential skills by working in self-managed teams on activities that involve guided discovery, critical thinking and problem solving and include reflection on learning and assessment of performance. The essential skills ... lie in the areas of information processing, critical thinking, problem solving, teamwork, communication, management and assessment. Performance skills in these areas, just like skills in laboratory work and athletics, can be developed, strengthened, and enhanced through practice.

The main aim of the research was to develop a new model for classroom instruction in response to a range of issues which included: the perceived ineffectiveness of sessions, marked by low student attendance, in which tutors answered questions and worked problems for the students; negative perceptions and attitudes regarding chemistry and science displayed by many students; and lack of any connection to the real world in the types of experiences offered to students (for example, there was little provision for teamwork and application of concepts).

The authors posit that introducing process workshops can provide a mechanism by which a lecture-based course can evolve into a more interactive, learner-centred, process-oriented format. The premise is that if students are actively engaged in learning and have the opportunity to exercise process skills in key areas, then they will grow intellectually and become better learners, thinkers and problem solvers, and will improve their examination grades and be more successful in the real world.

The research takes the form of a case study which lasts for one semester and which involves a full cohort of approximately 1300 chemistry students. The case study provides a rich account of the learning, teaching and assessment processes used within the process workshop under the following headings: the process-workshop classroom; use of learning teams; guided discovery and exercises; problem solving; reporting; assessment; and the role of the instructor.

In order to evaluate the success of the approach, a range of comparisons is drawn with the previous cohort of students. The text and instructors were kept the same and efforts were made to make the examinations equivalent. (However, it should be noted that no measures were taken to establish the equivalence of the student cohorts.) Positive findings are reported on: attendance at the sessions; students’ affective responses to the workshops; ratings awarded by the students to their instructors; examination performance; enrolment in the second-year organic chemistry course; and instructors’ reports on improvements in student skills.

In conclusion, the researchers note the journey over a 4-year period – from apprehension on the part of the instructors when the workshops were first introduced, towards becoming more relaxed as they perceived that students were becoming more active in their learning and were encouraged by their own accomplishments and by sharing experiences with other students, to outright enthusiasm for the approach.

This research has significance for thinking skills and pedagogy in post-16 learning contexts because it provides a very clear articulation of learning, teaching and assessment processes which are very well grounded within a constructivist tradition and which are not restricted in their application to chemistry. Furthermore, the approaches are geared towards developing in students the key skills that many employers value highly.

2.2.34
Teaching practices and emphases in advertising creative courses. Journalism and Mass Communications Educator, 54(3), 57–64.

The authors present the findings of a quantitative survey conducted with teachers of creative advertising courses in 45 US universities. The survey focused on the teaching approaches employed for entry-level and advanced-level courses. The respondents had an average of 14 years’ full-time professional experience, with most noting that they continued to consult. The article cites other research that reported a rift between the academic experience and the demands of the professional world, with practitioners questioning the experience of lecturers, the relevance of the creative aspects of the curriculum and the value of the creative course content.
The findings of Robbs and Wells’ survey suggest that, within the constraints imposed by budgets and accrediting rules, university programmes are providing students with the sort of intensive training now required by advertising agencies. Educators and practitioners agree about the importance of teaching students to think conceptually and strategically as well as about less crucial matters, such as the type of material that students should create for their portfolios. (It is questionable, however, whether the students themselves would view this example as less crucial, given the importance of the portfolio for getting a job.) It is a common situation with regard to the academic preparation of students for professional careers, that there are complaints about the lack of preparedness of new graduates for the world of work. This research seeks to address this issue constructively within a creative field, and for this reason, the approach is of interest to post-16 educators, as well as casting some light on current pedagogies.

2.2.35

The authors report on a study which incorporated the teaching of creativity into a class in magazine design in a US university, and which tested the effectiveness of the creativity-enhanced curriculum with an experiment using pre-tests and post-tests on treatment and control groups. The purpose of the study was to change the way creativity is taught in journalism design classes, from an anecdotal approach to one that is theoretically and empirically based. The article discusses at length definitions of creativity, the characteristics of creative people, creative environments and the creative process, and how to incorporate creativity in the classroom, before focusing in on creativity in visual communication, which is of particular relevance to the students’ curriculum.

A model for introducing creativity into design classes is then presented and discussed, comprising the following elements: cultivating creative awareness; incorporating active learning about creativity; practising brainstorming; constructing a creative setting; incorporating choice; encouraging independence and self-direction; encouraging risk taking while minimising the influence of reward; encouraging association with other creative people; minimising constraints; and providing attention, praise and support.

The article then discusses the intervention in which 37 students participated, 24 in the creativity-enhanced magazine design course and 13 in a newspaper design course. The pre- and post-tests used a divergent thinking performance assessment – the figural forms of the Torrance Tests of Creative Thinking (1990) – which measures fluency, flexibility, originality and elaboration. It was found that both groups scored significantly better in the post-test; however, no significant differences were found between the post-test scores of the experimental and control groups, although the treatment group scored higher on some measures. The authors conclude that this result is most likely due to the small sample size, and point out that although the results of this study are inconclusive, the results of other studies are not. This article is useful for our review, in spite of the inconclusive results of the experiment, because of its detailed exposition of relevant research on creativity and teaching for creativity. Perhaps a different research design, such as an evaluative case study, could have unveiled more useful and fine-tuned evidence on the impact of the new curriculum.

2.3
Programmes designed to incorporate thinking skills throughout an existing curriculum

2.3.1

Within a larger, prestigious research project aimed at improving metacognitive knowledge, the authors used an experimental design to answer their questions about the trainability and transferability of orienting and self-judging activities as learning tools, and the effect of these activities on academic performance. In this study, the authors focused on teaching students to orient themselves towards the study of their course by preparing themselves to tackle the course effectively through gathering data about learning goals, the study load of the course, the practical organisation of instruction, the study material and other instructional aids, the learning content, the necessary study activities and assessment requirements. Orienting activity involves making use of appropriate informants or sources of information. Self-judging involves making judgements about oneself as a learner or problem solver. For example, a student can evaluate his or her learning speed as being too slow in general, or can judge his or her prior knowledge as insufficient to start a specific assignment. In this study, the authors restricted self-judging to students’ orientation to the course.
Orienting and self-judging have wide applicability in the FE and HE sectors. Both activities can be applied to specific tasks such as an assignment or problems, as well as to whole courses or modules within courses. Armed with orientation data, a student can better plan his or her problem-solving or learning process, and regulate his or her own learning by self-judging progress with tasks.

An experimental group and two control groups participated, each comprising 47 first-year business economics students in a Flemish university. The intervention was embedded in the natural context of university teaching over 10 class sessions. In order to promote transfer of learning, the students in the experimental group practised orienting and self-judging not only in relation to their business economics course, but also in relation to all nine courses in their first-year programme. One of the two control groups practised more specific cognitive activities such as analysing problems, concretising and relating concepts in their textbooks and summarising chapters. In the interests of promoting transfer, they too practised these activities in relation to all courses in their programme. Students in the second control group were exposed to normal university teaching.

After the final intervention session, students’ progress was measured in various ways which included asking students to write their response to the question: ‘What do you have to know at the start of a trimester in order to be able to organise and plan your study for a particular course? Also mention how you can obtain that information.’ Students’ writing was content-analysed. Self-judging was assessed by asking students to write responses to questions such as ‘What personal characteristics of a student can be an advantage and disadvantage for studying this course?’ A test of transfer aimed to assess the extent to which students could use the orienting and self-judging activities in relation to a course that was not involved in the intervention. The impact of the intervention on academic performance was evaluated by looking at students’ scores in each of their courses at the end of the third trimester (ie two trimesters beyond the intervention).

Overall, complex statistical analyses revealed that students in the experimental group had significantly more knowledge of orienting and of self-judging than students in both control groups, and that these activities mattered with regard to academic performance. The experimental-group students provided more evidence of orienting and of self-judging in relation to the course not involved in the intervention than did their peers in the control groups. Thus, there was some evidence of transfer of learning. There were no overall differences between the two control groups. The authors point out that they measured knowledge rather than action competence. However, many studies point to strong relationships between knowledge as beliefs and action in learning.

Given the wide applicability of the educationally significant findings, the rigour of the research design and the international reputation of the authors, this study merits wide dissemination.

2.3.2

The paper describes a 2-year ‘writing across the curriculum’ (WAC) project in a school of nursing in a large urban university in the US. This is a useful descriptive study that provides a brief survey of literature on the pedagogical approach known as ‘writing to learn’ (WTL), which is one of two approaches used in most WAC projects, and which lies within the broad framework of constructivism. It is claimed that WTL encourages students to engage in activities that the authors suppose to be aspects of critical thinking: processing, analysing and articulating concepts as they are presented. Thus, as students write, they are encouraged to ‘sort through ideas, connect thoughts, reflect on their constructions’ (2001, 363).

As is the case in most reports of similar initiatives, many barriers were encountered. The authors conclude that two major characteristics of successful WTL strategies are as follows.

- The strategies ‘blend’ with existing course objectives and enhance the teaching of existing content.
- The writing is valued in students’ assignments.

3
Studies whose purpose is to identify features of curricula and teaching associated with development of thinking in one or more than one domain

3.1
Tsui L (1999a).

The aim was to illuminate how different types of course and instructional technique affect college students’ growth in critical thinking, using self-report data from a national follow-up study of first-year students in the US (n = 24,837). Results revealed that taking writing, interdisciplinary studies, history, science, women’s studies, mathematics, foreign language and ethnic studies courses and enrolling in honours programmes are positively associated with improved critical thinking.
The results are consistent with models proposed by prestigious researchers (e.g., Perkins 1993) that emphasise the importance of understanding concepts that seem to be central in disciplines. It is possible that certain kinds of content might be more likely than others to offer concepts that facilitate analysis of issues. This rigorous, large-scale study would be well worth following up with the aim of teasing out characteristics of programme content that seem likely to influence students’ critical thinking.

Post-16 curriculum developers might then explore the nature of the content and learning outcomes in the programmes in which students reported greater growth in critical thinking, and consider the extent to which such characteristics are typical in the courses they develop. Consideration might be given to the question of whether critical thinking could be enhanced by incorporating such features into courses in which, traditionally, they have not been prominent.


The authors review current literature, describe the Broad Analytical Expository Report (BAER) approach to teaching critical thinking, and relate experiences in using the BAER in experimental general education courses at a typical US regional state university. They suggest ways to reduce cognitive-affective trade-offs and institute general education reform.

This is a useful text for enabling participants in CPD programmes in the post-school sector to extend their understanding of the wide range of approaches that have been used to promote critical thinking about subject matter, and of the idea that some changes in institutional factors impede or enhance tutors’ efforts to develop students’ thinking.


As the title suggests, the aim of the study was to assess the impact on students’ critical thinking of two sorts of course. The authors carried out a meta-analysis of studies and, using the Binomial Effect Size Display, found that instruction in communication skills generated a 44% increase in critical thinking ability. They also found that participation in forensic studies had the largest positive impact on critical thinking improvement, but that all communication skills experiences had a significant impact on students’ ability to think about their coursework.

The results are consistent with those of Tsui (1999a; reviewed at 3.1), whose research seems to indicate that some subject matter has more potential than others for developing students’ thinking. It seems likely that, to study forensics successfully, students need to consider what counts as evidence, to weigh up available evidence and, in general, to adopt an enquiry approach to their study. The finding that instruction in communication skills generated a 44% increase in critical thinking ability is consistent with the idea that communicating and defending judgements about forensic issues offers opportunities to practise elements of an enquiry approach.

Post-16 curriculum developers might want to consider how an enquiry approach that involves discussing and weighing evidence could be built into many other areas of post-school learning.


The aim of the study was to investigate instructional methods that effectively enhance the development of students’ critical thinking. A comparative case study was used. Four institutions were selected for study: at two of these, students reported experiencing high degrees of growth; and at two, students reported experiencing low degrees of growth. Analysis of the data, which came primarily from 55 interviews and 28 classroom observations, suggests that the development of critical thinking is linked to an emphasis on writing and rewriting.

At the two colleges scoring high on an Institutional Growth in Critical Thinking (IGCT) measure, there was a strong focus on writing – a focus absent from the two colleges that scored low on IGCT. At one college (high IGCT, low selectivity), a curricular policy stipulates that writing should be an integral part of all course programmes (which are taught by a multi-disciplinary team of faculty members). Another classroom factor which appears related to the development of critical thinking is an emphasis on class discussion, which again exists at the two high IGCT institutions.

The study was a rigorously conducted one. Appendices include a table showing selection criteria for case study sites, a summary of classroom observation data and descriptions of categories for the observation data.
The results of this study are consistent with literature that allocates a central role to students’ writing as a means of developing a capacity to think about ideas (e.g., Bereiter and Scardamalia 1993). Plainly, the implications of this study are that academics might re-examine the role of writing in the courses they design, and consider whether the apparent importance of writing is reflected in student activities.


This study focused on the relationship between instructional strategies and students’ reported meta-skill attainment in an adult education context. Using the data collected from 2507 end-of-course surveys of students in the Graduate Studies in Education programme at Indiana Wesleyan University, analyses were run to test for correlations between the independent variables (19 instructional strategies) and each of 10 dependent variables (10 meta-skills). The three key findings of the study were as follows:

- Instructional strategies clustered into four identifiable composites, each supported by a current and credible educational theory.
- The curriculum composite of instructional strategies strongly correlated with reported attainment of all 10 meta-skills.
- The assessment composite of instructional strategies correlated with reported attainment of meta-skills.

Important conclusions were that curriculum and assessment require substantial resource investment and attention to design, and that direct meta-skill instruction should be a component of courses offered in formal adult education programmes.

This was a large-scale, rigorously conducted study which used a method that would be worth replicating with undergraduate populations in the UK. Potentially, the method offers prospects of adding very significant knowledge of ‘what works’ in developing the abilities targeted in this study, and what might be facilitating conditions. A limitation of the study is that its conclusions are based solely on student self-report, with no direct tests of self-reported meta-skill attainment.


The authors use the interactive, collaboratively based instruction that worked well in smaller class settings and find ways to economically accommodate classes of up to 100 students.

Relative to students taught in traditional classes, SCALE-UP students are better problem solvers, achieve nearly four times the gain on some conceptual tests, have better attitudes toward science and report greater satisfaction with their instruction. Failure rates for females are half those in regular classes. For minorities, the failure rate drops by a factor of four. Technology is used to provide a phenomenological focus for students, allowing data collection, analysis, mathematical modelling and advanced simulations. As student attention is drawn into analysing different physical situations, teachers circulate around the room and engage students in Socratic dialogues. Lecturing is minimal, primarily for motivation and to provide an overview of topics. The main objectives of the course are presented along with a discussion of some of the instructional techniques employed.


The Student-Centered Activities for Large Enrollment University Physics (SCALE-UP) Project at North Carolina State University (NCSU) is developing a curriculum to promote learning through in-class group activities in introductory physics classes of up to 100 students. The authors are currently in Phase II of the project, using a specially designed multimedia classroom for 54 students to teach the introductory physics course for engineering majors. This is an intermediate step towards the full SCALE-UP classes (99 students) that will be taught when the larger classroom is completed. Both classrooms are designed to encourage students to work in groups of three, provide each group with a laptop computer that has access to the internet and allow instructors to interact with each student group.

Traditional lecture and laboratory sessions are replaced with an integrated approach using active learning cooperative group activities. The project is investigating several aspects of instruction including classroom design, classroom management and curriculum materials. The curriculum materials include adaptation of research-based/informed activities from the literature to the SCALE-UP classroom and the development of new activities.
This paper focuses on the evaluation of the project, in which an important learning objective was that students should begin to develop expert-like problem-solving skills in mathematics and physics. Students were taught expert-like problem-solving strategies. Analysing and interpreting experiments were also important learning objectives.

Evaluation methods of the SCALE-UP classes taught during 1998–2000 include concept tests, individual and group examinations, peer evaluation, video analysis of classroom talk and focus-group interviews. The results show that students are building a better understanding of the main physics concepts, are more successful at solving problems and are generally ‘on task’ and communicating well during group activities. SCALE-UP students showed signs of understanding such strategies in solving problems which are normally considered too difficult for introductory physics classes, and classroom videos showed them asking more thoughtful questions. On examination problems, the SCALE-UP students outperformed the students in the regular lecture programme 88% of the time during one semester and 69% of the time during the following semester. When students in the regular programme outperformed SCALE-UP students, it tended to be on one-step problems like simple unit conversions. SCALE-UP students showed signs of expert-like problem-solving behaviours.


The main aim of this research is to review learning and teaching from a cross-cultural perspective. Aspects such as understanding, the role of memorisation and developing creativity are examined. The background is in research studies that examine students’ approaches to learning.

A meta-analysis is performed on studies in which it has been established whether students adopt ‘deep’, ‘surface’ or ‘achievement’-focused approaches to learning, using inventories as research tools (Biggs’ Learning Process Questionnaire and Entwistle’s Student Process Questionnaire). Using a search of the literature, a database has been constructed for analysis that includes data on over 8000 school and university students from across eight Western and eight non-Western countries. In-depth research on Chinese students, which draws on both quantitative and qualitative perspectives, is used to question the validity of a number of basic Western notions of educational psychology regarding the nature of motivation and the role of memorisation.

Across a range of very different cultures at both school and university level, it has been found that higher-quality learning strategies are associated with higher student self-esteem and internal locus of control. These results are consistent with the theoretical proposition that deeper approaches to learning are more likely to be adopted by students who are confident in their own capacity to learn and accept responsibility for their own learning. Also, deeper learning outcomes are associated with students feeling that they are involved in their classes, have supportive teachers and a fair workload. It has also been found that Chinese educators tend to see both creativity and understanding as slow processes requiring much effort, repetition and attention rather than relatively rapid, insightful processes. Consequently, while for many British teachers, ‘children learn through being creative’, Chinese teachers see the process in reverse. It is concluded that educators need to look more seriously at the validity of reforms designed to encourage more independent, creative learning outcomes in relation to their cultural context.

This research has significance for thinking skills and pedagogy in post-16 learning contexts because first, it examines systematically the often-overlooked issue of cultural differences in relation to teaching and learning approaches; and second, the findings relate directly to issues concerning how teachers might actively seek to develop deep understanding and creativity in their students. It also has a sound theoretical grounding, particularly in relation to the body of evidence on students’ motivation to learn.

4 Research whose purpose is to examine and synthesise knowledge relevant to pedagogy for teaching thinking


Although Moshman and Geil’s study is important for its demonstration that peer interaction benefited post-16 participants in thinking through a problem which has been extensively researched, it cannot be classified as one of the three types of programme described above. Wason’s ‘selection task’ (or ‘four card’) problem makes high demands on aspects of logical thinking that, according to research, are required in handling many everyday and workplace problems. It is a problem that typically defeats over 90% of graduates (see Johnson-Laird and Byrne 1991). Detailed analysis of the dialogue of pairs of participants as they set about jointly solving this task illustrates how even very abstract and difficult logical problems can be jointly solved through the mechanism of arguing, implying that practice in argument skills enhances reasoning performance.

The aim was to review and propose alternative interpretations of the results of European and North American studies on children’s and adults’ misconceptions about mathematical and scientific concepts. These studies have been interpreted in the light of theoretical frameworks about alternative conceptions. From a rigorous methodology, the authors derive different interpretations of the same results, in terms of people using ‘intuitive rules’. For example, post-16 biology students were asked to say whether or not the time required to cool the same amount of milk in a baby’s bottle would vary according to the shape of the bottle. Approximately one third of the students abandoned what they had learned about ratio of surface area to volume in favour of an ‘intuitive rule’ that provides the wrong answer.

The point of this research paper is that if educators are aware of ‘intuitive rules’ that students might invoke, and take appropriate pedagogical action to help them to revise such rules, students will be saved from failure in programmes requiring the application of mathematical and scientific concepts. It is suggested that educators provide examples of when the ‘intuitive rules’ apply and when they do not apply.

There are many post-16 programmes in which drop-out rates could be reduced if staff were to apply the messages in this study.


From sophisticated statistical analysis of scores on two standardised inventories, this study examined whether 210 Spanish college students’ learning styles (LS) and thinking styles (TS) were interrelated, and if these could predict academic achievement.

The results indicated that students’ learning styles (LS) and thinking styles (TS) were inter-related, but that TS accounts for much more of the variance in achievement than LS, and that students’ academic achievement was influenced by their styles. The authors urge caution in interpreting their data since the Learning Styles Questionnaire (LSQ; Marshall and Merrit, 1986, based on Kolb’s learning styles inventory [LSI], 1984) which they used has shown a fairly limited relationship with other current measurement instruments of learning styles. They point out that relationships between learning and thinking styles are complex, since both styles are influenced by many variables which need to be researched in depth. From this analysis, the authors conclude that the Sternberg Thinking Styles Inventory (Sternberg 1997) can be used as an efficient instrument.

The authors conclude that thinking styles that do not lead to good learning are rewarded in most parts of higher education through assessment systems. This conclusion can be reached also about the FE sector. Students in this study with a thinking style that predisposed them to tasks in which it is possible to work independently from others, in which a guideline can be followed and which require no planning of strategies, ideas or tasks were those who obtained highest grades.

This study produced some of the most secure knowledge about the questions it addressed and provides a valuable literature review.


Langer’s book on presenting content ‘mindfully’ – reviewed by Pithers and Soden (2000a) – is consistent with Perkins’ (1993) ideas about the use of generative topics in teaching for understanding. Langer identifies ‘myths’ about learning to think critically which are similar to Sternberg’s (1987) ‘fallacies’ and suggests how they should be addressed: for example, he presses the importance of acknowledging to students that truth may be fluid and context-dependent.


This paper reviews the contextual pressures and personal dilemmas that exist for many academics considering the development of transferable skills teaching. After discussing a range of pressures and dilemmas, the author considers the possible different responses to the calls for transferable skills before going on to investigate what transferable skills are, and the diversity and synthesis which can exist between them and more traditional university activities. There is a very useful discussion of debates in the literature about the merits of different ways of characterising transferable skills. The interesting point is made that it is perhaps necessary to question whether many universities have not been teaching ‘transferable skills’ for some time, if such skills include surveying, questioning, interpreting and integrating material, all of which involve thinking critically about it.
relevant resonate with those reached by Soden and Halliday (2000), reviewed in Sub-section 2.2.10, and the learning described by Fieldhouse could be achieved through the pedagogy described by Soden and Halliday.

Drawing on Bruening (1997), the author argues for a fundamental revision of the curriculum of formal adult education to make ‘transferable skills of citizenship’ the heart of that curriculum. These skills include ‘...the ability to identify problems, find information, locate issues in a political and social context, to develop the sense of worth of the individual through both a knowledge that they have something worthwhile to say and the ability to speak in a way that will be heard; and to be able to work effectively in groups to achieve common goals and to be able to deal with difference, diversity and, at times, conflict.’

This paper from ‘empiricists’ and ‘realists’ offers an analysis of what it means to educate people, deconstructing critically ideas in the Dearing Report (NCIHE 1997). Conceptualising higher education as a project which gives students the means of thinking things through, the authors argue against a vocational education which encourages students to accept whatever is socially demanded, and for an education that helps students to come to an ‘understanding of things in a systematic way’. They assert that all students should have experience of critical thinking across the full academic spectrum from science to the arts. The authors then outline specific educational policies which, they argue, stem from their analysis.

The paper discusses how geography can be taught in ways which realise the authors’ vision of good education. Its broad description of methods is consistent with empirically derived findings about good practice in developing students’ thinking.

This is an important paper for those who plan staff development programmes in that it offers an analysis of what educators might be trying to develop in students. Without such an analysis, staff development can easily degenerate into a series of ‘quick fix’ approaches to teaching. It resonates with other papers in this sub-section in its insistence that teachers must be thinkers themselves if the vision is to be realised of enhancing students’ thinking, and that teachers should ‘think out loud’.

Embedding transferable skills in the adult education curriculum. Adults Learning, 9(5), 12–14.

The main thrust of this article is what should be taught, rather than pedagogy. Its conclusions about what is relevant resonate with those reached by Soden and Halliday (2000), reviewed in Sub-section 2.2.10, and the learning described by Fieldhouse could be achieved through the pedagogy described by Soden and Halliday.


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The author is one of the most prestigious researchers on critical thinking in the US, and her paper proceeds from a sound, extensive research basis. Halpern proposes a skills approach to critical thinking and bases her paper on two assumptions concerning teaching and learning thinking skills:

- that there are clearly identifiable and definable thinking skills that students can be taught to recognise and apply appropriately
- if these thinking skills are recognised and applied, the students will be more effective thinkers.

Accepting these assumptions, the author proposes a four-part empirically based model for teaching thinking skills that, according to her, will transfer across domains of knowledge. The four parts of the model are:

- a dispositional or attitudinal component to prepare learners for effortful cognitive work
- instruction in and practice with critical thinking skills
- training in the structural aspects of problems and arguments to facilitate transfer across all contexts
- a metacognitive component used to direct and assess thinking.

The author argues that although thinking always occurs within a domain of knowledge, the usual methods that are used for teaching content matter are not optimal for teaching thinking skills that can be used in multiple domains, because the instruction in most courses focuses on content knowledge instead of transferability of critical thinking skills. Furthermore, Halpern suggests that critical thinking requires the conscious exertion of mental effort and that learners need to understand and be prepared for this effort so that they do not abandon the process too soon. Consequently, thinking skills need to be explicitly and consciously taught and then used with many types of example so that the skill aspect and its appropriate use are clarified and emphasised.

Her argument in relation to the first part of the model centres on her belief that critical thinking is more than the successful use of a particular skill in an appropriate context. It is also an attitude or disposition to recognise when a skill is needed and there must be willingness to apply it. Halpern identifies five dispositions or attitudes that she believes learners require in order to be effective critical thinkers. She emphasises that it is important to separate the disposition or willingness to think critically from the ability to think critically. Some people may have the ability to think critically, but choose not to put in the effort to do so.
Halpern offers a short taxonomy of critical thinking, namely:

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

The suggestion is that thinking skills instruction can be organised around the categories and skills listed in the taxonomy.

This paper raises many interesting points concerning the teaching of thinking skills. It is unfortunate that evidence to support the effective use of the four-part model proposed by Halpern is not detailed in this paper. She does say that there are numerous, qualitatively different types of evidence showing that students can become better thinkers as a result of appropriate instruction. Indicators of positive change include self-reports, gains in adult cognitive development, higher scores on commercially available and research versions of tests of critical thinking, superior responses to novel, open-ended questions (graded blindly - without the rater knowing if the student received instruction in critical thinking), and changes in the organisation of information. However, the paper does not indicate the use of any of these techniques to evaluate the model proposed. A study following a cohort of students who had engaged in the instruction process as outlined by Halpern would have made for interesting reading. Effective transfer across domains is implied in the paper, but the evidence to support this claim is not provided.

The model offered reflects a view of thinking as a generic ability that transcends subject matter. For those who accept this view, the model is a useful one for informing empirical research. For participants in CPD programmes in the post-school sector, the article is useful for illustrating the instructional consequences of working with certain sets of assumptions about the nature of thinking and how its development might be facilitated.

The author builds a case for a careful re-examination of what it means to teach students to think critically. He alleges that three noteworthy studies of higher-order thinking programmes rest on fallacious assumptions. Leming discusses these assumptions and goes on to propose an approach to higher-order thinking entitled ‘reflective judgement’ which, he claims, is a more realistic and attainable approach.

Participants in CPD programmes in the post-school sector would do well to engage with the author's discussion of the fallacious assumptions on which some programmes rest, and to debate his proposed way forward. Having engaged in such exploration, they would be in a better position to judge the merits of approaches to teaching thinking that are often included in CPD activities.


As in the Halpern paper reviewed at 4.8, the authors view thinking as a generic ability that transcends subject matter. They assert that becoming adept at understanding the logic of subjects, issues and questions is a competency that, once learned, becomes a foundation for highly skilled and practical teaching and learning. They promote the idea of teaching students to seek the logic of things through the logic of science. Keefer (1996) points out the limitations of this view of thinking.

Richard Paul has an international reputation as a leading researcher in this area. This article is useful for introducing participants in CPD programmes in the post-school sector to certain sets of assumptions about the nature of thinking and how its development might be facilitated. Other texts reviewed in this sub-section provide different sets of assumptions. What is important in CPD programmes is that participants explore a range of assumptions and their implications for teaching thinking.


From her review of critical thinking instruction in HE classrooms since previous articles (1980, 1987) on this topic, Halpern concludes that changes in technology and workplace requirements have made the ability to think critically more important than ever. There is an examination of definitions and assumptions, web-based teaching guides, dispositions for critical thinking, the author's model of critical thinking instruction and applications of cognitive psychology.
This article provides useful analyses of three widely held conceptions of critical thinking: as one or more skills, as mental processes and as sets of procedures. The authors consider each a misconception and offer alternative proposals for teaching critical thinking.

The ‘career preparedness’ component of British Columbia’s career and personal planning curriculum (CAPP) curriculum commits two fundamental category mistakes in its classification of employability skills, both with potentially serious consequences for education. The first type of category mistake is incorrectly conflating distinct categories of concepts under the general rubric of generic skills and thereby disregarding the contextual understanding, background knowledge and epistemic attitudes required to achieve certain desired cognitive competencies. Concepts describing mental processes such as understanding, problem solving and critical thinking are applied in the same logical fashion as those denoting physical operations. Their evaluation in the prescribed fashion presents insurmountable difficulties for teachers since mental process concepts are inseparable from the context in which they are used. CAPP makes available no pedagogical approaches that include: a context for, and adequate background knowledge of, the problem to be solved; adequate content knowledge of the subject being communicated and the context in which the communicative act occurs; or facts relevant to the matter being critiqued. The second type of category mistake committed by CAPP is including values and attitudes under the rubric of generic employability skills and, in so doing, obscuring important ethical distinctions between the contentious area of values education and basic skills instruction.

Haroutunian-Gordon says that analysis of transcripts of interpretative discussions reveals that the remarks that people make are not random. The creation of shared meaning seems to proceed by forming questions – by uncovering what people believe the text to be saying and, in so doing, creating questions that presuppose the existence of certain conditions. Clusters of questions (a basic question and follow-up questions) emerge as people follow certain patterns of discovering and creating meaning that can be identified. In order to make her point, Haroutunian-Gordon uses three texts (one literary, one musical and one classroom exchange) which she claims function as analogies that suggest a way in which reflective thinking, as it occurs in interpretative discussion, proceeds.

Although the evidence to support Haroutunian-Gordon’s claims is thin, it does add support for Guest’s (2000) argument for the use of discussion and debate in the development of thinking skills.

Leat’s article explores the reasons why classrooms are so resistant to the kind of change that thinking skills programmes demand, through the consideration of a number of constructs of teacher development and the voices of teachers who have been involved in teaching thinking interventions. Teachers generally feel that they have been through a period of intense change, whereas classroom researchers find it difficult to find evidence of that change. He cites Tangerud and Wallin (1986), who suggest that by and large, schools have not changed fundamentally over some decades. Leat suggests that there seems to be a heartstone in classroom interaction that is incredibly enduring and makes some forms of educational change extremely problematic. When he claims that, in general, innovative programmes fail to make a lasting impact in the classroom, he is implying that the lack of impact of thinking skills programmes is no different from any of the other programmes of change. Leat does, however, suggest that there are features of thinking skills programmes that provide particular difficulty. His article focuses on individual teachers’ classroom practice rather than institutional or cultural barriers to change.
Before discussing a number of factors regarding the reasons why thinking skills programmes face an uphill struggle to be embedded in the school curriculum, he sets out some of the principles of thinking skills (TS) programmes identified by Baumfield et al. (1995).

- They change the learner - in general, they are constructivist in origin.
- They make students transfer their learning - they usually specify a stage at the end of activities where the teacher supports students to make links between what they have just learned and other contexts, a process known as bridging.
- They promote learning with others – programmes assume cooperative learning where ideas are shared and understanding develops through discussion. Vygotsky's concept of the zone of proximal development (ZPD) is invoked – students are assisted in their performance by more able peers and adults.
- They encourage students to regulate their behaviour.
- They challenge the learner.
- They are carefully structured to employ measures to ease students into tasks and to establish personal meaning for the learners.
- They develop core concepts and skills such as concept formation, enquiry and reasoning skills, which better equip students to be independent learners.
- They make students think about thinking – not only are students asked for their answers, they are also asked to describe and explain how they have done the task, thus exposing their cognitive processes.

Leat claims that a powerful set of socialisation factors is at work in schools which influences teacher and pupil behaviour and explains their resistance to change. He provides evidence to support this claim by providing a selection of teachers' comments. For example, 'The activities, although often apparently straightforward, usually require a certain way of thinking and depth of thought which pupils are simply not accustomed to. It is therefore necessary to “train” children to learn in a different way... ' (1999, 391).

He draws attention to discourse pattern in the classroom and suggests that it is one of the key features that affect teacher and pupil willingness and capacity to engage in new activities. He says that the established discourse pattern is one where the teacher initiates (I) usually via a question, pupils respond (R) and the teacher provides feedback (F). He suggests that teaching thinking skills demands a change in this I-R-F pattern in order to allow pupils to initiate the questions. Without this change, he says that many of the principles identified by Baumfield et al. (1995) may not be successfully implemented in classroom practice.

Leat points out that TS programmes often depend on cooperative group work, in which understanding is constructed through discussion. To be successful, cooperative activities require pupils to cooperate and listen. The reality of the classroom suggests that this is not likely to be the case in all circumstances. He says that when TS programmes run into problems, socialising forces will encourage teachers to return to a default mode. In this scenario, they are likely to return to a traditional discourse pattern.

New and more demanding activities that ask pupils to take more responsibility and make decisions are far more problematic for the teacher to organise and control. Leat suggests that to introduce a major innovation into the classroom risks disruption to the flow of activities and jeopardises the chances of order. He cites a report from a teacher who found his experiences of using TS principles de-skilling. TS programmes place demands on teachers to develop new teaching strategies and may threaten the identity of teachers who wish to hold fast to the notion of ‘teacher-expert’. He says that in all sorts of ways, teachers are having to refine their craft knowledge.

Leat also highlights the importance of subject knowledge. He suggests that the intention of infusion programmes such as TS programmes may run counter to the usual subject-related intentions of teachers. Many teachers who feel secure in the pedagogical content knowledge associated with their subject may feel unprepared for the demands imposed by the greater emphasis on process.

Another difficulty which the author raises relates to the need to alter long-standing images of what teaching is and prior perceptions of models of teaching which do not equate with the TS programme. According to Leat, understanding of children's learning hardly featured in many prior models of teaching and established patterns of behaviour can be very hard to change. He emphasises that the whole process of change is emotionally charged and some teachers experience greater difficulty than others. He cites Robinson et al. (1991), who suggest that teachers differ in the extent to which they are prepared to take risks.

According to Hargreaves (1992), cited by Leat, the teacher is the ultimate key to educational change and improvement. The paper suggests that individual teachers face some difficult challenges in introducing TS programmes. Leat says that they require a conceptualisation of teaching and their subject(s) that accommodates an emphasis on developing learning skills, reasoning patterns and transfer. They have to be determined enough to overcome any resistance from their pupils and they need to establish a classroom discourse which encourages pupils to initiate, speculate and accept that there is not one right answer. Teachers need to be able to maintain this style when there may be pressure to be more didactic, and they need to be able to defend and justify their approach in the face of scepticism, indifference and ignorance.
Leat concludes by emphasising that teacher efficacy has been identified as the factor that best predicts the success of programme implementation (citing Woolfolk and Hoy 1990). He says that personal efficacy is the belief that one has the skills to implement change; outcome efficacy is the belief that when the skills are implemented, they will lead to desirable outcomes; and teaching efficacy is the belief that one can overcome outside influences. He points out that even if a teacher has the appropriate conceptual structures for TS, personal efficacy and outcome efficacy are not sufficient for implementing TS programmes. The teacher must believe that he or she can overcome all the problems that the teaching environment poses.

This is an interesting paper that raises many points which require further consideration if the implementation of thinking skills programmes is to be effective. Leat is emphasising that it is not enough to consider the different approaches to teaching thinking in isolation. One must consider the whole learning and teaching environment and the range of factors that will have an impact on new learning and teaching strategies and ultimately determine their success or failure.


In the field of engineering design, Sadowski and Connolly discuss the need to develop creative thinking in students, and examine the nature of the creative thinking process, linking creativity to problem solving. They draw out some principles for the design of the curriculum and learning environment, but do not go beyond this.

5 Studies describing teachers’ thinking skills or conceptions relevant to teaching thinking skills


The purpose of this paper is to study differences between the two genders’ perceptions of mathematical and scientific higher-order thinking, ways of identifying when higher-order thinking occurs, and methods of mathematical and scientific enquiry that assist in developing higher-level thinking in 13-year-old students. Main considerations included the identification and definition of the role of enquiry in developing higher-order thinking skills in boys and girls, and children’s perceptions of mathematics and science topics.

The useful review of literature on how to develop enquiry-based teaching, with plenty of practical suggestions, together with a theoretical justification in terms of Piagetian and Vygotskian research, make this paper a valuable resource for teachers, particularly those who teach mathematics and science topics. Some of Kelly’s points about changes required in teacher/pupil relationships echo those made in the Prior (2000) article reviewed in Sub-section 2.2.7.

The intervention with 17 pre-service teachers that is described in this paper involved the teachers’ ‘overall immersion’ in enquiry teaching. Each participant was required to teach a minimum of three enquiry-based lessons over a 12-week period at 2–3 week intervals and to engage in written metacognitive reflection. The author reports that at the beginning of this study, most teachers did not see the purpose of enquiry methods. A secondary approach required teachers to work with a specified number of boys and girls in order to understand gender perceptions of enquiry. Rigorous evaluation, which included complex statistical analysis of appropriate data, led to some interesting conclusions which are also found in other literature. These conclusions include the following points: teachers should be encouraged to use active listening to hear what students are saying when they work together; teaching should be directed towards clarifying students’ conceptions of what science is. Both genders of students maintained similar perceptions about enquiry and approaches to higher-order thinking, thereby suggesting that there is little reason to suppose that females perceive such thinking as gender-inappropriate.


Soden and Maclellan explored the extent to which 32 UK teachers engaged in thinking critically – in writing about learning, in the context of their practice, and during an in-service programme in which the pedagogy was compatible with critical thinking. The results suggest that the teachers rarely evaluated evidence they cited in the light of appropriate criteria, a behaviour that appears in most definitions of critical thinking. This finding implies that the teachers are unlikely to be effective in promoting such thinking in students.

Arguing that it may be important to plan development programmes to enhance the level of teachers’ own critical thinking, Pithers and Soden attempted to find a starting point by assessing some critical thinking skills in a population of 256 Scottish and Australian vocational education tutors who were enrolled in university teacher education programmes. They used the Smith-Whetton Critical Reasoning Test (CRT), a reasonably valid and reliable standardised psychological test. The results suggest that developing the teachers’ own critical thinking skills might be a necessary initial step in preparing them to help students to think well.


The purpose of this study of 40 Israeli teachers of 14–18 year olds was to characterise patterns of their beliefs regarding low-achieving students and instruction in thinking skills. From rigorous content analyses of transcripts of semi-structured interviews, based around a specific pedagogical task, the authors concluded that 45% of the teachers in the sample believed that higher-order thinking is inappropriate for ‘low-achieving’ students. Their findings are consistent with other research studies they cite which imply that teachers’ beliefs contribute to differences in achievement, because they dispose teachers to expose ‘low-achieving’ students to learning tasks that require little thinking.

This area of research has important implications for post-school education, particularly in National Certificate courses in the FE sector which attract students who have not prospered in the school system. Particularly relevant is the finding that the impact of teachers’ beliefs was more marked when the researchers compared teachers’ accounts of working with classes of different academic levels. If students are not encouraged to think well in National Certificate courses, they will be ill prepared for Higher National Certificate (HNC) work, and might not even aspire to it if learning goals in the first year are uninteresting.

There is a danger in such courses that teachers with beliefs similar to those described in this study will interpret requirements that students make, install or repair artefacts of some kind as exonerating the teacher from using the production process as a vehicle for developing thinking skills.


When considering the nature of creative thinking, Puccio and Murdock begin by examining the broader construct of creativity. They view creativity as not being limited to one theory, model, definition, concept or approach (and point to the dizzying array of definitions that exist); and consider that it is best understood through a dynamic, multifaceted perspective. They argue that a simple, brief definition of creativity cannot serve well in all circumstances and for all purposes. Nevertheless, there is agreement among many scholars that the multifaceted nature of creativity involves at least four discrete elements concerned with, in turn: the characteristics and skills associated with the creative person; the stages of thinking that comprise the creative process; the qualities of the creative product; and the nature of the environment that is conducive to creative thought. The term ‘creative thinking’ is thus most closely associated with the process element.

Puccio and Murdock stress the ubiquitous nature of creative thinking, since every problem that has no preset solution, and every opportunity that has no prescribed pathway to success, demands creative thinking. Referring to the research evidence, the link is also made between being able to use one’s creative thinking skills, for example, in work environments, and well-being and good mental health.

When it comes to the question of how to nurture creative thinking skills, the three basic elements of problem defining, idea generation, and solution development and implementation are focused upon within a general problem-solving model (Creative Problem Solving or CPS). Both divergent thinking (a broad search for many diverse options) and convergent thinking (focused search and selection) are invoked in this process; and, in addition, metacognitive processes are engaged. The set of skills which is developed through this process can be classified as cognitive, affective and metacognitive. The cognitive skills are closely aligned with the stages of the process; for example, in relation to problem defining and idea generation, the following skills can be developed – identifying problems and opportunities, asking better and different questions, judging relevant from irrelevant data, isolating productive problems and opportunities, etc. Examples of the affective skills are developing tolerance for ambiguity and engaging in playful thought and behaviour. Examples of metacognitive skills are strategic planning, goal setting and decision making.
Bringing these various elements together, they define creative thinking in the following broad terms (2001, 70–71):

- Creative thinking is an essential life skill. It is a rational process that enables people to successfully produce novel and useful responses to open-ended challenges and opportunities.
- Creative thinking involves specific cognitive, metacognitive, and affective skills. Once internalised, these skills can be readily applied to all areas of life.
- Creative thinking is subsumed within the domain of creativity and reflects the inherent multifaceted nature of this broader construct. Thus, although creative thinking is at first an individual process, it is affected by such factors as the surrounding environment and the task at hand.
- Finally, creative thinking is not rare. All normally functioning people have the ability to think creatively. Moreover, this ability can be taught and enhanced through such methods as CPS (Creative Problem Solving).


Treffinger and Isaksen's view of teaching for creative learning is broadly in alignment with Puccio and Murdock's (2001) definition of creative thinking, although the former place greater emphasis on the characteristics of the individual learner. They view teaching for creative learning as a process involving: the provision of instruction in methods and tools; establishing an environment for these to be learned, practised and applied and for metacognition to develop; and differentiating instruction appropriately to learner characteristics and styles.

They trace five decades of developments in creativity research, from an initial focus in the mid-20th century on developing divergent thinking through using open-ended exercises – Torrance's fluency, flexibility, originality and elaboration (1962, 1966) and Osborn's emphasis (1953) on deferred judgement and brainstorming were influential – to the nurturing, in the 1970s and 1980s, of more complex skills and processes such as creative and critical thinking, problem solving and decision making. By the 1980s, researchers had established the following characteristics of creativity.

- It is complex and multifaceted.
- It does not reside solely within the individual – rather, it arises from the complex and interdependent interactions among each person's characteristics, the operations each is able to perform, the context, and elements of the tasks or outcomes themselves.
- Creativity and problem-solving skills can be taught.

Treffinger and Isaksen discuss the fact that present-day programmes highlight flexibility in process and engagement in real-life problems and challenges. There is an emphasis on a natural, dynamic and flexible approach to creative problem solving linked to people's needs and tasks, rather than always deploying a single fixed set of steps and stages. They propose a systematic model for instruction, comprising the three components of teaching the fundamental tools for generating or focusing options, guiding students to working on realistic tasks, and dealing with real-life challenges and problems.

When considering how best to nurture creativity, they argue that it is necessary for researchers to explore the complex and varied interactions among learner characteristics, process variables and situational or contextual variables. There needs also to be a better understanding of how to make creativity instruction more responsive to learner characteristics and styles, and to variables involving the situational context. Another issue that could benefit from further research is to distinguish among several possible levels of complexity, from simple tools for generating or focusing options or ideas, to more extensive and sophisticated frameworks for productive thinking. There is also the question of the methodology: whether direct instruction – teaching creativity as a stand-alone set of tools – or infusion is more effective.


Neill's appraisal of assessment-driven school reform in the US is highly critical of current testing practices. Neill argues that the 'high stakes' testing on which many states are beginning to rely is a clear instance of test misuse, since multiple sources of information should be used for determining key decisions affecting students. From evidence of scores on national surveys of achievement and state tests in the US, he argues that tests do not lead to improved learning. Teaching to the test means focusing on the tested sample rather than on the whole subject, and as test score gains cease to be valid measures of broader learning, the results mislead the public about educational achievement.
While few states claim factual recall and basic procedures as their goal, this is nevertheless what their tests seem designed to measure. The typical state writing examination is dismissed by Neill (2001, 513) as ‘a completely formulaic exercise in the irrelevant’, which controls how writing is taught, leaving many students unable to communicate well for a variety of purposes and ‘switched off’ from writing. He argues (2001, 513) that the tests cannot easily be fixed: ‘...multiple-choice items cannot assess most higher-level skills, short-answer items provide no space for real thought, and “extended response” items consistently embody narrow cultural experiences, triviality, or are even nonsensical.’

According to Neill, ‘high stakes’ tests intensify the problem because they increase the imperative to teach to these flawed instruments; and when the tests are made difficult, they increase the drop-out rate, especially among ethnic minority students. What makes the tests difficult is that they demand memorisation of masses of information, not thinking, and items are made difficult by their obscurity, not their cognitive rigour. To avoid the ‘insane overload’ of most state standards imposed in a ‘one size fits all’ manner, Neill recommends the use of local authentic assessments that focus on an essential, but limited, body of knowledge, and on skills and habits of mind.

6

Studies of transfer of thinking skills from one domain to another

6.1
On the road to transfer: an introduction.

This brief review article was written for a special issue of the International Journal of Educational Research which addressed problems about transfer of learning and which was based on a symposium at the 24th International Congress of Applied Psychology in August 1998. It provides a brief, but powerful, analysis of the concept of transfer and outlines the five chapters plus a final commentary included in this special issue of the journal. De Corte points out that the five chapters contribute to unravelling the learner characteristics, task components, and context variables (including instruction) that individually and collectively, can facilitate or inhibit the occurrence of transfer. Several theoretical and empirical approaches are taken in the issue. De Corte sees this diversity as a help rather than a hindrance.

6.2

The following articles were outlined by De Corte (1999; see 6.1 above).

6.2.1
Alexander P and Murphy K (1999).

The authors review five generalisations about transfer drawn from the extensive literature on transfer, domain learning and analogical reasoning. Against this background, they derive from their research on domain-specific learning three fundamental learner characteristics as the seeds of transfer:

- subject-matter knowledge
- general cognitive and metacognitive strategies
- motivation.

They discuss three instructional barriers to transfer and offer three recommendations for enhancing transfer. The barriers are:

- mentioning versus teaching: that is, failure to encourage in-depth study of important domain concepts
- instructional enabling: entails the tacit agreement between teachers and students whereby students are not academically challenged, but are given high marks if they perform well on relatively undemanding tasks
- decontextualised and disconnected instruction.

The three recommendations for enhancing transfer are:

- stage a three-pronged attack
- strive for principled understanding
- model and reward analogical thinking.

6.2.2

Simons initially distinguishes three types of transfer that have much in common: from prior knowledge to learning, from learning to new learning, and from learning to application. It is argued that in all three cases, learners are confronted with paradoxes - seemingly contradictory positions they have to be able to deal with in order to achieve transfer. Six such paradoxes are discussed, such as the paradox of finding prior knowledge, which knowledge to use and which to ignore. For each of the three kinds of transfer, illustrative studies are reviewed, showing how instruction can help learners to solve the paradoxes.

Stark et al. identify several difficulties that students experience when applying their acquired knowledge. They report on experiments on the potential of a variety of instructional variables to foster the transfer of knowledge of management and accounting in post-school students; for example, multi-staged problem-solving guidance versus no guidance, worked-out examples and example elaboration.


Mayer analyses the conditions under which multimedia learning environments can promote problem-solving transfer (e.g. content is presented as verbal narration or text, or as visual illustrations or animations). Starting from a cognitive theory of multimedia learning, a series of design principles for multimedia instructional messages is presented. More than 40 studies are briefly reviewed in which these principles were systematically tested. The results suggest that problem-solving transfer can be enhanced by helping students to connect verbal explanations with visual representations.


Volet's focus is the broader socio-cultural context and this focus is elaborated in the final chapter by Hatano and Greeno: both articles are informed by situated perspectives. They propose to use the term productivity instead of transfer to refer to the generality of learning. They criticise approaches to transfer which focus too exclusively on the initial phase of learning and the resulting acquired knowledge.

7 Reviews and studies of learning to think conducted in upper primary and secondary education

7.1 Reviews of literature


The focus of this analysis is on the aspects of this review that appear to be most salient for post-16 learners. Two of its aims are to identify current approaches to developing children’s thinking and to evaluate their effectiveness, and to consider how teachers might be able to integrate thinking skills into their teaching. The report does not discuss the strategies used to conduct the literature search.

McGuinness develops the theme that earlier attempts to teach thinking took the form of ‘bolt-on’ thinking skills programmes focused on enhancing students’ cognitive achievements, while more recent attempts have focused on thinking classrooms. This trend has been revealed by evaluations and an emerging conceptual analysis of successful teaching methodologies.

A set of core concepts which underpins frameworks for developing thinking skills is identified (this paragraph draws on McGuinness 1999): the idea that learners are active creators of their knowledge and frameworks of interpretation; the value of focusing on thinking skills to support active cognitive processing which makes for better learning; being explicit about what we mean by better forms of thinking and of educating directly for thinking; the availability of a range of taxonomies of thinking; using tasks which are not routine to develop high-quality thinking; giving learners time and opportunity to talk about thinking processes and to acquire metacognitive skills; designing socially mediated activities from a thinking skills perspective; creating dispositions for good thinking; and teacher development.

A three-way classification of approaches to developing thinking is adopted.

- **General** (later referred to as structured): this category is sub-divided into context-independent, e.g. Feuerstein’s Instrumental Enrichment programme (Feuerstein et al. 1980); and context-dependent, e.g. Cognitive Acceleration through Science Education (CASE) (Adey and Shayer 1994).
- **Subject-specific**: thinking associated with a discipline or domain (e.g. problem solving in mathematics, enquiry skills in science).
- **Infusion**: teaching thinking is infused across all areas of the curriculum.
Each approach has associated with it particular problems in seeking to maximise transfer effects. McGuinness notes that if general thinking skills (context-independent) are targeted in a separate programme in the curriculum, they may become ‘locked in’ and fail to transfer into the mainstream curriculum; and the same risks are associated with programmes confined to one discipline. On the other hand, infusion runs the risk that the thinking skills get lost in the midst of subject knowledge-based teaching.

In the review of general programmes with particular reference to the UK context, McGuinness discusses Blagg, Lewis and Ballinger's (1994) Thinking and learning at work (see Section 2.2.13 of this appendix), which is an extension of the Somerset Thinking Skills Course into occupational settings. Evaluations show positive effects on a range of cognitive and affective outcomes. McGuinness highlights CASE as providing a very strong model for successful cognitive interventions: characterised by strong theoretical underpinning, well-designed and contextualised materials, explicit pedagogy including the use of bridging in order to promote transfer of a thinking skill learned in one context to others, teacher support and programme evaluation. Although CASE is designed for 11–14 year olds, this general model has clear applicability to interventions designed for post-16 learners.

McGuinness notes that domain-specific interventions within a thinking skills framework are particularly evident in the sciences and mathematics and, increasingly, in history and geography. Schoenfeld's (1985) method of teaching mathematical problem solving to college students in the US, which focuses on specific mathematical knowledge, heuristics (eg analyse the problem, draw a diagram, etc), metacognitive skills and affective components such as attitudes and beliefs about mathematics and mathematics learning, has been evaluated as effective in equipping students to solve both familiar and unfamiliar problems. These aspects, when combined with a focus on realistic and authentic contexts, could be brought out in relation to problem solving in other domains for post-16 learners.

De Corte (1990) has developed the concept of powerful learning environments (initially explored within a LOGO environment) which have been successful at promoting higher-order thinking and transfer of learning to new contexts in both mathematics and science. These are characterised by a good balance between discovery learning and personal exploration on the one hand, and systematic guidance and instruction on the other. Teaching strategies include modelling, coaching and 'scaffolding', exploration in small groups, and encouraging students to articulate as clearly as possible the procedures that they used. In history, an evaluation of History 13–16 (Shemilt 1980) – a schools' council project, where students were introduced to the nature of historical evidence, reasoning from evidence, and problems of reconstruction from partial and mixed evidence – showed increases in students' levels of understanding compared to a control group. However, there has been criticism of the methodology of the evaluation (Wineburg 1996), because it has failed to explain how the ideas were translated into everyday classroom practice.

In geography, Leat (1998) focuses on six ‘big concepts’ which are important for geography learning and teaching (cause and effect, classification, planning, etc). Each lesson targets one or more of these concepts and is designed around a ‘strategy’, like fact or opinion. The approach is adaptable to the age/ability of the group (it has been used with students from Key stage 3 to A-level) and is still being evaluated.

The ACTS Project (Activating Children’s Thinking Skills), which McGuinness herself directed, adapted this cognitive framework and began by analysing the Key stage 2 Northern Ireland curriculum to identify contexts for developing different kinds of thinking (McGuinness et al. 1996, 1997). There is a particular methodology associated with the approach; for example, the use of thinking diagrams that help to make the steps in the thinking process explicit. Project teachers attended six training days and produced between them over 100 infusion lessons demonstrating 10 different thinking strategies. The evaluation focused on teachers’ impressions and opinions of the impact of ACTS on the pupils, and not on the learning outcomes, a limitation which McGuinness highlights in the report.
The key question that must be highlighted for post-16 formal education is whether infusion across the curriculum can be made to work within modular programmes that offer students a choice of modules to study. Not only is the task of mapping particular thinking skills across the different domains more complex, but also the learning experiences of the students are more variable: when attempting to bridge between one domain and another, which domains are common for all students? This suggests an individualised approach. The language in which this endeavour is couched in the post-16 sector is also different – key skills, core skills, generic skills, etc.

The role of ICT in developing thinking is also discussed by McGuinness. She highlights the use of exploratory environments or micro-worlds (eg The Geometer’s Sketchpad), multimedia technology, the potential for peer collaboration and the idea of networking classrooms to create learning communities. However, she cautions that computers alone do not mediate thinking and learning – good software design and an appropriate pedagogy are crucial. Also, many evaluations are from small-scale studies that have been highly supported by research teams or teachers well attuned to the required pedagogy, and therefore transporting the effects to ordinary classrooms may require a new set of considerations. Finally, good infrastructure is important to underpin successful interventions.

Some of the better-known examples of approaches to teaching thinking are outlined and the evidence from evaluations presented. Wilson, following Nisbet (1990), lists specifically designed programmes, and approaches which are embedded/infused in the curriculum (within specific subjects or across the curriculum more generally). This latter category subsumes McGuinness’s ‘subject-specific’ and ‘infused across the curriculum’ categories. There are no new studies encompassed beyond those reviewed by McGuinness. As with the McGuinness review, there is no discussion of the strategies used for conducting the literature search.

The conclusions are broadly in line with those of McGuinness, although Wilson is more cautious about the evidence on the value of teaching thinking skills, preferring to say that ‘the jury is still out’ on this particular issue. In terms of future directions, Wilson highlights the following issues and questions.

- The need for more evidence of outcomes in order to weigh up whether the use of special programmes or infusion is more effective.
- Whether it will be possible to construct a curriculum with core thinking/problem-solving skills without overloading teachers.
- Which are the most appropriate stages for teachers to introduce metacognitive development?
- The potential of ICT to develop accelerated thinking.
- Is there sufficient availability of high-quality teaching/learning materials on core skills suited to the Scottish curriculum?
- What support do teachers need?

7.1.2

Wilson’s discussion paper has a different thrust from the McGuinness review, but nevertheless ends up in similar territory. It poses a series of questions; for example, in Section 2 the overarching question is ‘Can thinking skills be taught?’ which leads into consideration of ‘What does science tell us about thinking?’, ‘What are thinking skills?’ and ‘Why are thinking skills considered to be important?’

The overarching context is set out in the introduction as follows:

- a long history of interest in the workings of the mind by members of disparate disciplines
- a dissatisfaction with the concept of intelligence as one stable measurable quality (Gardner 1993)
- the possibility now with the development of magnetic resonance imaging of observing the brain ‘at work’
- renewed interest in the ways in which children learn; and
- the belief that educationalists can improve children’s thinking with specific interventions.

7.1.3

Some of the studies in this review involve pre-16 learners in Europe and the US. Anderson and Soden note that the relevance of such studies to post-16 education is that many demonstrated that thinking can be improved through peer discussion, although beneficial features of the discussion may vary with the age ranges. A series of studies focuses on subject matter close to that studied in post-16 education.
Patronis, Potari and Spiliotopolou (1999) undertook an ethnographic study of 14-year-old US school students debating a socio-scientific issue (the design of a road in their area). The students worked first individually, then in small debating groups, and finally had to arrive at a whole-class decision concerning the siting of the road and the design of a bridge on that road. Patronis, Potari and Spiliotopolou claimed that the arguments that students used in this context (in which they are, to quote the authors, ‘really involved’) differed from the types of argumentation normally found in science classrooms; in particular, they argued that justifications were more likely to refer to personal experience and ideology. Although the argumentative reasoning skills were practised on socio-scientific knowledge, the researchers intended that such knowledge would become better integrated with values, context and personal knowledge. The reasoning skills seem to be generalisable to many areas of the curriculum and to the workplace. Therefore, the study seems to straddle the domain-specific and infusion categories.

Schwarz et al. (2003) report on a study which, although its participants were children (120 Grade 5 US school students), is worth reviewing because it offers pedagogical ideas which seem helpful to learners of any age and which could be developed as either a discrete or infused programme. The participants completed peer interaction tasks on the topic of animal experimentation, in a 5-stage intervention procedure. In stages 1, 3 and 5, individual participants wrote arguments on the topic. In phase 2, triads of participants debated the topic and at the same time had access to a database of relevant statements (eg ‘A lot of research based on experiments on animals is used to find medication against cancer’; ‘Experiments are often done on animals to develop weapons’) as a resource upon which they could draw when constructing their arguments within the debate. During phase 4, triads in one condition collectively filled in a two-column table with headings ‘pro’ and ‘con’ to help them write a collective essay on the topic. In the other condition, triads used a computerised tool which helped them to draw an ‘argumentative map’ which allowed them to represent arguments as conclusions supported by premises, and display whether particular reasons support or oppose particular conclusions. Again, this was designed to aid the production of a collective essay on the topic, but by representing argument structure, it went beyond the ‘pro’ and ‘con’ table in its capacity to provoke dialogue among the learners.

Several measures were taken of the written arguments based on measures previously used by Means and Voss (1996) and Kuhn, Shaw and Felton (1997). On all measures, individual performance improved as a function of having participated in the group activities. The collective arguments produced during the peer interaction sessions were of superior quality to the individual arguments, and those collective arguments that were produced in the ‘argumentative map’ condition were better in quality than those produced in the ‘pro and con table’ condition. The durability of the gains accrued was not tested, and neither was any generalisation.

7.2 Discrete programmes for teaching general thinking skills (programmes separate from existing components of a curriculum)


Having set the context in a special school for children with social, emotional and behavioural difficulties, the article introduces two central concepts of Instrumental Enrichment (Feuerstein et al. 1980) – structural cognitive modifiability and mediated learning experience. An experiment is then described in which six pupils had four 40-minute periods per week (the duration is not mentioned) on Instrumental Enrichment lessons. A profile of each pupil is given pre- and post-intervention, based on data gathered from teachers. Improvements were observed in five of the pupils against six indicators of progress.

The study focuses on a range of objectives (learning to learn, defining and solving problems while restraining impulsivity, addressing behavioural difficulties). There are also references to improvements in pupils’ school work and general behaviour. In addition to its small scale, a limitation of the research design is that the pupils’ views were not sought. The study may be of relevance in some post-16 settings, and may be of interest because it spans the cognitive and affective domains.


This paper ostensibly reports on research conducted in primary and secondary schools in Slovenia on developing critical thinking (broadly conceived), but fails to explain clearly the research focus, methods or findings. Instead it discusses contextual factors, and relates these to the author’s theoretical stance.
7.3
Programmes in which the main purpose is to improve students’ ability to think with specific subject knowledge

7.3.1
Reynolds Y and Brosnan T (2000).

The article reports on an experiment conducted with children of different ages (between 11 and 18) which has the unusual focus of examining the power of speculative thinking as an aid to developing understanding of chemical changes. It uses computer-produced sentences about four everyday changes in materials, some of which make good science sense (eg When sugar dissolves in water, the sugar disappears) and some of which do not (eg When sugar dissolves in water, the molecules of sugar disappear because they react with the water). It invites the children to indicate for each sentence whether it makes sense to them, does not make sense or might make sense. Students’ accounts of what happened in the four changes were audio taped. Four vignettes are presented of students with contrasting thinking styles. A disposition to move between different levels of thinking was identified in more advanced students. Characteristic of the more speculative styles in younger and older students was the free use of analogy. It is concluded that children’s imaginations are an important resource for understanding chemistry.

The study is discipline-embedded; its key purpose is to develop disciplinary understanding by harnessing children’s imaginations and by fostering open, speculative thinking, and therefore the focus is on thinking to learn. No implications for learning other subject matters are drawn out by the authors. It is a well-focused and well-constructed study, covers a range of age groups, is well theorised within the discipline, and well communicated in the article (although the scientific content makes the sample student responses more difficult for the non-specialist to appraise). Although the authors provide advice on how the approach could be introduced by teachers to ordinary classrooms, the ratio of knowledgeable adults to pupils in ordinary classrooms is vastly different from that in the experiment. The outcome could be much unbridled speculation that is never properly harnessed to build understanding. The study is relevant to post-16 science teaching, and possibly to other fields in which it is helpful to speculate in order to understand more deeply (social subjects or literature, for example). It is of particular interest because of its focus on speculation and imagination.

7.3.2

The argument posited is that pupils should be enabled to ‘think like scientists’ and understand the ‘nature of science’ and for this, it is necessary to have an understanding of the substantive ideas of science and a procedural understanding (the body of knowledge that underpins an understanding of scientific evidence). A summary of concepts of evidence is presented and discussed in relation to the design of biology investigations. The questions of why and how to develop pupils’ procedural understanding are then addressed. It is noted that pupils need to be taught the ideas of importance to a wide range of biology investigations, not just laboratory-based manipulations which have come to dominate current teaching. Work at the University of Durham (Gott and Johnson 1999) demonstrates that the concepts of evidence are ideas that can be taught at secondary school level and BAEd (primary level). They need explicit teaching if pupils are to develop a procedural understanding, using both practical and non-practical activities. Several questions for the future are posed.

The study is discipline-embedded; its key purpose is to develop procedural understanding of biology investigations, and therefore its focus is on thinking to learn. It is theoretically informed, has a practical focus, and is likely to be of value to biology teachers. However, there is no evaluative data presented, other than a reference to a recent paper. The study appears to be relevant to post-16 biology teaching; the concepts of evidence could be re-examined for use in other investigative contexts, and so the ideas are potentially generalisable.
This is a report on an empirical study to investigate possible differences in school students' scientific reasoning abilities relative to their informal learning environments, teaching procedures and scientific instruction (non-enquiry, enquiry). The authors note that research on informal learning is not as ‘researcher friendly’ (due to the difficulty of evaluating heterogeneous subjects, environments, activities and everyday situations) as the traditional classroom arena. Apart from museum activities, children's non-school time is largely unaccounted for in science education research. Available research indicates that informal science learning contains the same fundamental elements that may be present in effective formal learning situations (eg cognitive challenge and social interaction). Therefore it may facilitate the development of reasoning abilities that are prerequisites to learning and understanding science processes and concepts. Enquiry-oriented teaching focuses on providing students with direct experiences with phenomena that induce cognitive conflict and hence encourage learners to develop new knowledge schemes that are better adapted to experience. Practical activities and active discourse form the core of such pedagogical practices. Enquiry-oriented teaching is an adaptation of Bloom's taxonomy (1956) was used. Biology is taught in Israel using an enquiry approach. The second purpose of the study was to assess the amount of enquiry questions students were required to answer. In order to identify teachers’ use of enquiry questions, sub-categories of the TIMSS 1992 IEA coding key were grouped.

The main findings were: from classroom observations, only 18.9% of teachers’ questions in JHS and 26.1% in SHS required students to think, with a higher percentage in lessons which were not teacher-centred and in lessons where many questions were posed. In tests, there was a decrease (since a previous study in 1977) in knowledge-recall questions, from 43% to 18.9%, and in open-ended questions, but an increase in objective questions tapping higher-order thinking. The authors conclude that, although there are many enquiry items in the Israeli matriculation examination, enquiry has not yet become a routine component of biology lessons. While this study does not propose or evaluate innovative methods for assessing thinking, nevertheless it is clearly useful to gain a measure of the extent to which teachers use formative techniques – questioning, homework and routine tests – to engage their students in higher-order thinking. This can serve as a baseline measure within an evaluation of a thinking skills intervention.


This empirical study was conducted in biology classrooms in junior high school (JHS) and senior high school (SHS) in Israel, and involved 23 teachers who opted to participate. Its main purpose was to address the nature and quantity of higher-order thinking activities in classes when teachers were not explicitly ‘teaching for thinking,' but rather were acting and behaving routinely. This involved an analysis of teachers’ questions, posed during class, in homework assignments and in tests. In order to identify the cognitive levels of questions, an adaptation of Bloom's taxonomy (1956) was used. Biology is taught in Israel using an enquiry approach. The second purpose of the study was to assess the amount of enquiry questions students were required to answer. In order to identify teachers’ use of enquiry questions, sub-categories of the TIMSS 1992 IEA coding key were grouped.

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The study involved 505 students, selected from a larger sample of 1178 students from Grades 7–10. The study selected for the study (approximately 50% of the original sample) were those with impoverished informal learning environments and those with enriched informal learning environments. Those with mid-range learning environments were removed. Data gathering instruments included: an Informal Learning Opportunities Assay (ILOA) (41-item questionnaire) which covered a wide range of activities and yielded quantitative and qualitative data; a 12-item written classroom test of scientific reasoning; and interviews with teachers to identify them as an enquiry or non-enquiry science teacher. A two-way ANOVA (Analysis of Variance) was conducted to examine possible differences in students’ scientific reasoning relative to informal learning environments and classroom teaching procedures. Students with enriched informal learning environments scored significantly higher than students with impoverished informal learning environments. Students taught by enquiry scored significantly higher than students taught by non-enquiry. There was no significant interaction between learning environment and teaching procedure.
The article reports on the development of a CASE-style lesson for Key stage 4. There is brief reference to CASE, the five components of a CASE lesson, and Piaget’s concrete and formal operational stages. The term ‘bridging’ in the title is used to mean designing a lesson along CASE lines. There is a discussion of the preparation of the learning resources, and a brief mention of piloting (eg ‘The acetate sheets and cards needed to have the nucleus marked more clearly...’). There is no evaluation of the learning, and the study is poorly theorised (reasoning is mistaken for metacognition).

The article presents an argument for incorporating a thinking skills approach into geography fieldwork. The article identifies three sources of evidence – from the experience of teachers and inspectors, educational psychology (experiential learning) and empirical research. Drawing on the empirical evidence, Foskett notes that affective gains from fieldwork may be important not just for their own sake, but because they appear to accelerate cognitive gain.

The article uses an example of a student fieldwork exercise on visitor management at a popular historic monument, which is mapped onto Sternberg’s (1985) triarchic classification (knowledge components, performance components, metacomponents) together with a consideration of transfer. Transfer is viewed as either ‘lateral’ – the ideas and skills are used in a different, but no more challenging or complex situation; and ‘vertical’ – the element of challenge or complexity is present. If fieldwork can support transfer, then its role in enhancing student performance across the curriculum may be important.

Although no evidence is presented, a framework which is designed to enable geography teachers to identify the opportunities for developing thinking skills already present in fieldwork activities (an auditing approach) is discussed. The idea is that the thinking skills can then be made more explicit to both teachers and pupils. Drawing on CASE and Leat’s research (1998, 1999), particular teaching and learning strategies that will accelerate cognitive gain are identified – group work, student talk, teacher–student talk, teacher–student discussion, hypothesising.

The study is discipline-embedded. Its purposes are the development of thinking skills and cognitive acceleration (learning to think), and the raising of attainment in geography (thinking to learn). Teaching for transfer is discussed. The study is well argued and theoretically informed, with a strong practical focus. However, no evaluative data is presented to support the case. It would appear to be very relevant to post-16 geography teaching; the framework and audit approach could be applied to any post-16 context. Of particular interest is the affective-cognitive interaction that the article discusses.

A brief article designed to be thought-provoking for mathematics educators. It presents a short experiment that mathematics educators could conduct with their students to identify whether these students rely on rote methods (algorithms) or reasoning to perform a mental calculation. The implications – a major shift in thinking and practice – are raised.

The approach is discipline-embedded, and concerned with mathematical reasoning – therefore the key focus is thinking to learn. The article is well grounded in current thinking on mathematics learning and teaching. It provides a starting point for reflection, but would need to be supplemented in order to inform practice. It is relevant to the post-16 context because it is not only children who use rote methods, and mathematics is not the only subject where rote methods tend to dominate. It is of interest because short articles like this can provide a ‘route in’ for practitioners to reading research on mathematics learning and teaching (there is a short reference list) in order to inform their practice.

This article evaluates an infusion approach that combines direct teaching on problem-solving strategies, modelling of solution processes, ongoing formative assessment, and developing metacognition through processes of reflection, articulation and exploration. It uses a case study to provide an example of how these approaches can be interwoven within a problem-based learning methodology for teaching computer programming at an introductory level to 14–16 year olds. The progress of one mixed-ability class was followed closely over an 18-month period. The teacher participated actively in the research by assisting with the planning and conduct of interventions and with the appraisal of the research outcomes.
The learning and research environment was designed to foster higher-order thinking, problem solving and metacognitive skills in addition to an understanding of elementary programming concepts, principles and skills. The case study was preceded by a staff development project (Kirkwood 2001) which provided opportunities for 40 computing studies teachers to participate in collaborative action research to develop a new programming curriculum.

The evaluation was framed around the intended educational outcomes of the study which related to, in turn: students’ understanding of programming concepts, principles and techniques and competence at solving programming problems; students’ development of higher-order thinking skills, metacognitive skills and learning strategies; students’ reflections on the broader applicability of problem-solving strategies and ability to demonstrate near transfer in the context of practical problem solving using a spreadsheet; and students’ affective responses to learning to program. A range of instruments was used, including programming assignments, folders of classwork, student questionnaires and interviews, and students’ written reviews of their learning.

The article reports positive findings on all of these learning outcomes. All students succeeded in learning to program at an elementary level. Their programming solutions were well designed and contained few logical errors. They were able to demonstrate higher-order thinking across a range of performances – practical, written, and spoken. The case-study environment enabled students to ‘learn how to learn’ by strengthening their metacognitive skills, while also supporting them to take responsibility for their learning. For the majority of students, near transfer occurred from programming to practical problem solving using a spreadsheet. Many could generalise the approaches to other (non-computing) contexts. Students’ self-assessments (of understanding, confidence, etc) were carefully formulated and were generally quite accurately reflected in their performances. The majority of students expressed positive views on the learning resources and the way in which the programming class was run. Students seemed to benefit from the added flexibility of classroom transactions in comparison to more traditional teacher-led approaches. They operated flexibly in their interactions with others, maintaining a pace of learning that suited them individually while still being able to discuss problems, compare solutions, combine resources, or get help with problems.

The author concludes that ideas on teaching for understanding have been successfully combined with other ideas on the thinking curriculum and learning to learn, resulting in the achievement of balanced educational outcomes. A number of implications are raised relating to: the lack of connectedness between subject disciplines; the success of the infusion pedagogy; the complexity of the ideas contained in some curricula and the implications this has for students and curriculum planning; the importance of good relationships between teachers and students; and the need for teachers to attend to how their students actually tackle their learning and not merely to outcomes.

The study is discipline-embedded. A range of purposes is evident – the development of higher-order thinking and problem solving (learning to think), the development of metacognition (learning to learn), and the fostering of understanding of programming concepts and principles (thinking to learn). Teaching for transfer is focused upon in relation to the strategic dimension of programming. The study is theoretically informed, with a strong practical focus, and is situated in the authentic context of an ‘ordinary’ computing studies classroom. It gauges the students' perspectives on learning and, in addition to other measures, evaluates the learning outcomes. A potential limitation of the study is its location within computing studies, which, although well established in the Scottish secondary school curriculum, is not so well established elsewhere. Also, any curriculum materials in this field become quickly outdated because of the pace of change in the technology. The infusion pedagogy could, however, be applied to other post-16 curricular areas – particularly any in which problem solving features strongly.
Alexander P and Murphy K (1999)  
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The LSRC welcomes continuing interaction with researchers and research users. Please contact us with your questions, ideas and information.

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