DEVELOPING AND ASSESSING THINKING SKILLS

The International Baccalaureate Project 2014

Final Report Part 1

Literature Review and Evaluation Framework

by

Robert Swartz

National Center for Teaching Thinking
Boston, USA

and

Carol McGuinness

Queen's University Belfast
Northern Ireland

Funded by The International Baccalaureate Organisation

Table of Contents

1 The Purpose and Structure of the Final Report

In this report we will address the two main topics identified in our initial proposal:

- The state of the art today with regard to identifying important and teachable kinds of thinking, how they can *be taught,* and how they can *be assessed*.
- How the present IB programmes align with this picture.

These topics will be addressed through a literature review, firsthand experience, and a document analysis of the IB curriculum materials that were available through the OCC. Using the literature review strategy outlined in the initial proposal (see Appendix 1), over 700 references were identified for the time period 1998-2013, and these did not include the classic journal articles, texts and edited volumes. While some up-to-date references were identified through the search, the general shape of the field had not changed substantially from previous reviews conducted by the authors (e.g., McGuinness, 2005). Thus, the following strategies guided the selection of references for this report.

Four thinking-related constructs had been previously identified as the basis for the coding matrices – thinking processes (to include skills and strategies); metacognitive thinking; thinking dispositions; and beliefs about knowledge. The justification for identifying these specific constructs was informed by our previous knowledge of the research and practice literature and, for this report, we have selected and organised the literature around these concepts. With the possible exception of beliefs about knowledge and learning (mindsets and beliefs) - which we identified as a construct that is only emerging as important for teaching thinking - there is a general consensus that the other three are central to most theoretical approaches, albeit with different emphasis (for a recent overview, see Schraw et al., 2011). Consequently, for the purposes of the report, we have focused on thinking skills/strategies, metacognitive thinking and thinking dispositions.

We noted that the IB programmes drew heavily on Bloom's taxonomy (with some modifications) throughout their three programmes, and this prompted us to lead with a critical analysis of Bloom's approach and to offer alternative, though related, approaches as a way of making thinking more teachable and assessable for the programmes.

Finally, we have shaped the account of the literature to match our three-part analysis related to:

(1) identifying desired thinking objectives for a thinking curriculum and how to frame these objectives to make them more teachable and subsequently assessable;

(2) identifying an appropriate pedagogical approach for teaching thinking, together with specific teaching methods and techniques; and

(3) identifying principles and models for assessing thinking that formatively support students' learning how to think more skillfully and that summatively assess their level of achievement. This three part analysis is consistent with the notion of constructive alignment between curriculum objectives, pedagogy and assessment (Biggs & Tang, 2011).

Overall, our purpose is to create a research-informed and coherent framework for teaching and assessing thinking, to enable us to evaluate the IB programmes against the framework and to make recommendations.

With this purpose in mind, the report will be presented in two parts. The first part, Final Report Part 1, consists of three sections, each related to thinking objectives, pedagogy and assessment. Each section will begin with a brief overview of key concepts and key approaches from the research literature and will then develop specific concepts and/or practices. Over the three sections, a coherent framework will be developed. The second part of the report, Final Report Part 2, will then present our evaluations of the PYP, MYP and DP against the three part framework, using the coding matrices as summary aids. Building on the evaluations, we will make both general recommendations and recommendations specific to each IB programme.

2 Framing Key Thinking Objectives for a Thinking Curriculum

2.1 Different Theoretical Frameworks on Types of Thinking

There are many different and sometimes competing theoretical frameworks to inform schools and teachers about what might be worth identifying as thinking objectives in a school curriculum. For example, Moseley et al. (2005), in a thorough review, analysed 41 different frameworks, which were then further grouped into four categories. Although so many frameworks exist, not all of them have been well researched and/or have found their way into practical applications in schools and classrooms on a wide scale. For our purposes, we have identified three traditions broadly defined by their disciplinary origins – education, philosophy, and psychology – and we have selected frameworks as examples of each tradition.

Originating from a dissatisfaction with the outcomes of students' learning in higher education, Bloom's taxonomy of six educational objectives (Bloom et al., 1956) – knowledge, comprehension, application, analysis, synthesis, and evaluation – is probably the best known framework. The final four objectives in the taxonomy have come to define "higher order thinking" and the movement from the first two goals (knowledge and comprehension) to the final four goals (application, analysis, synthesis, and evaluation) represents a shift from lower order thinking to higher order thinking. Thus, Bloom's taxonomy, and more recent modifications (e.g., Anderson & Kratchwohl, 2001) have become a prevailing influence in the field of teaching higher order thinking and in moving students' learning away from rote memory and superficial understanding.

In philosophy, and spilling into other fields, since 500 BC, there has been a continual and deep concern with helping people think more clearly and critically. This has manifested itself in a tradition of Socratic questioning and the study and use of deductive logic to recognise – and correct – errors in thinking. But as we move into the years after World War II in the 20th Century it is increasingly recognised that this approach is not effective and not nearly sufficient to have an impact on improving the general thinking habits of our population. John Dewey, in the USA, was an early proponent of a different approach. In the post-war years, the figure that stands out as a leader in this revisionist movement is Robert Ennis (1962, 1987, 1996, 2009, and 2011). Ennis' contribution is to move away from the idea that learning to identify invalid arguments is at the core of critical thinking and to identify a broader and more differentiated taxonomy of more positive thinking objectives in the form of a list of abilities as appropriate goals for a *critical thinking* curriculum.

While these do include abilities to do with the clarification and analysis of arguments, and assessing the validity of arguments, they also include abilities at judging the credibility of sources, deduction and induction, evaluating value judgements, uncovering and challenging unstated assumptions, and suppositional thinking. Ennis' list of thinking abilities does change slightly in different publications, but these are good samples. All of these types of thinking characterize critical thinking – they need to be individually and collectively taught, learned and eventually mastered, if a student can be truly called a critical thinker.

Another theoretical perspective on potential objectives for teaching thinking comes from psychology. This can be traced to both cognitive psychology and developmental psychology. Whereas earlier analysis of cognitive functioning from a psychological perspective had focused on notions of fixed intelligence, the new cognitive psychology of the 1970s introduced a more dynamic view of thinking as a flow of information through the cognitive system. Thus, good thinkers were those with 'strategies' to manage their thinking more effectively, whether it be reading and comprehending text materials, reasoning and testing hypotheses as in scientific thinking, or problem-solving in specific domains such as mathematics. In other words, good thinkers were those who could exert some strategic control over their thinking. From this basic insight grew ideas about learnable intelligence rather than fixed intelligence, and the focus shifted to cognitive strategies and heuristics, metacognition and self-regulation as important objectives for a thinking curriculum. Early examples of this theoretical orientation included Feuerstein's theory of cognitive modifiability (Feuerstein et al., 1980) and Sternberg's Intelligence Applied (1986) based on his triarchic theory of intelligence. Perkins' (1995) commentary in his *Outsmarting IQ* identified an emerging science of learnable intelligence (also, Perkins & Grotzer, 1997; Perkins, 2008). The idea of learnable intelligence is also prominent in more recent popular writings by Lucas and Claxton (2010) who talk about a "new kinds of smart" and in theoretical work on why education needs a more 'plastic' view of general ability (Adey et al., 2007)

In addition to this perspective on learnable intelligence, more specific forms of thinking have been the focus for instruction, particularly problem-solving. Within the newly emerging research on problem solving from a computational perspective (e.g., Newell & Simon, 1972), various stages in problem solving were identified – identifying the problem, representing the problem, selecting an appropriate strategy, implementing the strategy, and evaluating solutions. In addition, a number of important and general problem solving heuristics were found useful, such as identifying goals, means-end-analysis, setting up sub-goals, and working backwards, and these have formed the basis for instructional texts (e.g., Hayes, 1989). Another important influence on the teachability of

problem solving came from the work of Paul Torrance (see A Tribute to E. Paul Torrance in a special issue of *Creativity Research Journal*, Kaufmann & Baer, 2006; and Treffinger et al., 2012) and from Osborn, Parnes and Treffinger on what they called "creative" problem solving (summarised in Isaksen & Treffinger, 2004). A whole class of non-quantitative problem solving, including both every-day problem solving, and on-the-job problem solving, was the focus, and they developed special creativity-focused heuristic models with the aim of making the processes of creative problem solving more explicit. The emphasis on creative thinking and creativity focuses on the use of such techniques as brainstorming in generating possible solutions to problems, and especially skill at blending two or more familiar items or ideas to generate new and creative syntheses.

Drawing on this broad range of research from cognitive psychology and beyond, Halpern (1984, 1st edition; 2013, 5th edition) has created a taxonomy that embraces not only argument analysis, but also hypothesis testing skills, probabilistic reasoning, problem-solving, decision-making and creativity and her work is accompanied by instructional texts and manuals, aimed primarily at high school and college level students (Halpern & Riggio, 2003). And the infusion program developed by Swartz and colleagues ("Thinking-Based Learning") have also drawn upon these three traditions to create a comprehensive set of thinking objectives, primarily focusing on the development of skillful thinking, but also incorporating an adjunct set of objectives relating to thinking dispositions (Swartz et al., 2007). They have also produced collections of infusion lessons from teachers in elementary and secondary schools who practice this approach (e.g., Swartz et al., 1994, 1998, 2000a, 2000b, 2000c).

In conclusion, although Bloom's taxonomy can be said to be a prevailing influence on what is now understood as higher order thinking skills, the different origins and theoretical approaches that we have just outlined expand the range of types of thinking that might be desirable to pursue as educational goals in a thinking curriculum and introduces newer concepts related to metacognition, thinking dispositions and self-regulation.

For the moment, because of the prominent place that Bloom's taxonomy currently occupies in the IB programmes, we shall make this framework the focus for closer analysis in the next section, in order to develop a better understanding of the nature of *skillful* thinking. We shall return to some of the other concepts such as problem-solving, metacognition and thinking dispositions in later sections.

2.2 Broad vs. Differentiated Types of Thinking Objectives

Although many educators describe their objectives in teaching thinking in a variety of different ways, in this section two alternative approaches, Bloom and Ennis, will be compared, with the ultimate intention of framing thinking objectives in a manner that make them more teachable.

Bloom's six goals are broadly framed, while Ennis has generated a more differentiated taxonomy with specific reference to critical thinking. We do not view these two ways of articulating the goals of teaching thinking as either incompatible or mutually exclusive. There is not any one type of thinking activity that we do that counts as analysis. There are different ways of analysing something. For example, analysing *how an object's parts contribute to what it is or does* (e.g., wheels on a car function to make it move quickly), or becoming aware if *an object's characteristics and what having these characteristics implies* (e.g., glass blowing generates great heat, hence there is a danger to humans), or analysing *what follows from something being classified a certain way* (e.g., nutritious implies that it can benefit humans who eat it).

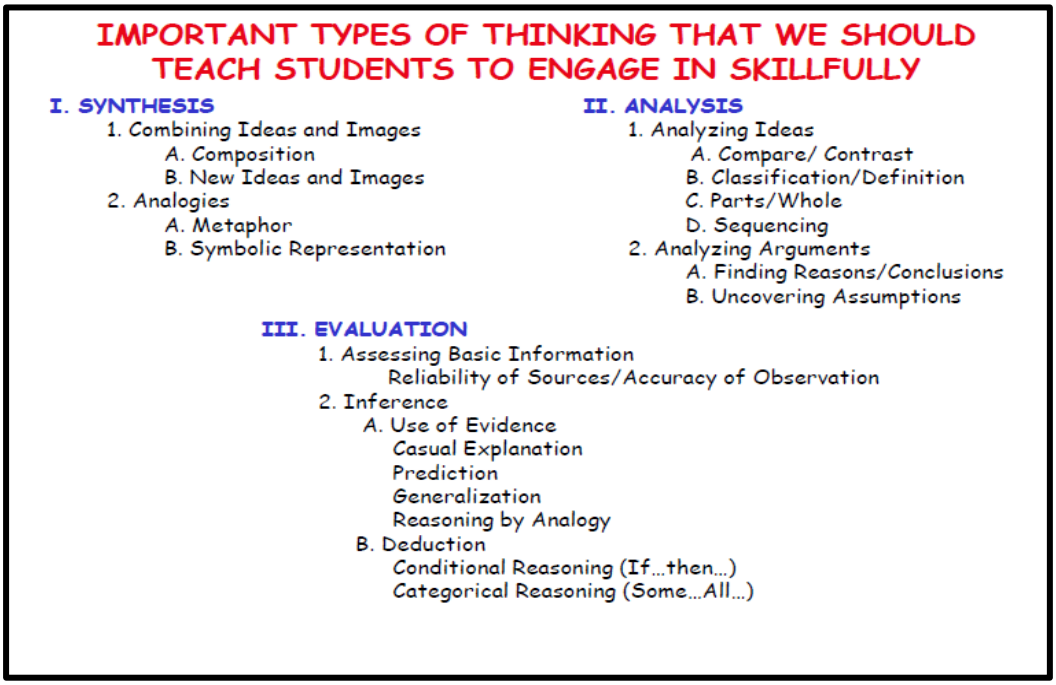
The same multiplicity of different ways of synthesizing things, or of conducting an evaluation of an idea, yields the same multiplicity of sub-categories under each of the Bloom designations. To be a good thinker vis-à-vis analysis, synthesis, or evaluation has its cash value in identifying a number of different types of thinking that fall into each category, all perhaps with the same overall goals, but each of which needs to be mastered if a person is to become a good thinker. The insight of Robert Ennis is the need to make these explicit in an organised way and taught separately if we are to do a good job of helping students learn how to evaluate ideas – that is, think critically.

Indeed, we should add here that many teachers, who start with the use of Bloom's Taxonomy, or one of its more recent derivatives or modifications, tend to gravitate, in instruction, to more specific types of thinking that fall under each category. For example, comparing and contrasting is often introduced as a mode of analysis, as is articulating the structure of an argument.

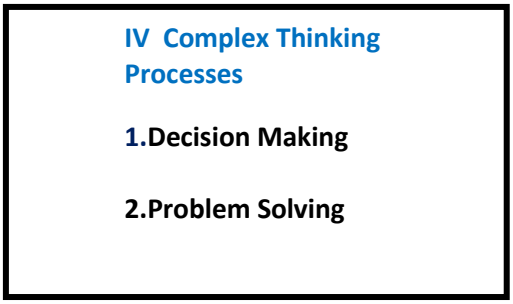
Supplementing Bloom's Taxonomy with a systematic list of different ways that each of the broader types of thinking can be done is a model for making sure that thinking instruction aims at all of the important varieties of thinking in each of the Bloom categories (and the IB Command Terms document recognises this).

Based on Swartz' own work (Swartz & Parks, 1994; Swartz et al., 2007) here is a way of combining these two approaches to stating the objectives of teaching thinking. Note that although the

objectives are more differentiated, they remain grouped under three of Bloom's higher order thinking headings.



But even these categories may not be sufficient. Because of their prominence in other frameworks, it might be important to consider both *decision making* and *problem solving,* as many people do not do these very well and students can be taught to do them more skillfully. Hence we may want to add another category to the above list:



2.3 The Elusive Nature of Thinking Skills

We now turn to another complexity with regard to framing objectives for a thinking curriculum. There is an almost universally accepted presumption in both the theory and practice of teaching thinking that our main objective is to teach students *thinking skills* that students can then use to think beyond mere memory when engaging with curricular content. Both when the Bloom categories are taken as the primary goals of teaching thinking or the more finely tuned Ennis-type

categories, each are often taken as defining the list of *thinking skills* that we need to teach students to become better thinkers. Thus *analysis* from Bloom's taxonomy is often described as a thinking skill. Judging the reliability of a source is taken to describe a *thinking skill.* And there are other thinking activities like these that are often described as thinking skills as well – the range of other Bloom categories and from those who focus on more specific types of thinking like those advocated by Ennis, *comparing and contrasting, classifying, sequencing*, *predicting*, etc. often get added.

Whichever of these two approaches to stating the primary goals of teaching thinking are adopted, the way this translates into both instruction and assessment is to use words like these as explicit prompts to bring out these kinds of thinking. But there is a different view of what a thinking skill is. This other view affirms that what are described in these classifications are NOT 'thinking skills'. This claim takes seriously a distinction made in Ennis' later work. There, judging the credibility of a source is again identified as something that critical thinkers need to be able to do. But Ennis suggests that such an activity needs to be manifested in a "strong performance", and that occurs only when certain criteria defining how to judge the credibility of a source are well satisfied, for example, that the "expertise" and "reputation" of the author needs to be considered, that "established procedures" are used, that there is "agreement with other sources" and so on. So we might, as a starter, want to say that to exercise skill at judging the credibility of a source we should ask and answer the following questions, and judge credibility based on the answers:

Judging the Credibility of a Source Skillfully

What is the expertise of the source?
What is the source's reputation with regard to this kind of information?
Did the source use established procedures in getting the information?
To what extent do other sources confirm what the source tells us?

Perhaps this can be refined even further, but it is enough to make an important point, if we follow Ennis' reasoning. Judging the credibility of a source is not, strictly speaking, a "critical thinking skill", but rather a way to engage in critical thinking that can be done with skill but also in rather superficial ways. So learning how to do it with skill and exercising that skill in a habitual way is, more strictly speaking, what a thinking skill is.

This applies to all of the other types of thinking included in the chart above as well as, especially, decision making and problem solving, where examples of making decision and solving problems in sloppy non-thoughtful ways are frequently encountered.

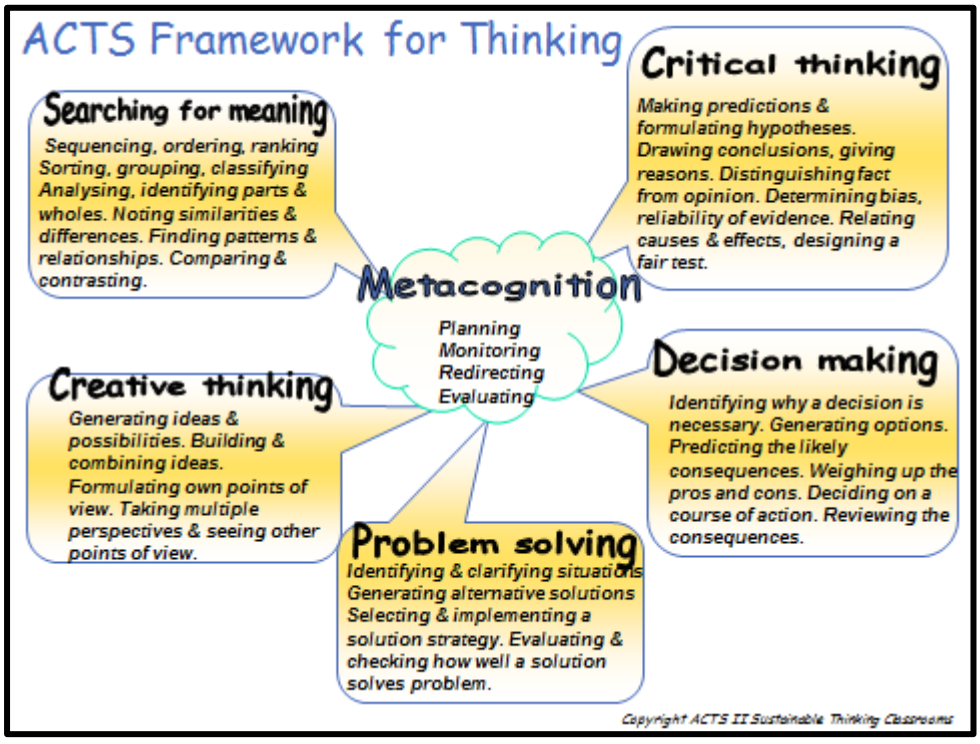
2.4 Metacognition as an Objective in a Thinking Curriculum

In an earlier section, we identified the idea of a person having strategic control of their thinking as one characteristic that has come to define high quality thinking. The term, metacognition ('meta' means 'going beyond'), was introduced by Flavell (1979) to capture the notion of cognitive monitoring and related metacognitive processes, though the concept can be traced back to earlier writers (e.g., Dewey). Metacognition now occupies such a central place in many theoretical frameworks for cognitive development (Kuhn, 2000, 2008, 2009) that we suggest that it can now be treated as a thinking objective in its own right. The term is often used interchangeable with 'thinking about thinking' and it certainly does involve an act of reflection. But in the context of learnable intelligence it has a more precise meaning with regard to the 'thinking' that is the object of the reflection. In the psychological literature, metacognition generally refers to two complementary strands (1) knowledge about cognition – about cognition in general and one's own cognition - involving some degree of awareness; and (2) self-regulation or the ability to plan, to monitor and adjust one's thinking in relation to task demands and to evaluate thinking outcomes (Flavell, 1979; Brown, 1987; Kuhn, 2000). Thus, in order to be able to plan and adjust one's thinking, learners need to be aware of their own thinking processes, and the classroom techniques that make thinking more visible are a necessary first step in helping thinking become more metacognitive. A more precise meaning might be:

- knowing about thinking strategies in general;
- becoming aware of one's own thinking strategies;
- reflecting on and evaluating one's own thinking strategies
- with the intention to plan and direct future thinking in more skillful ways.

This meaning is at the heart of the notion of learnable intelligence. The expectation is that the student will eventually internalise the more skillful thinking and use it spontaneously in future contexts. Thus the instructional goal of metacognitive thinking – to help the learner become more self-regulated – will be achieved. There is growing body of evidence that approaches to teaching thinking that adopt a metacognitive perspective are more successful than those that rely on merely practising cognitive strategies. In a meta-analytic review of 29 well-designed evaluations of the effects of thinking skills interventions on a range of learning outcomes (reasoning tests, curricular attainments and attitudinal measures), Higgins and his colleagues (Higgins et al., 2005) reported that metacognitive interventions had a more positive effect on the students' learning compared to the average effect reported across all the interventions. In quantitative terms, the learning outcomes

associated with the metacognitive interventions were 95% of a standard deviation higher than control groups, compared to 62% of a standard deviation higher than control groups for thinking skills interventions more generally. So, both for its theoretical relevance and practical importance in contributing to students' learning, metacognition merits treatment as a thinking objective. The diagram below illustrates how metacognition was included in the thinking objectives for the ACTS (Activating Children's Thinking Skills) programme in Northern Ireland (McGuinness et al., 2006), objectives derived in part from the earlier work of Swartz and Parks (Swartz & Parks, 1994). The way in which the metacognitive component is outlined differently (in a bubble) than the cognitive components (in a rectangle) is intended to communicate that metacognition has a different status as an objective compared to the other forms of higher order thinking that are represented in the model, acting as it does as an appraiser, monitor and adjuster of the other thinking objectives in the model.



2.5 Thinking Dispositions as Objectives for a Thinking Curriculum

In *How We Think* (1933), after advocating that we teach students strategies for what he called "reflective thinking" (in 21st century terms, critical thinking), John Dewey said "You can teach students how to think reflectively, but if they don't care about doing this, they won't". This is a comment made earlier by William James, and by J. J. Rousseau. And indeed, this problem is

reflected in a set of approaches that stresses the need to teach "Thinking Dispositions"[1] (Ennis, Perkins, Ritchhart and colleagues) or "Habits of Mind" (Costa and Kallick, and colleagues) as well as thinking skills. Let us make some comments about this idea that, besides thinking skills, it is important to teach students certain thinking dispositions if we are aiming at helping them become good thinkers.

Efforts to teach students thinking skills aim at helping students not only learn how to manifest these skills, but also to developing the habit of doing so when called for through continued practice and sensitivity to where these skills are needed. "Internalization', which we will discuss in greater length later, is a goal in teaching thinking, with metacognitive thinking as a means for self-management and self-regulation. These practices all contribute to building the habit of thinking well. So in a sense we want our students to develop the habit/disposition to think about options and consequences when they make decisions. But what various researchers have called "thinking dispositions" are more than what we have just described.

Doing something skillfully when you are trying to do it is important but why try? Trying presupposes that the person is *motivated* to do a kind of thinking well – that there is an initial "push" to engage in it and an inclination to continue to engage in a regular way. Thus, what many have called "thinking dispositions" are not just the habitual use of a skill, but more like character attributes, attitudes or values that incline us to exercise skill at thinking when it is called for. To help students develop these seems to require something different from teaching thinking skills.

Robert Ennis was the first contemporary author to make note of the need to teach these in his work and he identified several dispositions that he considered important for critical thinking – the desire for clarity, to understand other points of view and be understood; to be truth-seeking; to be open-minded and seek alternatives; to be precise (Ennis, 1987, 1996). He points out that not only do we need to be able to think skillfully but we also need to have the inclination to do it regularly, and these dispositions represent what provides such an inclination. The distinction between thinking skills and thinking dispositions was further confirmed in an expert consensus statement on critical thinking for the purposes of education and assessment, published by the *American Philosophical Association* (The Delphi Report, Facione, 1990). The statement pointed to a range of what they

[1] A related concept called 'learning dispositions' has been discussed at length by Carr and Claxton (2002). Their development of the idea of disposition is very similar to that which is discussed in this section, but the type of dispositions they reference relate to much broader orientations to learning than those that are the focus of thinking dispositions. For example, their learning dispositions are resilience, playfulness and reciprocity.

called 'affective dispositions for critical thinking' such as inquisitiveness, open-mindedness, honesty in facing one's own biases and prejudices, fair-mindedness and so on.

Perkins and his colleagues (Perkins, Jay, & Tishman, 1993) have explored the sense in which exercising a thinking skill or ability can become habitual/dispositional. The active use of thinking skills has three components – inclinations, sensitivities and abilities. Each of these can be taught and can be an objective for a thinking curriculum. For example , as we have remarked, reflection on decision making leads to knowing how to make a decision (ability/skill), but to be a good decision maker a person must also be alert to occasions on which decisions need to be made (sensitivity) and must also be generally inclined towards making decisions and taking responsibility for decision-making (inclination).

In addition, Perkins has identified seven broad thinking dispositions – thinking motivators: *to be broad and adventurous; to be curious and oriented towards problem-finding; to seek understanding and build explanations; to be planful and strategic; to be intellectually careful; to seek and evaluate reasons; and to be metacognitive.* To date there is no consensus between Ennis, Perkins and the Delphi statement on exactly what the dispositional thinking drivers are.

We need to add to this duo another researcher, Costa, who has focused his attention on what he calls "Habits of Mind" (Costa & Kallick, 2000a, 2000b, 2000c, 2000d, 2014). Habits of Mind (16 habits) are construed as 'intellectual behaviours', such as persistence, managing impulsivity, listening with empathy, thinking flexibly, striving for accuracy, thinking interdependently, to name a few.

What is clear from Costa's work is that what he describes is not really meant to focus exclusively on the broad thinking dispositions of either Ennis or Perkins. For example, serious and respectful listening is one of his habits of mind. This is a particular type of *intellectual behaviour* that can enrich our thinking, but, in contrast, "striving for accuracy" is a broad inclination that can drive a lot of specific thinking skills, like analysing and evaluating arguments and judging the reliability of a source of information. The important thing about Costa's work is that he is interested in thinking-related habits, hence the importance of developing a habit of respectful listening, but also of striving for accuracy, for clarity, and to communicate well with others. Of course, for each of the thinking skills we mentioned helping students make their use habitual should also be added to his list.

We recommend that we identify as "thinking dispositions" only those broad desires *like being curious,* or *seeking the truth,* that drive our use of specific thinking skills and of specific behaviours

like listening that we judge to be means to this noble end. Appendix 2 provides more details about dispositional approaches.

3 Positioning Thinking in the Curriculum

Before launching into issues about the principles and practices for teaching and assessing thinking, an important question is where the teaching of thinking should be positioned in a school curriculum, as there is likely to be ever increasing demands to include additional educational objectives with associated courses and units. The answer to this will depend on whether an overarching set of thinking objectives are to be adopted, such as the ones that we have outlined in Section 2, or whether the thinking objectives are to be specifically pursued as targets only in specific subject areas, such as science, history, or general studies, or in a specific project-based unit (see Section 4.9 for further development of this idea). Even if an overarching set of general objectives is the desired approach then a decision needs to be made as to whether a separate course on, for example, critical thinking, will be sufficient to meet the objectives, or whether a more cross-curricular approach is desirable, or indeed, feasible. So there are decisions here about what is likely to be most successful and also about what can be implemented.

3.1 Stand-Alone Courses on Thinking

Irrespective of the theoretical tradition from which they grew, most of the early thinking programmes were stand-alone courses while in more recent years there is a shift to having thinking objectives and thinking skills as part and parcel of the regular curriculum design.

For example, in higher education stand-alone courses have a long history, manifesting themselves in courses in logic, both usually emphasizing formal (deductive) logic, and sometimes inductive logic, as exemplified in the sciences. The emphasis in such courses is on arguments and how to check their validity, though the overwhelming number of examples usually involves formal deductive arguments. Then, especially in the 1990s, many of these courses morphed into courses that provide instruction in both formal and *informal* logic (usually emphasizing identification of types of fallacies in reasoning, like the *ad hominem* fallacy, as a way of identifying everyday arguments that are suspect or downright invalid). And the practice examples, still involving argument, shifted in these courses to accommodate this change. And through the 1990s into the 2000s, this all morphed again into courses that were called “Critical Thinking”, and focus almost exclusively on techniques for identifying, analysing, and evaluating arguments, as they appear in everyday discourse and in perhaps in the sciences. So-called “inductive” arguments appeared as a major focal point, though the technique of identifying fallacies in these arguments still dominated the methodology. The A-

level syllabus on Critical Thinking which is available as a public examination in the UK is an example of this tradition (Black, 2012). Schools in many EU countries have, at the high-school level, required philosophy courses such as these. And many high school and college courses in the US continue to be are taught largely as stand-alone courses, for example, Halpern's course on critical thinking (Halpern & Riggio, 2003).

At the school level as well, many of the pioneering courses for teaching intelligence, such as Feuerstein's Instrumental Enrichment that was more remedial in its outlook, advocated specifically that the course be taught outside the traditional classroom curriculum where, he argued, the original 'bad habits' of thinking were practiced. His expectation was that, if children's basic abilities were enhanced, they would have a snowball effect on thinking generally, which would transfer to the mainstream curriculum. *Philosophy for Children*, developed in the 1980s by Martin Lipman (Lipman et al., 1980; Lipman, 2003) with a focus on developing younger children's reasoning abilities through a form of Socratic questioning and enquiry, is also delivered as a separate part of the curriculum, though there are recent moves to include curriculum-related materials as the stimulus for Socratic inquiries and to embed the practices as a regular part of primary school teaching (e.g., Fisher, 1998; Cleghorn & Baudet, 2003).

There are two sorts of problems that have been identified with the separate critical thinking course model. The first is practical. Many schools have little room for another separate course in what has become an overcrowded curriculum. But of course if a new course is considered very important, there always seems to be a way of squeezing other curricular components to make place for it.

The second set of problems is more serious. They relate to either the perceived or documented ineffectiveness in changing the thinking habits of students both in their other academic work and in their lives outside of school. A standard diagnosis is that students tend to treat what they learn in separate critical thinking courses as self-contained skills, and while they may do well in such courses, once they are done they are done and, like much else of what they learn in school, it is time to move on to something else.

Rigorous research evaluations of *Philosophy for Children* programmes, for example, do show positive effects of participation on the quality of the children's discussions, on post-test measures of their reasoning abilities and on measures of achievement such as reading comprehension (Trickey & Topping, 2004). However, there have been no studies that have examined the degree of transfer of

the children's newly acquired reasoning to other areas of curriculum learning or to their thinking outside the classroom, although Trickey's study did show that those children who had participated in *Philosophy for Children* in primary school maintained their reasoning skills advantage as they progressed to post-primary school two years later (Trickey & Topping, 2007a, 2007b, 2007c). So there is some evidence of sustained effects from stand-alone courses.

But one of the main reasons for the worries about transfer is that the way critical thinking courses are developed and taught *normally* contains little if any t*eaching for transfer* – that is, direct instruction in which students are challenged in the course to use what they have learned about critical thinking with examples from their other courses, or with challenging situations that call for critical thinking in their lives outside of school. Equally, the instructors who teach the disciplinary courses do not normally provide opportunities for students who have taken critical thinking courses to use their critical thinking skills in connection with their other courses, so there is little support given to students to help them with transfer. When strong bridging between the CT course and the disciplinary content courses does occur, then the instruction begins to morph with the infusion approach, where the responsibility for teaching critical thinking (and creative thinking) is distributed across teachers, subjects and grades, all following a coherent instructional model embedded in content. We shall return to the issue of transfer in a later section when we will identify some optimal conditions for transfer irrespective of the curriculum approach adopted.

3.2 Infusing the Teaching of Thinking into Content Instruction

Normally, the practice of *infusing instruction in thinking skills into content instruction* stands in sharp contrast to the use of stand-alone courses as the primary vehicle for introducing students to thinking skills and giving them practice in using them. It is typically the approach adopted when wide ranging thinking objectives are set across-the-curriculum.

As practised by Swartz and his colleagues in their approach called *Thinking-Based Learning* (Swartz & Parks, 1994; Swartz et al., 2007), this involves teachers designing lessons where the thinking skills and the curriculum content are taught simultaneously. The students are introduced explicitly to strategies for more skillful thinking, and then prompted to use these strategies to think about the content they are learning. By putting an emphasis on higher-order thinking into content instruction, deeper understanding is reported, as is better writing, and more engaged interest by students in what they are learning. When infusion is accompanied with the introduction of explicit thinking strategies, together with highly scaffolded guidance by the teacher, and prompted reflective

metacognition and strategic planning by the students about how they will engage in the same sort of thinking skillfully next time (preparation for transfer), a very powerful learning environment for teaching thinking is created. While a good deal of the evidence for the success of the specific TBL approach comes from the testimony of participating schools around the world, there have been some formal research evaluations of the general infusion approach in the UK (e.g., McGuinness, 2006; Dewey & Bento, 2009; Burke & Williams, 2008) and in Spain (De Acedo Lizarraga et al., 2010).

Here are some examples of lessons that infuse skillful thinking into content instruction.

Comparing and contrasting Abraham Lincoln and Frederick Douglass, (Grade 6, USA), Goya and Velazquez (Grade 6, Spain) using a 5-step strategy for skillful compare and contrast.

Judging the cause of the Titanic hitting an iceberg in April, 1912 , (Grade 6, Northern Ireland), using skillful causal explanation.

Deciding what the best dominant energy source should be for your country using skillful decision making (Grade 8, USA, and Spain).

Determining how the parts of the American Kestrel (or Cerniculo in Spain) work together based on their functions to make this bird an effective hunter using skillful parts/whole thinking (Grade 6, USA, Spain).

Ranking the European Explorers with regard to the amount of unknown territory they made known using skillful ranking (Grade 5, USA).

Determining how best to get apples off apple trees so that they can be marketed and sold (Grade 2, USA) using skillful problem solving.

Judging the reliability of two conflicting accounts of the start-up of the American Revolutionary War (Grade 7, USA).

Classifying animals by the way they protect themselves using skillful bottom-up classification (Grade 10, USA, Chile).

Analyzing and Evaluating arguments pro and con in the 19th Century about giving women the right to vote (Grade 6, USA).

Two additional comments about the practice of infusion are in order here. The first is that there is evidence that sustained practice in forms of skillful thinking taught to students even as early as in

pre-K instruction is desirable to create a pattern and habit of use of the strategies being taught, and that, without this, there tends to be some backsliding in thinking habits by students. This means that the use of the same thinking vocabulary, and the same thinking strategies, though often adjusted upwards in complexity as the grades progress, need to be integrated into the teaching of all of the teachers in a school and coordinated with each other, across grade levels and subject areas. This is now a practice in many schools.

The second point is that many such schools are trying to extend the use of the thinking skills taught to students in their classrooms into the life of the schools. These schools are thinking of themselves as creating a "culture of thinking" not only in their classrooms but throughout the whole schools. They are, indeed, striving to be "thinking schools", a concept introduced by the Prime Minister of Singapore in 1997 at the 7th International Conference on Thinking hosted by his country then. His idea was that all Singapore schools should become Thinking Schools, thereby making Singapore a "Learning Nation" (Saravanan, 2005). This represents one of the earliest public proclamations that the infusion model needed to be a national goal. Since then at least half-a-dozen other countries, including New Zealand, Northern Ireland, and Israel, have embraced the same idea (Zohar, 2008; Gallagher et al., 2012). Since 2013, Australia can now be added to this list, http://www.australiancurriculum.edu.au/GeneralCapabilities/critical-and-creative-thinking/introduction/introduction.

For additional information about the approach adopted in Northern Ireland, see http://www.nicurriculum.org.uk/TSPC/what_are_tspc/framework/

.

4 Teaching Thinking: Principles and Practices

4.1 Eight Principles

While Section 2 examined taxonomies and frameworks as potential candidates for the goals of a thinking curriculum, and Section 3 asked questions about where best to position thinking in a curriculum, this section draws on a different body of research and practice in order to identify emerging pedagogical principles that have been found to be successful for teaching thinking, as well as specific practices and techniques. To do this we draw on systematic reviews, both narrative reviews and quantitative meta-analysis summarising trends and findings, as well as closely examining the approaches adopted by specific programmes that have made a positive impact on students' thinking and learning of various kinds, for example, *Thinking-Based Learning* and infusion approaches (Swartz & Parks, 1994; Swartz et al., 2007) and associated approaches (McGuinness, 2006; Dewey & Bento, 2009); *Cognitive Acceleration through Science Education*, CASE (Adey, Shayer & Yates, 1989), *Cognitive Acceleration through Mathematics Education*, CAME (Shayer & Adhami, 2007) and *Let's Think (*Adey, 2008); the *CORT Programme* (de Bono, 1986); *Making Thinking Visible* (Ritchhart et al., 2011); *The Thinking Classroom* (Tishman, Perkins & Jay, 1995); *Philosophy for Children* (Lipman et al., 1980); *Instrumental Enrichment* (Feuerstein et al., 1980); *Thinking Together* (Mercer, Wegerif & Dawes, 1999; Dawes, Mercer & Wegerif, 2004) and other dialogical approaches (Wegerif, 2011). More details about these programmes are in Appendix 3.

From this analysis we have identified the following principles as important to successfully teach thinking, irrespective of precise theoretical orientation. All the principles are not exemplified in every approach, but there is sufficient overlap to point to a common pedagogical framework. These are:

- Teach explicit thinking organisers/strategies in the classroom;
- Prompt the students to make the thinking that results from their use visible and public;
- Advance deep thinking challenges using engaging questions as a form of prompting rather than didactic instruction;
- Engage students in collaborative thinking to ensure joint meaning making, interaction, and dialogue;
- Prompt students to adopt a strong metacognitive perspective;
- Explicitly teach to facilitate the transfer of the learned thinking procedures to other curricular and non-curricular contexts;

- Cultivate thinking dispositions and habits of mind;
- Generalise the instructional approach used in thinking classrooms to multi-grade and multi-subject curricula, and hence meld it to create model thinking-based schools with a commonality of purpose and practice.

4.2 Making Thinking Explicit: Implications of a Combined Bloom/Ennis Approach for Teaching Thinking

While the distinctions we have been making in Sections 2.2 and 2.3 may seem rather abstract, they are very important when we set out to plan and to teach thinking in the classroom because they play out differently. Let us imagine that a teacher adopts the first approach (which we will call Approach 1) in which she assumes that naming, and even explaining, a type of thinking is sufficient to prompt its exercise, and when that happens, students are then on their way to developing a thinking skill, which they do by repeated practice. For example, a teacher uses a generic thinking vocabulary (which may be defined) like "explain why", "predict", "compare and contrast", "analyse" with regard to ideas in the curriculum she wants students to learn to engage in in these ways. And she may put students into discussion groups in which they engage in these types of thinking in the course of the discussion. Students might be provoked with challenging stimulus material, through reading or a case study, or being presented with some challenging social issues to discuss in which different viewpoints are likely to be expressed, like capital punishment or global warming. Many of the activities associated with The *Philosophy for Children* program are of this kind in which students read a text in which characters raise intriguing philosophical questions, like "Do humans have free will?" These kinds of discussions are often characterised as creating a community of enquiry and include forms of 'Socratic' dialogue, good questioning and linking techniques. In all of these examples, students are prompted to think in deeper ways than in rote-learning/memory oriented classrooms, and often their engagement involves analysis, synthesis, or evaluation. The defining feature of Approach 1 is that immersion in the challenging thinking task is deemed to be sufficient not only to provoke the thinking –which it most likely will – but to teach it – which it most likely will not.

Contrast this with Approach 2 in which the teacher makes explicit an organised strategy, the practice of which makes the kind of thinking she wants the students to engage in ("judging the credibility of a source", "prediction", "explaining the cause of") *more skillful*, and then works with her students to provide them with opportunities to practice doing this kind of thinking skillfully on a regular basis to lead to its becoming habitual and internalized. The very same thinking challenges described in Approach 1 might be vehicles for the practice of such thinking-organising strategies. The big

difference between Approach 1 and Approach 2 is that students are given the opportunities to become more skillful at a type of thinking *before* they practice it in more spontaneously occurring exchanges and discussion.

Let us give an example. Prediction is often mentioned as a thinking skill, and "Predict……" often given as a prompt to solicit a Bloom performance of an act involving inference. How might this be handled by someone who works with Approach 1? Well, a teacher might ask students to *predict* what the result of a certain chemical test might be if the substance being tested is rich in nitrogen, or to *predict* what a character might do as the result of being faced with the situation she is presently in in a novel being read, or *predict* the effects on the economy of their country if interest rates were suddenly lowered two points. These are fairly standard scientific, literary, and economic predictions. The literary request, in fact, represents a standard mental move that most people make routinely as they read. Notice that this prompt is couched in thinking language using a thinking word, "predict". And it does involve a certain amount of thought – thinking ahead is often based on an awareness of the circumstances and relevant information that students retrieve from their working memory. At first sight, Approach 1 looks like a fruitful approach. It seems to involve the exercise of a thinking skill, and the more students do this the more they may develop a sense of when such predictions are either needed or appropriate. And the more they guide themselves to make these predictions, the less they need external prompts to do so.

However, based on what one sees in these classrooms, something different happens. If someone just makes a prediction, that is not enough to say that a thinking skill is being exercised. The prediction may be no more than a guess, or if it is an "educated guess", it may be made on the basis of limited understanding of the present circumstances or on limited relevant background information. In fact when asked for a prediction anyone can predict anything and still be making a prediction. The headline in the latest New Year's Day tabloid that the world will come to an end in that year is no less a prediction than that, when provoked, a snake will bite. Is the prediction in the tabloid one that a person can say *is likely to happen* as the prediction about the snake is? People who are careful about the predictions they take seriously usually want to give themselves just such an assurance before they accept – and perhaps act on – a prediction.

To facilitate a more skillful kind of prediction, a teacher following Approach 2 would want to do more with the students than just have them make predictions. This could involve helping the students use a more finely tuned and explicit heuristic strategy for how to make predictions with skill, again couched in the language of thinking. It may look like the following:

SKILLFUL PREDICTION

- What do you think might happen?
- If you want to do a thorough investigation, what information or evidence might you gather to help you decide with confidence, if the prediction is a good one -- likely or unlikely?
- When you look for such evidence, what do you find?
- Based on this evidence is the prediction likely, unlikely, or uncertain?

Formulating an explicit strategy like this to guide students is often the result of judgments made by the teacher about common problems that arise when students engage in types of thinking like prediction with poor results. For example, they often miss things that are obvious or are accessible with a little training that can yield better thinking results. Examples of failed decision-making or problem solving – that is, making a choice or adopting a solution to a problem that leads to unacceptable, bad, or even disastrous results – are good examples of such failures. Swartz and Perkins, 1989) summed up these general negative tendencies in our thinking as:

- Hasty – impulsive, with insufficient effort to process deeply and to examine alternatives;
- Narrow – failure to challenge assumptions and examine other points of view;
- Fuzzy or vague – careless, imprecise, full of confabulations;
- Scattered or sprawling – generally disorganised, failing to advance or to conclude.

Organised strategies, like the one for predicting that is outlined above, which identify questions that are important to answer before completing the thinking (e.g., endorsing a prediction, making a decision, etc.), and which are followed, can correct for these, though, of course, there is always the possibility that something unexpected will happen that will still yield an unfortunate choice.

Here is a strategy to guide students' decision making so that it will be more skillful:

SKILLFUL DECISION MAKING

- Why do I have to make a decision – what is its goal?
- What are my options?
- What would the positive and negative consequences be for each of these options, including long-term and short-term, and consequences for others as well as myself?
- How important are these consequences?
- In the light of all of this what is the best option?

Approach 2 is more likely to reassure a teacher that the student has engaged in more skillful prediction or decision making, compared to Approach 1.

To summarize: there are four important focal questions to ask about what appears in the IB documents about our goals in teaching thinking:

- To what extent is there a consistent, explicit, and organised program regarding thinking, couched in thinking-related language that runs throughout the PYP, MP, and DP?
- Is the approach to teaching thinking based exclusively on Bloom's Taxonomy, and if so, what role does the taxonomy play in defining the goals of the thinking program? To what extent are specific types of thinking that fall into the Bloom categories identified and, if so, what is their role in defining the goals of the thinking program?
- To what degree do performances of any such specific types of thinking as predicting in appropriate circumstances alone constitute the methodology of instruction in teaching thinking?
- Are performing such types of thinking articulated in a way that defines how to engage in them *well* or *with skill*. If so, to what degree are these made explicit in instruction in thinking so that students can be guide to do the thinking well.

We will see how these ways of interpreting what the teaching of thinking might involve helps to frame what appears as we work through the IB curriculum.

In conclusion, we have just argued that it was important to be specific about the thinking objectives of the curriculum and to frame these in a way that would prompt students to become more skillful. We showed this by contrasting Approach 1 and Approach 2 – where Approach 2 not only explicitly labelled the type of thinking, but articulated, through a series of teacher/self-questions, how a student might navigate their way more skillfully through mental moves required. There is now considerable research evidence to support the position that deliberately labelling the kind of thinking to be exercised, outlining a possible plan for the thinking or a thinking strategy, and discussing with students some common pitfalls in thinking, lead to better learning outcomes than just immersing students in open-ended challenges that require deep thinking – important though these are, as the next section will discuss. In a comprehensive meta-analysis, Abrami and his colleagues (Abrami et al., 2008) compiled the results of 117 studies that had taught critical thinking in a variety of curriculum arrangements: as a separate general course with explicit critical thinking objectives; using an infusion approach with content objectives and an explicit emphasis on critical thinking; using a mixed approach where a general approach preceded infusion; and an immersion

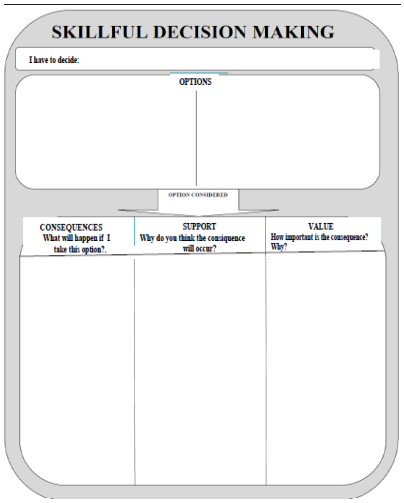
approach, where case studies, vignettes, inquiries, etc were the only methods adopted to provoke the thinking and no explicit mention was made of specific strategies. For our purposes in this section, it is sufficient to report that all the explicit approaches had a more positive impact on critical thinking (as assessed by post-test measures of critical thinking) than the immersion approach. Whatever the limitations of the meta-analytical approach to reviewing previous studies (where the exact details of a specific critical thinking intervention are often lost), they do capture general trends and the growing consensus is towards making the thinking more explicit.

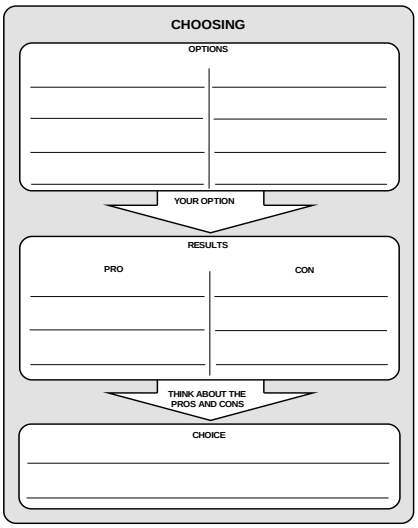
4.3 Thinking Organisers: Maps and Graphics

In the classroom, what it means to make thinking more explicit can refer to different things. Because thinking is a mental activity, it is often said to be 'hidden', especially from novice learners. When we ask students be 'think more critically', sometimes they just do not know what they have to do. So making thinking explicit can refer to the actions that the teacher takes to make the mental moves in the thinking more transparent to the learner, like outlining a plan for more skillful thinking through a set of questions, as was illustrated with prediction and decision-making in an earlier section. These techniques are often referred to by the general term of 'thinking organisers'. Good examples are the thinking maps (guiding questions) and the graphic organisers that form the backbone of Thinking-Based Learning (Swartz et al., 2007, Swartz & Parks, 1994). See below for two graphic organisers for decision making – a sophisticated one that prompts not only a list of options and expected positive and negative consequences, but also some research into reasons for thinking that the consequence is likely, and judgment about how important the consequences are (based on the explicit strategy mentioned earlier), followed by a simple thinking map and graphic organiser for decision-making used with lower primary grade students.

The guiding questions that underpin the second graphic organiser used with younger students are:

- *What are some things I can do* (options*)?*
- *What will happen if I do these things* (predicting the consequences)?
- *Are the consequences positive or negative (*evaluating the consequences into pros and cons)?
- *Is this a good thing to do and why* (weighing up the pros and cons and making the choice)?





There are obvious benefits to these graphical techniques in that:

- they make the steps in the thinking more explicit;
- they slow down the thinking so the students have time to grasp what might be involved;
- they keep an external record of the thinking so that the students and the teacher can look back and reflect on earlier stages in the whole process;
- they can be used for work with individual students, groups and whole class teaching;
- they can be simplified or made more complex depending on the age and competence level of the learners;
- they can be used as classroom posters to illustrate good models of thinking;
- teachers can construct their own graphic organisers and 'build a strategy' to suit different thinking activities;
- they can be used as prompts for subsequent written work and as the basis for assessing written work.

But two words of caution. Using graphic organisers as worksheets should be avoided. For example, some graphics are more like mind-maps. They simply record the content of the thinking and fail to prompt the learner to think in a more advanced or skillful way.

And not every program that uses graphics uses them to prompt skillful thinking. For example, overlapping Venn Diagrams are often used to provide an image for students to enter lists of similarities and differences when they compare and contrast. But more skillful compare and contrast involves the students in thinking about these similarities and differences, identifying the important

ones, and drawing rich conclusions from the comparison and contrast. Some programmes, such as Hyerle's *Visual Tools for Thinking* (1996, 2008) make extensive use of diagrammatic representations as an aid to thinking, but the use of some of these can be restricted to recording the results of recall or just simple identification of qualities.

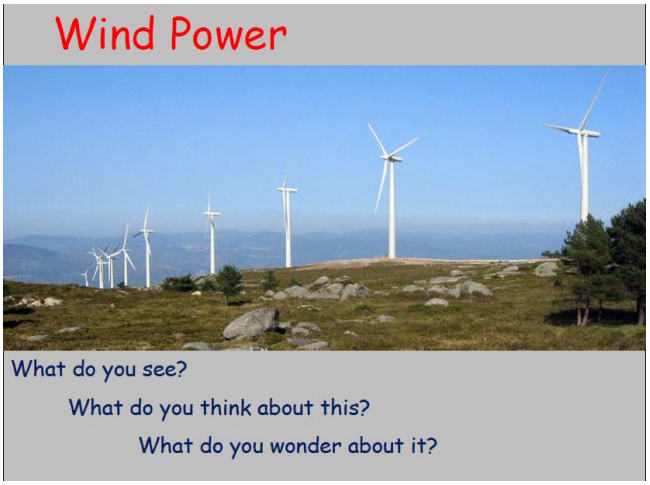
4.4 Other Thinking Organisers: Thinking Routines

Another method for making thinking more explicit can be seen in the CORT programme, the creation of Edward de Bono (de Bono, 1985, 1986, 1990). This program consisted of a series of thinking activities in which people were given short explicit procedures to guide their thinking and they were asked to use these to think about certain interesting situations, initially outside of the curriculum. One such procedure was called a **PMI.** This was short for "Plus, Minus, and Interesting". Students in the program were asked to turn these into prompting questions that could guide their thinking. One famous example was "What if all the Volkswagens were painted yellow?" If you did a PMI you were to ask: "What are the plusses, what are the minuses, and what things are interesting?" These prompts elicited many responses: "You could spot a Volkswagen very far away" (a Plus), "If you owned one it would get dirty easily" (a Minus), "People who made yellow paint for automobiles would make a lot of money" (something interesting). There were a number of these activities motivated by different acronyms.

Clearly these acronyms used in this way prompted thinking beyond mere memory. Participants typically thought about associations and similarities with other situations that they knew about. But they did more – they judged whether these newly envisaged consequences were good ones, bad ones, or new and interesting ones. Indeed, one could make out a case that these were examples of Bloom's analysis, synthesis, and even evaluation. Indeed, as short focused activities in the CORT programme they seemed like interesting thought-provoking games, which may open those who practise them to more thinking. But they are more limited when considered in terms of the more comprehensive goals sketched above related to designing a comprehensive set of thinking objectives in a curriculum, helping students to avoid the pitfalls of bad thinking and the risks of serious consequences stemming from such faulty thinking. Nevertheless, they are examples of the explicit instruction in thinking strategies that can prompt people to broaden their thinking on the occasion of their use.

De Bono's thinking strategies are forerunners of what have been more recently called "thinking routines", though the use of thinking routines is embedded in a more sophisticated structure than we find in de Bono's CORT. A wide range of new Thinking Routines have been developed by

Ritchhart and his colleagues (Ritchhart et al., 2011). An example of a thinking routine, like de Bono's PMI, is the short but focused questions embedded in "See, Think, and Wonder", a typical thinking routine. This is short for "What do you see here, what does it make you think, and what does it make you wonder?" But typically now proponents of thinking routines argue directly that while they could be used in connection with any observation, their most important educational use is infused into content instruction. For example, one teacher, whose students were studying energy sources in science, showed them a photo of a series of contemporary windmills on a hilltop out in the country, asked to do a See, Think, and Wonder activity. But the teacher then asked them to not just think about these questions, or to just respond to them orally, but to write their responses down so that everyone could see. This is a basic principle of this approach – making *their thinking* as well as how they think *explicit* – what is called in some versions of this approach, making their thinking "visible". Here is a prompt and a chart that represents a set of responses from lower secondary students studying energy.



SEE	THINK	WONDER
Some windmills on a hill	These windmills must have been put on the top of this hill because it is where the wind blows the most.	How much do these cost?
A group of windmills making electricity	There is wind all over the world that can turn windmills like these.	How many of these would be needed to give Madrid all the electricity it needs?
The wind turning a group of windmills.to make electricity.	These don't seem to be very complicated machines.	Could we do this to run automobiles?
Modern windmills that make energy.	This won't work when the wind dies down.	Do a lot of windmills like these make a lot of noise?
This is a windfarm and the harvest is energy.	This is beautiful	Is this the best way to get energy?
	This is ugly and destroys the beauty here.	Will we have to use oil at all if we get energy from windmills?
		Do people like these?
		Can you put more blades down the poles to get more electricity?

What this shows us is how using this thinking routine can activate the same thinking/learning mechanism as the de Bono CORT strategies do and can, likewise, lead to interesting further thinking, and even, as in this case, research, and deeper learning and understanding. In this classroom the teacher used it as an initial orienting activity to open up some thinking on the part of the students, and then to lead into a second activity in which the students focused on an Approach 2 thinking skill excursion into skillful decision making about what energy source would be the best one to choose for their country as its dominant energy source. Would it be petroleum, or would it be one of the alternatives presently being explored, or another just being talked about now. And, of course, when they made their choice, they had to be prepared to explain why. Examples of other kinds of thinking routines are: Think-Puzzle-Explore; What Makes You Say That; Connect-Extend-Challenge.

So our sense is that while use of what are now called "Thinking Routines", including the CORT de Bono strategies, certainly stimulate thinking, and certainly are motivators of organised thinking, they do not bring students to level of developing sophisticated Bloom-type thinking skills. Yet they do serve well as entry points into explorations that involve higher-order thinking, and can supplement and enhance the use of these skills.

4.5 Adopting a metacognitive perspective

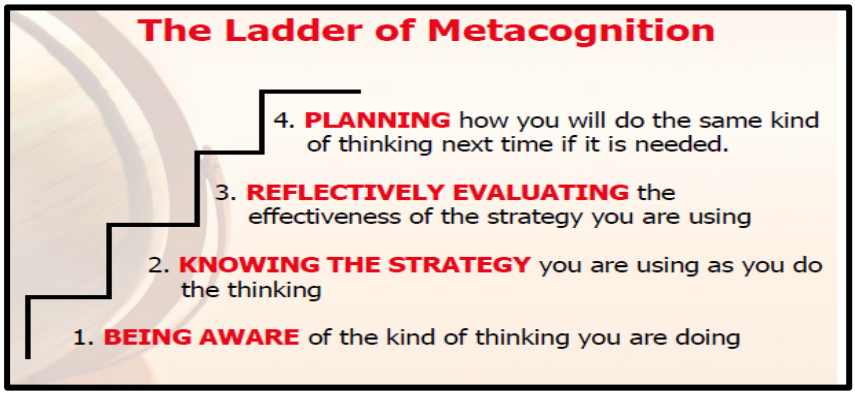
The importance of making thinking explicit or making it more visible is generally acknowledged in many programmes and approaches, primarily because it opens up the world of thinking for students, giving them opportunities to understand what thinking is, the variety of mental moves and strategies that comprise good thinking and as well as opportunities to practice it different contexts. But making thinking visible is even more important for the role it plays in metacognition.

4.5.1 Techniques for Prompting Metacognition: It is not surprising that metacognition plays a central role in most programmes and approaches. For example, in the cognitive acceleration programmes (Adey, 2008), metacognition is one of the three pedagogical pillars and it is promoted by helping learners to verbalize and to explain their thinking, thus making it potentially more available for use on another occasion. The general practice of 'thinking aloud' or talking about thinking has been identified as a metacognitive tool (McGuinness, 1990, 1993). Other techniques focus more directly on the phases of the task during which metacognition might be promoted. For example, Tishman, Perkins and Jay (1995, p. 77) describe a mental management strategy called FOURTHOUGHT, involving four steps:

1. Before Thinking – Get Ready, Identify a Plan
2. During Thinking – Use Goals and Standards
3. During Thinking – Keep Track of Thinking – remember to be a mental manager
4. After Thinking – Reflect – Review and evaluate, look for improvement

Swartz and Perkins (1989) have identified a Ladder of Metacognition that articulates a set of questions to prompt the use of a specialized metacognitive strategy. The goal of this strategy is to help students to direct their own thinking, using an explicit thinking strategy that has been previously introduced in a thinking based lesson and, up to this point, has been prompted by the teacher. It is for use either before, during, or after a deliberate thinking activity. The purpose is to transition the students into the regular guidance of their own thinking and, eventually, to the

internalization of the thinking strategy. Here is an image representing this ladder (or more precisely, “stairway").



These more direct approaches go some way to creating an explicit metacognitive thinking plan or thinking strategy in a manner similar to the explicit thinking strategies which were previously described.

Fogarty (1994) in her text *The Mindful School: How to Teach for Metacognitive Reflection* explains a variety of other classroom techniques for prompting metacognitive thinking at the planning, monitoring and evaluating phases of completing a task.

4.5.2 Towards Self-Regulation: Scaffolding and Fading. As outlined earlier, the ultimate goal of adopting a metacognitive perspective in the classroom is that students will internalise the thinking skill by making it an object of reflection so that students begin to use it spontaneously and independently in future learning. This may not happen, or happen as well, if the teacher keeps explicitly guiding the students through the process when it is needed. Many students develop a dependency on this guidance that becomes harder to break free of as they face new problem-solving challenges. So most teachers have learned that the sooner they remove the scaffolding without bringing the students back to where they started, the better. This gradual transition is sometimes referred to as ‘fading’ – as the responsibility for the thinking moves from being teacher-guided to being student-guided.

A shift in the classroom to having students engage in metacognitive reflection about the strategy they are using, or have just used, to make a decision or a prediction with skill – like asking “How did you make that decision” – and then following it with an evaluative prompt: “If this worked well for you, how will you do it again next time you have to?” pulls some of that initial scaffolding away and shifts to the students starting to guide themselves. Then the teacher can simply cue the students by saying something like “Let’s try some skillful decision making as we think about what the best thing

would be for Napoleon to do when faced with exile.", with no further guidance. In this case the students are expected to guide themselves in skillful decision making, as part of their practice with the skill. As they proceed, even this cueing can be withdrawn so that the students decide for themselves what the best skill would be to use to resolve the challenge posed by a situation, the resolution of which will lead to curricular-related learning.

The expectation is that students will identify a situation as one that calls for a certain kind of skillful thinking and guide themselves to engage in that kind of thinking quite naturally and not in a deliberate step-by-step procedure anymore. That, of course, is the basic goal of teaching students skillful thinking.

Here are some basic instructional strategies that teachers have used in this stage of thinking skill instruction.

- Cuing students to do a certain kind of thinking called for by a problem situation related to important content in the curriculum.
- Presenting thinking challenges related to the content curriculum without specific cuing about specific kinds of thinking to use.
- Challenging students to apply certain kinds of thinking to examples from other parts of their curriculum (transfer, see next section).

4.5.3 Teaching for Transfer: Transfer of learning is important for all types of learning, not just for learning to think. Essentially, transfer refers to the phenomenon of applying what is learned in one context to a new context. So if a student learns to make decisions more skillfully in her history class then to transfer that thinking into her English literature class, for example, she must be both alert to future contexts in which it might be useful and sufficiently competent to apply the skill in the new situation where some customisation and/or improvisation may also be needed. In an insightful analysis of the transfer of thinking, Perkins & Salomon (1989, 2001, 2012) point out that it may not happen automatically. They playfully characterise the automaticity belief, as the Bo Beep Theory of Transfer –"let them alone and they will come home, wagging their tails behind them". Unfortunately, much school-based knowledge and skill remains 'inert' - that is, locked-in to the situations in which it has been learned. Perkins and Salomon go on to outline distinctions between what they call *low-road transfer*, where the conditions of transfer bear strong perceptual similarities to the original learning conditions, thus facilitating some degree of automaticity, and *high-road transfer*, where " a more mindful abstraction of the skill or knowledge from one content for

application to another" (p.373) may be needed. This kind of transfer of course is harder to achieve. One of the greatest advantages in adopting a metacognitive approach to teaching a thinking skill is that it dis-embeds the thinking from the immediate context in which it has been practiced – deliberate mindful abstraction, in Perkins words – thus priming it as a mechanism for transfer. Metacognitive thinking can thus support not only forward-reaching transfer to future situations but also backward-reaching transfer, where thinking strategies used in previous situations are prompted before encountering new situations.

Transfer of skillful thinking has proved problematical for thinking programmes and for different reasons. For example, if a thinking programme is organised as stand-alone and taught in parallel with the mainstream curriculum, then the thinking skills that are learned in the programme may become locked into that context and fail to transfer. Many of the earlier thinking programmes (e.g., Instrumental Enrichment, critical thinking courses at college level) were critiqued for that very reason. The same risks are also associated with interventions that are confined to only one area of the curriculum – science or mathematics. For these reasons, most programmes now develop very specific methods to 'bridge' out to other curriculum areas, and with some success. For example, Cognitive Acceleration in Science Education (CASE, Adey & Shayer, 2002), working from a Piagetian model of cognitive development and with a strong metacognitive perspective, reported learning gains for students in subsequent state examinations, not only in science, but also in mathematics and English.

The infusion approach, where thinking is taught across-the-curriculum at the same time as curricular topics, is considered to be best placed to maximise transfer. But even with this approach, transfer is not automatic as students may fail to see the connections between similar types of thinking in different subject areas unless methods are deliberately adopted to make this happen. That is why we think teachers need to add more questions to the metacognitive phases of questioning in a classroom , questions like "where else in some of your other classes would you use this type of thinking?", "where have you previously used this type of thinking"? and "where else in your life outside school" might you use this type of thinking?" to ensure that transfer connections are explicitly considered. Beyond these classroom prompts for students, teachers have also worked together to identify opportunities where they can reinforce the practice of a particular type of thinking taught by one teacher in a different subject area taught to the same students, as well as being alert for spontaneously occurring opportunities for reinforcement. For primary schools, where a single teacher normally has full control over his/her class within a grade year, such reinforcement is relatively easy. For middle schools and high schools, ensuring cross-subject

transfer requires a greater degree of team curriculum planning than is the norm in many schools. Almost all writers on thinking skills stress the importance of transfer if any learning gains are to be long lasting (e.g., Halpern, 1998; Swartz et al., 2007).

4.6 Cultivating Classroom Talk, Dialogue and Collaborative Thinking

Although thinking is normally considered to happen 'inside the head', it is increasingly recognised that that thinking is not only a 'solo' activity. Certain theoretical perspectives, notably Vygotsky (1978), and more recent socio-cultural theorists (e.g., Wells, 1999; Mercer & Howe, 2012) point out that the relationship between social activity and individual thinking is a distinctive characteristic of human cognition. Vygotsky specifically proposed that, developmentally, learning involved internalising activities originally witnessed and practiced in co-operative settings. He believed higher mental functions first appear on the *interpsychological* or social plane and only later on the *intrapsychological* plane or individual plane.

Since the 1980s many schools have recognised the need to help students develop the kinds of social skills needed to collaborate well with others. One major influence on classroom practice has been the Cooperative Learning movement (e.g., Johnson & Johnson, 1994; Blatchford et al., 2003). Establishing groups in which students divide the group task, or have different roles in overseeing the workings of the group (one student as group coordinator, one as recorder, one as reporter, for example) are now common practices in many schools. While typically learning tasks, such as, "finding out the major events in the French Revolution" are the goal of such cooperative groups, they also serve to foster social interaction in thinking when the classroom has thinking-related goals. Cooperative groups can be particularly powerful when the group is specifically challenged with a thinking task, for example, "decide on the best decision for Huckleberry Finn at a crucial point in the Mark Twain novel", or for primary grade students, "what is the best decision for Peter Rabbit at the gate of Mr McGregor's garden?"

But whether the social context is a collaborative thinking group or the whole classroom, various classroom strategies enhance social thinking. Vygotsky's basic insight is reflected in programmes that focus specifically on classroom talk which can explicitly express types of skillful thinking that students are engaging in. Traditionally, classroom talk research has been interested in the role of the teachers' questions, like the impact of closed vs open questions, and the use of recall questions vs higher-order questions, reflecting the influence of Bloom. But there is a newer research tradition that closely studies the nature of student talk – how students elaborate and explain what they understand, how they explain their reasons and justify their points of view, the language they use to

move their thinking on, and how they respond in dialogic exchanges with other students when they work collaboratively on a shared thinking task. Drawing on this perspective, Mercer and his colleagues (Mercer, 1996; Mercer, Wegerif & Dawes, 1999; Dawes, Mercer & Wegerif, 2004; Mercer & Littleton, 2007) devised a programme where children are explicitly taught about, and engage in, a speech genre called Exploratory Talk that emphasises reasoning, sharing knowledge, and a commitment to working collaboratively. In terms of teaching thinking techniques for younger children, the programme consists of a series of structured lessons that establishes ground rules for thinking (turn-taking, listening and so on) and uses a Talk Box for each lesson that focuses on a different kind of thinking – giving reasons, exploring evidence, comparing patterns and so on. The programme does not directly teach thinking strategies nor does it expect students to be able to respond to a thinking prompt alone (as in Approach 1). Rather, the learning objective for the programme is 'a thinking type of talk', called exploratory talk. Essentially the programme provides scaffolds for talk such as linguistic phrases like "what do you think?" "I think because…" "I disagree because…" " I can say more about……". And of course an extension of this idea is to script deliberate exchanges between students in which questions like "What do you think some positive consequences of this option are?", or "Can you find any evidence for that prediction?" can be supported as part of the dialogue.

The shared nature of the thinking means that the children scaffold one another's thinking and enable their thinking to travel further than would happen if they were trying to solve a problem on their own. From the point of view of teaching thinking, we think this approach provides another way of making thinking more visible – through the thinking words and phrases that the students use in their shared experience of thinking – which can then become the object for metacognitive reflection. Moreover, from the point of view of formative assessment, careful listening to student talk by the teacher can give some indication of the how their thinking is developing.

The Thinking Together programme aims at the goal of establishing a community of thinkers in groups or in the whole classroom, and eventually a regular "culture" of shared thinking in a classroom or in a whole school. This has much in common with the vision of the 1980s-90s practice of trying to establish "communities of enquiry" often associated with the *Philosophy for Children* Program. Other approaches like Dialogic Teaching (Alexander, 2008a, 2008b) and Accountable Talk (Resnick, Michaels & O'Connor, 2010) strive to achieve similar goals.

4.7 Teaching Students to Develop Important Thinking Dispositions

Despite the differences between the theoretical approaches to thinking dispositions that we outlined in Section 2.5, when the practices for teaching dispositions are examined, there is common appeal to ideas like socialization of thinking, creating thought-full classrooms, enculturation and cultivating of thinking (e.g., Ritchhart, 2002). However, there is no strong consensus about how to teach thinking dispositions. There are many references to 'immersion' in a classroom culture of thinking, but no clear sense of how this works to build thinking dispositions. The clearest illustrations are the Pictures of Practices described in Tishman, Perkins and Jay's (1995) *The Thinking Classroom*. In more recent work Tishman and Andrade go much further than these ideas to identify the following elements of classrooms that may impact on the development of dispositions (https://learnweb.harvard.edu/alps/thinking/docs/Dispositions.htm):

- Making *models* of good thinking dispositions available in the classroom;
- Providing *explanations* of the tactics, concepts and rationales for good thinking dispositions;
- Prompting peer *interactions* that involve thinking dispositions;
- Providing formal and informal *feedback* around thinking dispositions.

We would add that

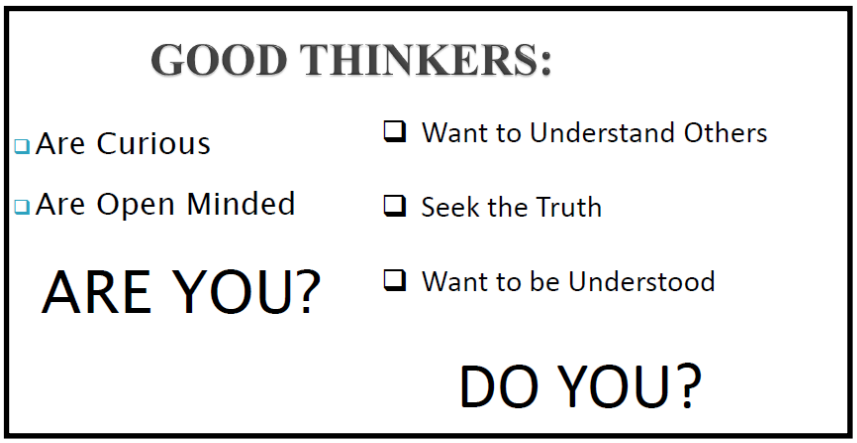
- Thinking dispositions should be the focus for *metacognitive* examination in the same way as thinking skills.

When these five elements are considered they bear a strong resemblance to the principles and practices that we have previously outlined with regard to thinking skills. Element 4, formal and informal feedback will be discussed in the Assessment section.

From our point of view, three focal points with regard to thinking dispositions are important in any effort to teach thinking skills:

- These broader dispositions should also be acknowledged as instructional objectives;
- Teachers modelling should be motivated by these dispositions and should draw attention to other examples , perhaps in fiction, history or contemporary culture;
- Developing these dispositions should be addressed explicitly in some way consistently in classroom activities that involve the use of thinking skills.

Here is a poster made by students in one school and posted on the walls to get students aware of the importance of developing these thinking dispositions.



4.8 Creating Extended Units in Which Thinking is the Driving Force: Problem/Project-Based Units

Thus far the examples we have discussed of instruction in thinking have taken the form of short lessons – one or two class periods on specific topics and using specific thinking skills. But many schools have developed longer units that combine both content and thinking skills to accomplish their objectives. These are often called "project-based learning" units.

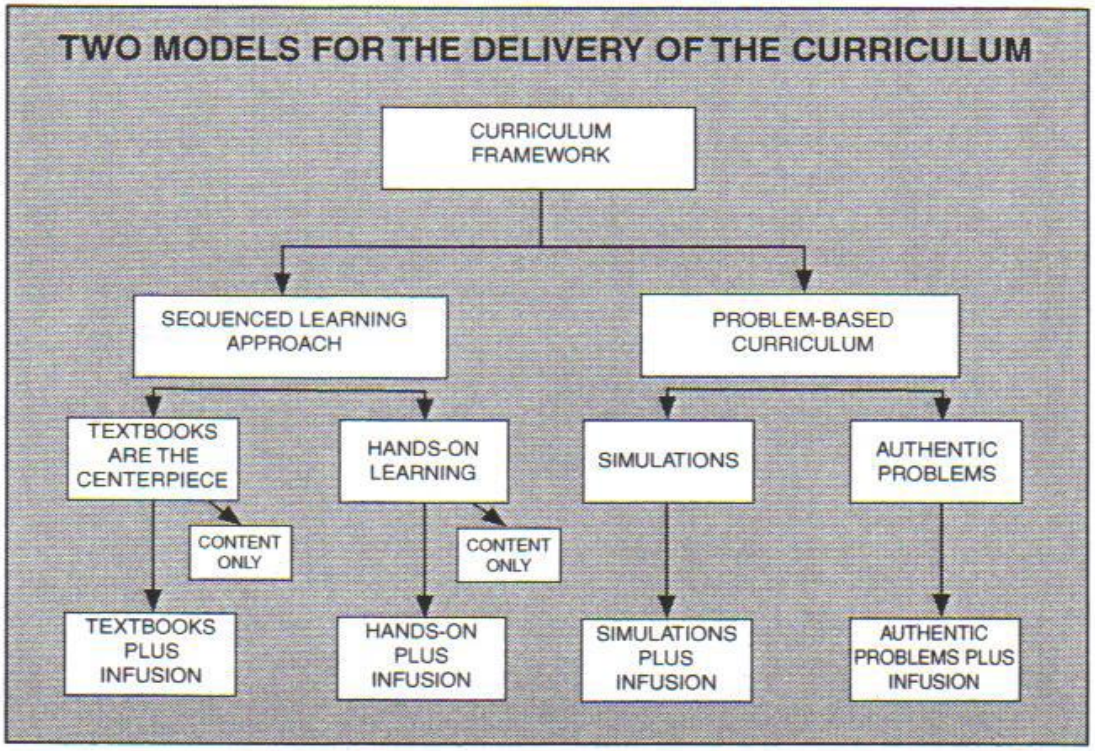
The primary model used for project work over the past 25 years, however, has been what came to be called "Problem-Based Learning" (PBL). PBL was initially introduced by a medical faculty member at McMaster University in Canada as an innovative way of learning to replace traditional medical school courses. Early in the medical education of new students they took a practice-oriented course in which they worked in teams, were given real or simulated medical problems, and they had to find out what they needed to know in order to solve the problem (Neufeld & Barrows, 1974). This model was simple, with supposedly radical implications for medical education. For example, instead of learning anatomy and physiology in standard courses, this learning, it was claimed, would take place in such problem-solving contexts. And, it was claimed, the learning would be deeper and richer than the rote-learning, whose half-life was a few days after a test. Content learning in medicine, it was claimed, would be long-lasting. For example, a group of students might be put in a clinical setting in which a real or simulated patient comes in complaining of stiffness in her knee. The job of the team is to diagnose this ailment and treat it. To do this the student team has to find out, through a process of inquiry, all relevant information about the knee.

The originators of this project claimed great success, measured, in large part, by student results on medical content tests and performance as MDs. However, even though there is controversy about the ability of this model to achieve the breadth of content coverage that exists in standard anatomy and physiology courses in medical schools, it was viewed as successful enough to find limited application in some of the most prestigious medical schools in the USA. Harvard Medical School, for example, introduced the "Pathway Program" in the 1980s, based on the McMaster model. And in the late 1980s and through the 1990s this model was applied to K-12 education, though there is still considerable discussion about what it can and cannot achieve in terms of learning outcomes (Dochy et al., 2003; Hmelo-Silver, 2004; Gijbels et al., 2005; Savery, 2006) and even what the key components are (Pease & Kuhn, 2011).

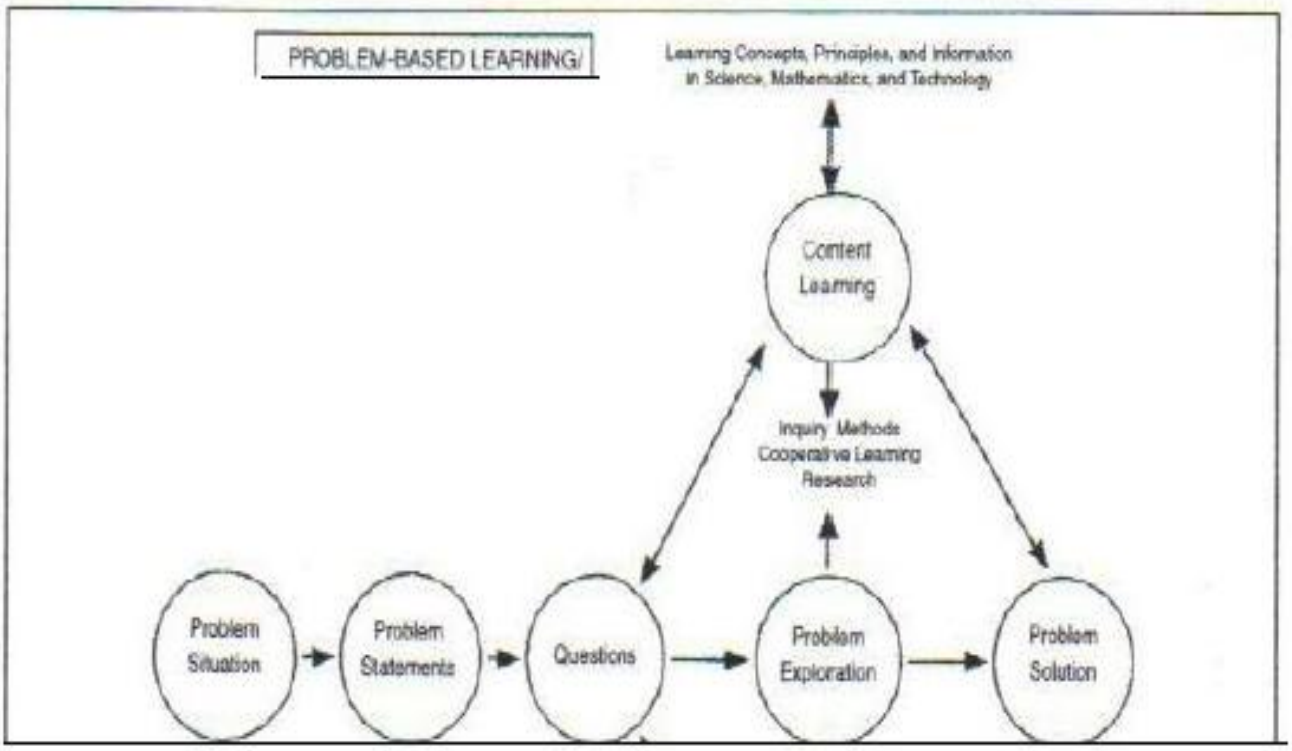
One important influence on the way problem solving and longer problem-based units were developed in pre-college education was the approach to teaching creative problem solving associated with Treffinger and his colleagues that we referenced in Section 2. As standard problem-solving activity morphed into longer and more developed problem-based units in some schools, these deliberate and more explicit techniques to foster creative solutions to standard but hard problems helped to organise the students' problem solving activities. Sometimes, though, this happened at the expense of the necessary critical thinking skills that would be needed to select the best solution to a problem. An example of this is in the Odyssey of the Mind competitions that occur periodically in selected schools internationally, originating from the Creative Problem Solving team at the State University of Buffalo in the USA. In this competition, awards are often made for highly creative solutions to problems, with little emphasis on the real feasibility of these solutions. Subsequent problem solving models then incorporated elements of both critical and creative thinking skills as the best approach to creative problem-solving (see Isaken & Treffinger, 2004, for the development of the Creative Problem Solving framework over 40 years).

One important fact about these attempts to replace traditional content teaching with a learning model based on solving problems is that its application in both medical schools and in K-12 education has been, typically, limited in scope. The practical problems in trying to replace a whole K-12 curriculum using PBL have made its actual use in schools and colleges very circumscribed. Nonetheless, PBL, from the beginning, was not an attempt to provide students with an opportunity to apply what they had already learned more abstractly in their courses to a real-life situation, but to provide a substitute for traditional learning systems like textbooks and standard courses. This diagram illustrates the more radical nature of PBL.

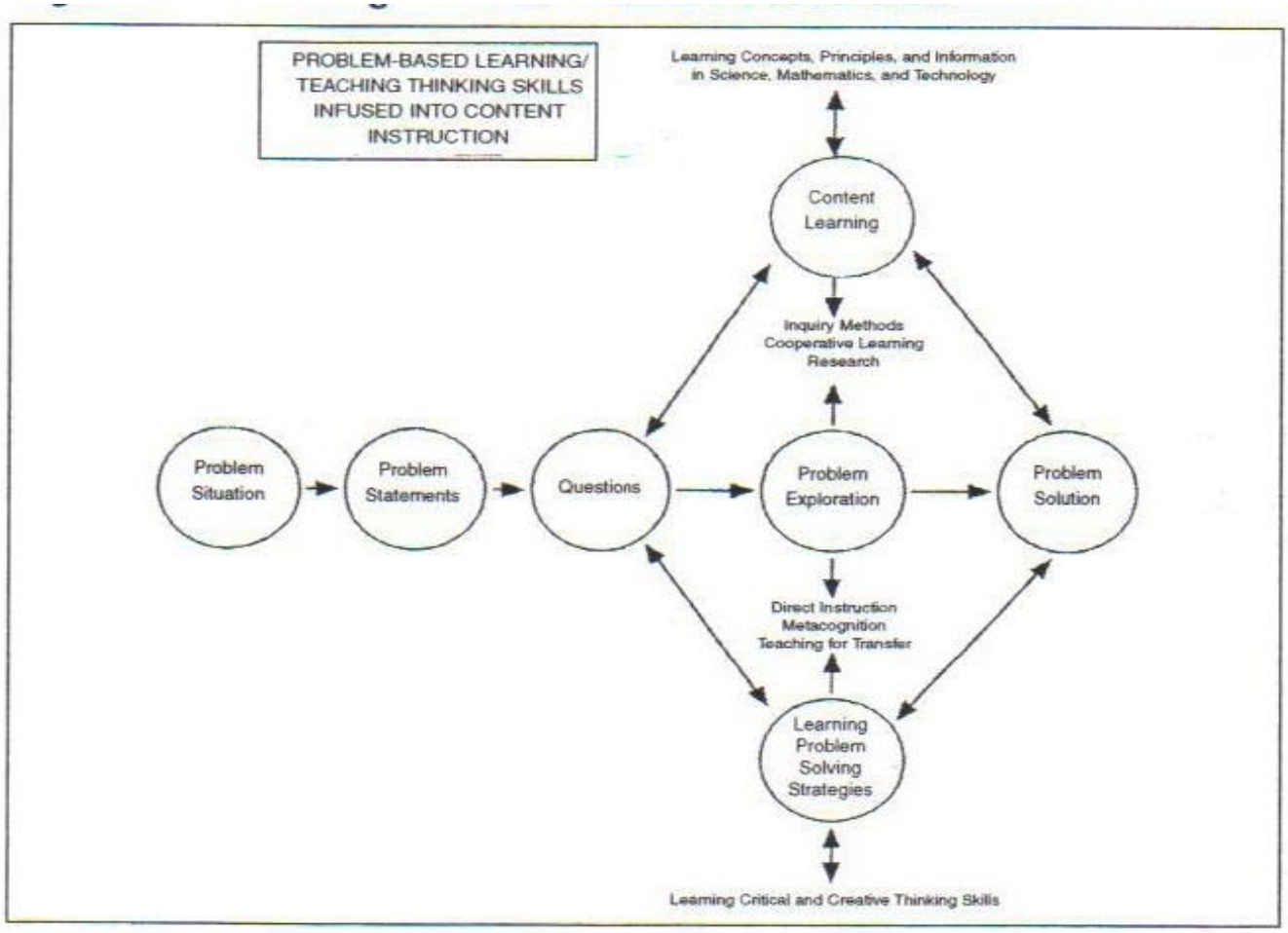
Figure 7-9. Problem-Based Versus Topic-Based Learning



Note that in this diagram there are two – as yet undefined – versions of PBL. One is the practice of solving the problem without any skills backup or scaffolding produced by the teacher. The other manifestation of PBL is flagged by the phrase "PLUS INFUSION". This refers to the deliberate instruction or integration of the use of specific, appropriate, and explicit thinking skills as the problem-solving process unfolds. In both cases there is usually a structure or pattern introduced by the instructor in the problem-solving process. In the first, without the deliberate and explicit infusion of thinking skills, students are prompted to raise questions that need answers to solve the problem. In the second, a structure is constructed in which specific thinking skills are introduced by the instructor as the problem solving proceeds and the students are expected to use these in their problem solving. The following diagram illustrates the first way that PBL has been practiced:



The expansion of PBL by infusing explicit instruction/use of thinking skills in the process looks like this:



On this model, practiced at some schools, the problem solving process is usually enhanced and guided by the introduction and use of a sequence of thinking skills based on the following identification of the types of thinking that enhance problem solving, with problem-solving, now interpreted as the practice of a thinking strategy being the overarching thinking structure that guides the process.

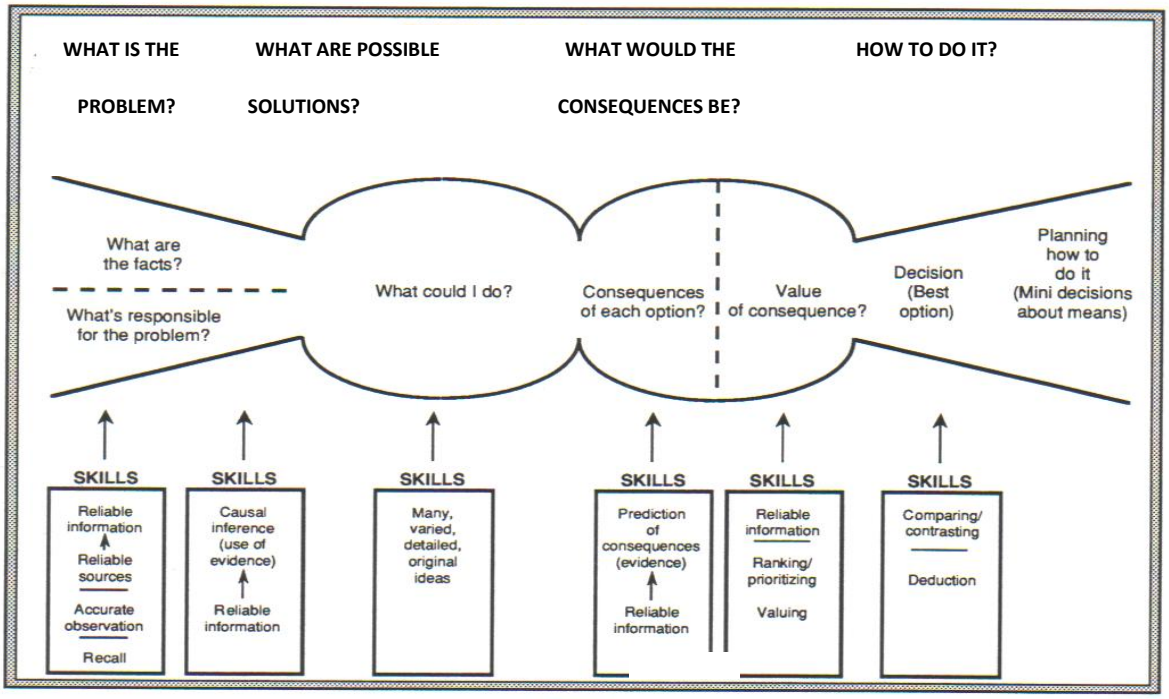


Figure 6

One final word about these models for extended projects in education: in the 2000s the orthodox medical-school model for PBL morphed into what is now called "Project-Based Learning" . Two basic changes are involved. The first is that the repertoire of contexts for such extended units was expanded to include projects and not just problems. So, for example, the PBL structure is used not only to help students try to solve problems about air pollution, or about a business whose profits are falling off, but to engage in constructive projects like designing a new park in an urban community or organizing a class field-trip to an archaelogical site. But the second, and more important from our point of view, is that the idea of replacing chunks of the curriculum with problem-based units that have specific content objectives has been further replaced, in most contexts, by the original model of project work – that is, the *application* of what students have already been exposed to in the curriculum and have achieved a modicum of understanding with regard to.

As an aside, we want to note that while many schools utilize the first model of PBL above – that in which groups of students work together on problems or projects, some schools practice the thinking-enhanced model of PBL. One example of the latter is a school in Barcelona, Spain – Collegio Montserrat – in which part of the academic program of the school takes students on an excursion into problem/project based learning, but always involving the explicit integration in one or more thinking skills into the process. Students not only simulate, for example, Martin Luther, facing the problem of disemminating his new ideas about Christianity, or President Harry Truman trying to decide what to do to try to end WWII, knowing that the USA now has nucear weapons, but they also

work on special projects, like designing a playground for young children with a variety of learning opportunities built in. Birkdale Intermediate School in Auckland, New Zealand, is another such example in which the whole curriculum consists of problem/project-based units into which explicit thinking instruction is infused.

Finally, the norm now is that when these projects are undertaken, whether they are based on PBL Model I or Model II, they are usually assessed in ways that contribute to the overall summative evaluaton of their academic work in school.

.

5 Assessing Thinking: Principles and Practices

We now turn to considering approaches and methods for assessing thinking and related constructs. There are essentially two general approaches that can be identified in the field: (1) the psychometric or testing approach, where critical thinking, for example, is considered to be a general capability of the person that can be assessed separately and relatively efficiently in a single testing session, similar to the principle behind intelligence testing; and (2) the curriculum approach, where thinking is assessed as it manifests itself in a specific learning context in terms of the quality of students' written work or a performance of some kind. The first tradition depends largely on multiple choice testing formats while the second approach on extended performances, written or otherwise, normally involves the use of criterion-related marking schemes and rubrics. This latter type of assessment is more associated with teacher-developed assessments, sometimes based on authentic contexts that form the basis of the assessments. In some incidences, criterion-related marking form the basis of public examinations. These all go beyond multiple-choice testing, though sometimes multiple choice items are also incorporated into these broader types of assessments

Because of the nature of the IB programmes and their assessment philosophy, we will focus on this second approach, but will draw on examples of the design of multiple choice item construction that might have more general application. Appendix 4 gives more details of some of the most widely used psychometric tests.

5.1 General Assessment Principles

There are some general principles for assessment that apply to all kinds of student work, and they apply equally to the assessment of thinking skills and related dispositions. We recognise that assessments can differ with regard to WHO makes the assessment (teacher, peer, self or external agent), the PURPOSE of the assessment (formative or summative) and the PERFORMANCE that is being assessed (e.g., essay, written exam, oral presentation, group discussion, enquiry project, portfolio). Nevertheless, the following principles can apply.

The alignment principle: It is important to align assessment criteria with the desired learning objectives of a programme, a unit of work, or a specific lesson. This alignment principle underpins the curriculum design approach called 'backward design' where the teacher is asked to 'think like an assessor' from the start, asking questions about the evidence that will be sought from the students' work to confirm the extent to which the objectives or learning outcomes have been achieved (e.g.,

Wiggins & McTighe, 2005). In the case of assessing thinking skills this can be seen as a problem, as the student work is likely to be a mixture of content understanding (or even recall), skillfulness in thinking, as well as perhaps written communication skills. Nevertheless, if the alignment requirement is to be fulfilled, and if thinking objectives are a prominent part of the curriculum, then thinking as a learning outcome must be given due prominence in the assessment. So while complex when there are multiple learning objectives being assessed, this is manageable.

The specificity principle: Following the alignment principle, good quality assessment requires that what is to be assessed should be as clearly and exactly specified as possible, that the assessment tasks actually explicitly demand that the students' demonstrate the desired knowledge or skill (Brookhart, 2010). In the case of thinking skills, the explicit demand or request that the student display a specific thinking skill like skillful decision making, or skillful comparing and contrasting, is a manifestation of this principle.

The standards principle: Building on the specificity principle it is also important in a good assessment program that the teacher knows what characteristics of the students' work will be taken as evidence (Brookhart, 2010). This needs to be added to the specificity principle because, for example, at different grade levels, like with any skill, the way the skill is taught and manifested may vary, perhaps with more performances demanded to display the skill in the upper grades. This is true of all skill development that proceeds in stages. For example, sometimes teachers who are teaching skillful decision making to students in the 1st grade only focus them on thinking of options and pro and con consequences, while teachers in the upper grades add a focus on ranking the consequences as important. Or in the lower grades, when the skill being taught is a critical thinking skill like judging the likelihood of a specific causal explanation of an event, it may be enough to find students able to *locate evidence* for or against the likelihood of the prediction, whereas in the upper grades we may well expect students to be able to judge that *direct evidence* has more weight than *circumstantial evidence*.

Applying these general principles to thinking, if we are interested in how skillfully students engage in specific kinds of thinking that we have been trying to teach them , it is important that

- the prompt makes clear what kind of thinking the student is being asked to show evidence of, for example, whether it is analysing, comparing and contrasting, decision making, challenging an argument;

- the kinds of thinking being assessed are aligned to the thinking-related learning objectives of the curriculum, unit, or program.
- criteria are developed that relate specifically to characteristics of the thinking and that these are reported separately so that feedback can inform students about the quality of their thinking;
- a rubric is developed that shows different standards or levels of proficiency of skillful thinking, with appropriate performance descriptors that distinguish between the levels.

We shall develop and illustrate these ideas in the next sections.

The assessment for learning principle: As well as the more technical requirements of the specificity principle, it is important to remember the role of assessment in the context of ongoing classroom activities. 'Assessment for learning' is a recently introduced term into the assessment literature and it goes beyond the more traditional meaning of formative assessment. Essentially, any assessment can be formative if it shapes the next instructional steps for teachers and/or the next learning steps for learners, so teaching needs be adaptive to where learners are at right now (Wiliam, 2011 for a good overview). In order to this, the following five key strategies have been taken from Leahy, Lyon, Thompson & Wiliam (2005) and we have customized them to focus specifically on thinking rather than on learning more generally:

- Clarifying, sharing and understanding *thinking objectives* and criteria for successful *thinking* ;
- Engineering effective classroom discussions, activities, and *thinking tasks* that elicit evidence of thinking;
- Providing feedback that moves the *thinking* forward;
- Activating learners as instructional resources for one another;
- Activating learners as owners of their *thinking*.

Viewed in this way, the assessment for learning principle can easily be translated into an 'assessment for thinking' principle which is entirely consistent with the teaching thinking principles, like making thinking more explicit, adopting a metacognitive perspective, collaborative thinking, that were discussed in Section 2.

5.2 Assessment Practices: Using Prompts, Criteria, Standards and Rubrics to assess Student Work

Following the specificity principle, if we are interested in how skillfully students engage in specific kinds of thinking that we have been trying to teach them, we can *prompt both written performances and oral performances in ways that reliably indicate the kind of thinking that we might want to find out about and its level of skill.* This, indeed, is a presumption accepted by everyone who has attempted to assess the quality of students' thinking.

For example, if we want to find out about a student's problem-solving abilities and we ask for a compare and contrast essay, we cannot fault the students if they don't show us how well they can think through a problem to try to solve it. So, as a minimum requirement for a reliable assessment of students' problem solving abilities, we need to prompt them in a way that *requires* them to engage in problem solving so that we can assess it. The best way to handle this is through the language used to formulate the prompt. We could just pose a problem and ask students what they would do in the circumstances, but if we follow the specificity principle it is preferable to formulate the prompt in a way that involves *the direct and explicit use of the term "problem solving"*. The conventional wisdom about assessing student thinking is that this second approach is one that makes what the students do in response a more reliable indicator of skill at problem solving than the former. This may seem like an obvious point but again we emphasise the need to be explicit.

However, even though being explicit about the specific type of thinking required in a student's performance is necessary to assess the quality of the thinking, it is not sufficient. To find out about quality, two other factors are usually acknowledged as necessary to be able to assess a student's thinking. These follow from the standards principle.

(1) The first factor relates to identifying the characteristics of the student's performance that constitutes the evidence for good thinking. These are usually referred to as the criteria against which the student's performance is to be judged. A good model of the components of a skillful performance is needed to inform such criteria.

It is also important that such criteria are reported on separately from any other desired characteristics, such as depth of topic understanding, factual accuracy or fluency in writing. If a teacher gives students an amalgamated grade for a piece of writing, there is no clear indication as to the quality of the thinking expressed in the writing. For this, also, it is usually recognised that even

though the performance being assessed has many aspects, the thinking assessment needs to be done on its own, based on the use of separate thinking-related criteria. Separate criteria and reporting will be sufficient even though the thinking and the substance of an essay or oral presentation are woven together in the performance.

(2) The second factor that is important is to be able to judge credibly *the level* of skill at thinking revealed in a student performance (e.g., a piece of writing). For this we need a clear, defensible, and explicit set of *standards*. Usually such standards are articulated in ways that are designed to avoid subjectivity in scoring, e.g., by the use of a scoring rubric. In the case of thinking, the gradations in the standards usually requires both a deep understanding of the model of skillful thinking and also how the skillful thinking will progress from a less well developed stage or novice stage to a more skillful and expert stage at the instructional level in which the assessment takes place.

The combination of these two factors – criteria and standards – lies behind the creation of the rubrics that are now commonly used to assess thinking from a criterion-related perspective. In this tradition, there has been some discussion of the relative merits of what are called 'holistic' or 'analytic' rubrics. In both types of rubric, the standards are identified and various terms are used to describe them. In the examples below, the word 'novice' is used to describe the minimum level of performance, and 'exceeds expectation' to describe a higher than expected standard for a particular cohort. Other terms used to describe a progression in standards are 'novice', 'apprentice', 'practitioner', and 'expert'. Sometimes the standards are just numerically ordered as Level 1, 2, 3 or 4. As the name suggests, a holistic rubric (represented schematically below) tries to capture the characteristics of thinking through a descriptive paragraph, leaving the assessor to make a judgement about how the student's performance best fits with the description. In contrast, an analytic rubric (represented schematically below) identifies separate criteria and the assessor systematically judges the student's performance separately and independently against each criterion. Then, some method of combining the separate judgements is completed.

Schematic Representation of an Holistic Rubric

Standards	**Overall Performance Description**
Novice	Description
In Progress	Description
Meets expectations	Description
Exceeds expectations	Description

Schematic Representation of an Analytic Rubric

____Criteria_____ Standards	**Criteria 1**	**Criteria 2**	**Criteria 3**	**Criteria 4**
Novice	Description	Description	Description	Description
In Progress	Description	Description	Description	Description
Meets expectations	Description	Description	Description	Description
Exceeds expectations	Description	Description	Description	Description

It is beyond the scope of this review to closely examine the overall merits of the different approaches (see Jonsson & Svingby, 2007 for an evaluation). But with regard to some of the ideas we have advanced about the importance of teaching explicit *strategies* for skillful thinking, it would seem that using an criterion-based rubric based on the specific components of the strategy being taught would provide novice teachers with more confidence in the accuracy of the assessment result, whereas experienced teachers proficient in teaching thinking skills, and with expertise themselves in spotting strengths and weaknesses in overall student performances, may well fine holistic assessment quick, easy, and reliable. A good, experienced, football coach, for example, can quickly and easily spot specific irregularities in the performance of players on his team without the need for a specific checklist.

We will use both types of rubrics to illustrate assessment practices below and make some evaluative comments as we proceed.

5.3 Examples of criterion-related assessment of thinking in practice

Example 1a: Assessing skillful decision-making in history in a classroom

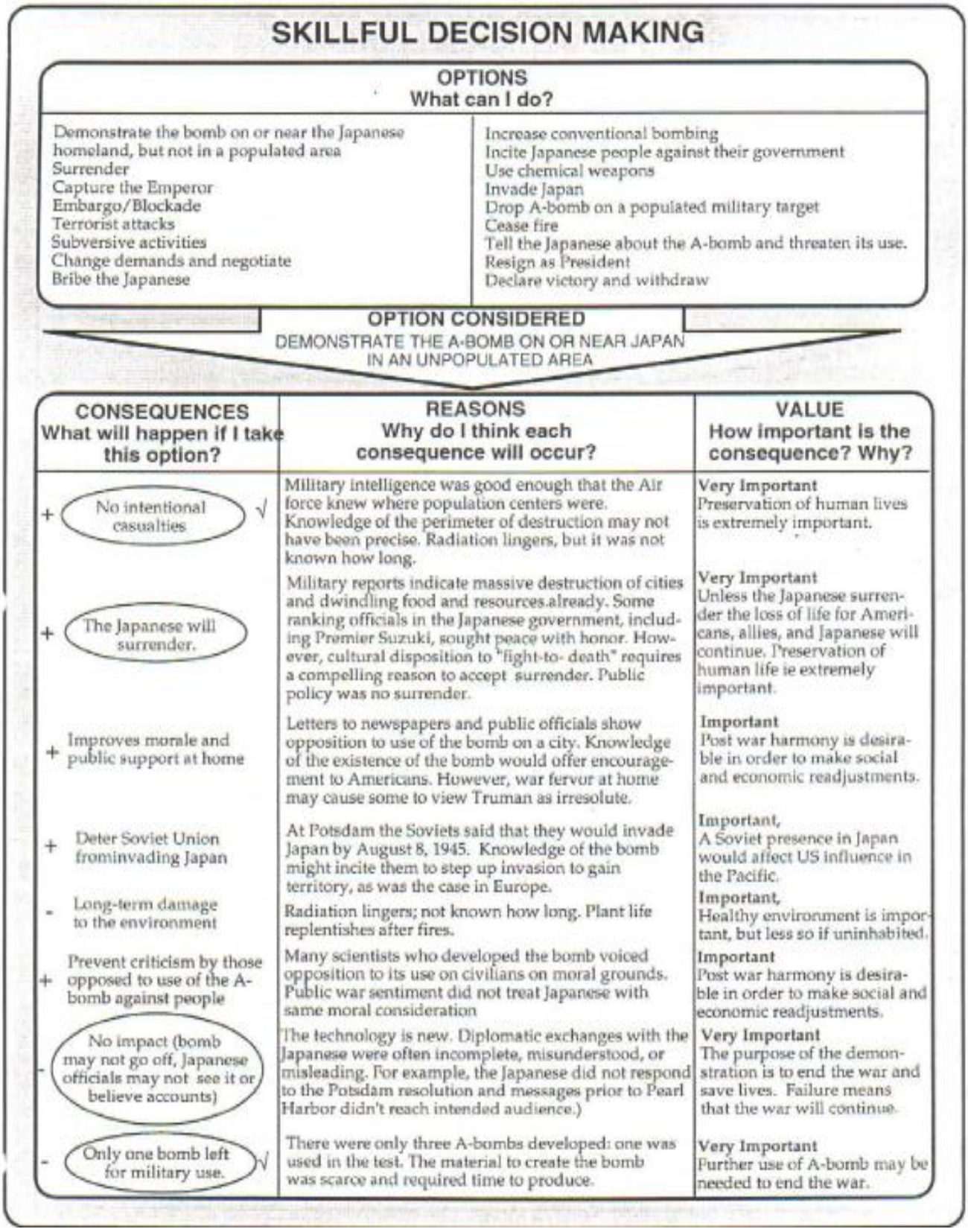
This is an American History lesson in which teaching skillful decision making is an added objective. There is a writing assignment to follow the decision making. The big question is how to best end

World War II. The teacher uses the practices of Thinking-Based Learning as her explicit approach to teaching thinking.

The Lesson: In the study of 20th Century history one teacher, who had introduced his students to a strategy like the one above for skillful decision making, posed the following challenge:

'Imagine you are President Harry Truman of the USA in early August, 1945, knowing that the US now has atomic bombs that can destroy Japanese cities, but trying to decide whether that's the best way to end World War 2.'

In this class the students use a specially-designed graphic organiser to record their excursion into higher order decision making. The diagram below shows an example of the work of one group of students who are considering an option that they included in a list of possible ways of ending WW II. They have worked together in collaborative thinking groups and used the strategy they have been taught for skillful decision making to research this question, exploring the historical data. The check marks indicate the consequences they think are likely based on the data they have found. When the groups report on each of their results, each student is asked to decide which option is best and to be ready to defend their choice.



SKILLFUL DECISION MAKING

OPTIONS
What can I do?

Demonstrate the bomb on or near the Japanese homeland, but not in a populated area	Increase conventional bombing
Surrender	Incite Japanese people against their government
Capture the Emperor	Use chemical weapons
Embargo/Blockade	Invade Japan
Terrorist attacks	Drop A-bomb on a populated military target
Subversive activities	Cease fire
Change demands and negotiate	Tell the Japanese about the A-bomb and threaten its use.
Bribe the Japanese	Resign as President
	Declare victory and withdraw

OPTION CONSIDERED
DEMONSTRATE THE A-BOMB ON OR NEAR JAPAN IN AN UNPOPULATED AREA

CONSEQUENCES What will happen if I take this option?	REASONS Why do I think each consequence will occur?	VALUE How important is the consequence? Why?
\+ No intentional casualties √	Military intelligence was good enough that the Air force knew where population centers were. Knowledge of the perimeter of destruction may not have been precise. Radiation lingers, but it was not known how long.	**Very Important** Preservation of human lives is extremely important.
\+ The Japanese will surrender.	Military reports indicate massive destruction of cities and dwindling food and resources already. Some ranking officials in the Japanese government, including Premier Suzuki, sought peace with honor. However, cultural disposition to "fight-to- death" requires a compelling reason to accept surrender. Public policy was no surrender.	**Very Important** Unless the Japanese surrender the loss of life for Americans, allies, and Japanese will continue. Preservation of human life ie extremely important.
\+ Improves morale and public support at home	Letters to newspapers and public officials show opposition to use of the bomb on a city. Knowledge of the existence of the bomb would offer encouragement to Americans. However, war fervor at home may cause some to view Truman as irresolute.	**Important** Post war harmony is desirable in order to make social and economic readjustments.
\+ Deter Soviet Union frominvading Japan	At Potsdam the Soviets said that they would invade Japan by August 8, 1945. Knowledge of the bomb might incite them to step up invasion to gain territory, as was the case in Europe.	**Important,** A Soviet presence in Japan would affect US influence in the Pacific.
\- Long-term damage to the environment	Radiation lingers; not known how long. Plant life replentishes after fires.	**Important,** Healthy environment is important, but less so if uninhabited.
\+ Prevent criticism by those opposed to use of the A-bomb against people	Many scientists who developed the bomb voiced opposition to its use on civilians on moral grounds. Public war sentiment did not treat Japanese with same moral consideration	**Important** Post war harmony is desirable in order to make social and economic readjustments.
\- No impact (bomb may not go off, Japanese officials may not see it or believe accounts)	The technology is new. Diplomatic exchanges with the Japanese were often incomplete, misunderstood, or misleading. For example, the Japanese did not respond to the Potsdam resolution and messages prior to Pearl Harbor didn't reach intended audience.)	**Very Important** The purpose of the demonstration is to end the war and save lives. Failure means that the war will continue.
\- Only one bomb left for military use. √	There were only three A-bombs developed: one was used in the test. The material to create the bomb was scarce and required time to produce.	**Very Important** Further use of A-bomb may be needed to end the war.

Then the teacher asks them the following:

'Now let's translate our good thinking into good writing':

The PROMPT for the assessment task was:

'Write a letter to President Truman to convince him that your option is best. Do this by showing him that you have thought as carefully as anyone can about this issue'**.**

Based on how the teacher was teaching skillful decision-making, she identified the following **CRITERIA** against which to assess the quality of the her students' decision making

- Several options are generated;
- Predictions are make about the likely positive consequences of some of the options;
- Predictions are made about the likely negative consequences;
- Precise judgments are made about the importance of those consequences;
- The basis for best option, in the student's opinion, is then explained.

She then generated the following qualities to identify the **STANDARDS** in the level of the skill and constructed an analytic **RUBRIC** to combine the expected standard for each criterion.

CRITERIA **----------** **STANDARDS**	**Options generated**	**Predicting consequences Pros**	**Predicting consequences Cons**	**Judging importance**	**Explaining choice of best option**
Good Thinking	Three or more options were considered	At least two likely pros were predicted for each option	At least two likely cons were considered for each option	Importance was finely judged using the 3-point scale	The recommended option was explained based on importance
Weaker Thinking	Two or three options considered	One or two positive consequences	Negative consequences were ignored	Importance was crudely judged as yes or no	Only the quantity of pros and cons were used
Very Poor Thinking	Only one option was considered	Consequences of any kind were ignored		No mention of importance	Option asserted with no explanation

Here is an example of a student's work to be assessed using the previous rubric.

Dear President Truman,

Our troops are dying. You must end the war. I know you've been thinking about dropping the new Atomic Bomb on a Japanese city. The Japs will surrender if you do. But at what cost? I urge you to consider some other options. You could negotiate peace, demonstrate the bomb and threaten to use it, or invade Japan.

Neither Invading Japan nor negotiating peace will work. Invasion will cost a lot of lives. And we have said that we want unconditional surrender. Negotiating now will make us look weak. That shows that these are really not very good options.

But if we demonstrate the bomb in the harbor and tell the Japanese what it is and that we will use it on Tokyo they will realize that they have to stop fighting and surrender.

I really strongly urge you to do this. We can't lose.

Sincerely

The teacher evaluated the student's letter in the following way, putting an **X** in the grid only where she judged the work had met the standard.

CRITERIA **STANDARDS**	Options generated	Predicting consequences Pros	Predicting consequences Cons	Judging importance	Explaining choice of best option
Good Thinking	X				
Weaker Thinking		X	X		
Very Poor Thinking				X	X

The teacher then went one step further in an attempt to turn the overall assessment into a quantitative score. The way this rubric works is getting an "x" in an upper box counts as a 3. If there

is an x in each upper box the total is 15, and that amounts to the highest score, or Good Thinking. If, on the other hand, there is an x in all of the lower boxes that amounts to a score of 5, or Very Poor Thinking. The designations "Good" or "Very Poor" are tied to the thinking objectives of the instructional program of this teacher vis a vis skillful decision making. In this case the thinking displayed turns out to be Very Poor and in need of improvement. Two of the classical problems in thinking – "narrow" thinking and "hasty" thinking --show up in this letter even though, at first reading, many people judge it as a pretty good piece of reasoning.

We would like to make some brief comments on this example as a model for assessing good quality thinking. One of the difficulties encountered in assessing student work using criterion-related rubrics can be the subjectivity of the classroom teacher's (or external examiners') judgements with regard to whether the work has met a particular standard or not, or whether each of the criteria should be given equal weight or not. This teacher resolved the dilemma by adopting a very quantitative approach, identifying the number of options, the number of predicted consequences and so on, and even assigning numbers to each cell to produce an overall numerical score. Sometimes such an approach is not appropriate, and, even with an analytic rubric, the expert judgement of the teacher/examiner must be relied upon. In these circumstances, some degree of standard setting and cross-moderation between markers will be required. This issue of reliability in the context of criterion-related assessment is not confined to the assessment of thinking.

With regard to assessment for learning practices, where the model of skillful decision-making had been openly shared with the students, through, for example, the explicit use of the thinking strategy and this graphic organiser, the students were already aware that carefully considering the options, making predictions about pros and cons, identifying important consequences from minor ones, and being able to justify their choices, was the expectation. So the success criteria, according to assessment for learning, were already shared with the class. Nevertheless, the example of the student's work shows that he had not fully grasped what was involved. The rubric facilitated feedback that was sufficiently specific to allow the student to improve this performance next time a decision-making dilemma was presented to him, or he had to engage in a classroom debate about the pros and cons of different options, or he had to write another essay appraising someone else's decision. So the rubric, although crafted in the context of a specific assignment, does have some generalizability. Also, in terms of shaping the teachers' next instructional steps, she will realise that the strategy for skillfully decision-making has not been fully internalised yet for some of her students, and that further practice with scaffolding needs to continue.

Example 1b: Here a similar well developed analytic **rubric for problem-solving**, from Burke (1994), *The Mindful School* (slightly adapted). In this example, the criteria are listed on the vertical axis, and the standards are phrased in terms of "novice", "in progress", "meets expectations", "exceeds expectations", indicating that the expected standard for the cohort is "meets expectations". Like the decision-making rubric, this problem-solving rubric has sufficient generalizability to be used across the curriculum, yet is appropriately specific to help students improve next time. (It should be noted that there may be important criteria missing in this rubric, such as planning solutions and predicting what might be a likely successful technique before actually applying a technique.)

Standard _____ **Criteria**	**Novice**	**In Progress**	**Meets Expectations**	**Exceeds Expectations**
Identifies problem	Does not recognise that there is a problem, it needs to be pointed out	Recognises there could be a problem but cannot identify the cause	Recognises there is a problem and understands the underlying cause	Recognises the real problem, the underlying cause, and the extent of the problem
Collects information	Does not collect information to solve problem, needs to be prompted	Collects inaccurate or incomplete information, is unsystematic	Collects accurate and complete information, spots and eliminates some irrelevant information	Collects accurate complete and relevant information, using a systematic method
Applies techniques to solve the problem	Does not apply any techniques to solve the problem	Applies one plausible technique to solve the problem	Applies two or three appropriate techniques to solve problem	Applied four or more techniques with some evidence of creativity to solve problem
Evaluates effectiveness of solutions to problems	Shows little evidence of reasoning skills to evaluate effectiveness of solutions	Analyses the effectiveness of or one or two techniques, demonstrates knowledge of problem solving process	Analyses and evaluates the effectiveness of all of the solutions, demonstrates an understanding of the problem-solving process	Evaluates the effectiveness of all the solutions, reflects on the implications, demonstrates in-depth understanding of problem-solving process, and looks towards improvement

Example 2: Assessing the quality of an argument in an A-level publication examination on Critical Thinking. This example shows how the quality of an argument can be evaluated, and comes from an A-level in Critical Thinking which is available from the Oxford and Cambridge Examination Board (OCR) in the UK, as a public examination. The focus of the examination is on the analysis and production of arguments, where the students must also show evidence of knowing the language of the formal elements of arguments. The example draws on just one part of the assessment, where students have to show that an argument that they produce as a counter-argument to a position taken by someone else on an issue is a well-developed argument.

In the examinations, students are presented with an extended written passage putting forward an argument that the' length of summer school holidays should be reduced'.

The **PROMPT** is

'Write your own argument to **challenge** the main conclusion of the argument in the passage. Marks will be given for a well-structured and developed argument. You should include at least 3 reasons, a well-supported intermediate conclusion and a main conclusion. Your argument may also contain other argument elements. You may use information and ideas from the passage, but you must use them to form a new argument. No credit will be given for repeating the reasoning in the passage'.

The **CRITERIA** and **STANDARDS** stated as an holistic **RUBRIC** are

Standard	Criteria
Level 4 (10-12 marks)	Candidates present their own relevant argument with a clear structure where the conclusion is supported by at least three reasons and at least one well supported intermediate conclusion. The argument is convincing and may rely on only one or two reasonable assumptions. The argument may also contain other relevant argument elements e.g., evidence/examples, counter-assertion. The main conclusion is precisely and correctly stated. Grammar, spelling and punctuation are very good: errors are few, if any.
Level 3 (7-9 marks)	Candidates present an argument that contains three or more reasons and there is an intermediate conclusion. The argument may be convincing in general but relies on some assumptions, so the link between reasons and conclusions is weakened. The argument may contain other argument elements that have less relevance to the overall argument. The main conclusion is clearly stated, perhaps with minor paraphrase(s). Grammar, spelling and punctuation are good: errors are few.
Level 2 (4-6 marks)	Candidates present a basic argument that contains one or more reasons of some relevance to the main conclusion. There is an attempt to form an intermediate conclusion. The argument will rely on several assumptions and is not in general terms convincing. The conclusion is stated but may have a slightly different wording and/or meaning to the conclusion required.

	Grammar, spelling and punctuation are adequate but with errors which are sometimes intrusive.
Level 1 (1-3 marks)	There is a limited attempt at an argument, which is related to that asked for in the question. The conclusion may be unstated, or different from that asked for in the question. At least one reason is given. There is no attempt to form any intermediate conclusions. Grammar, spelling and punctuation may be poor with errors which are intrusive.
No marks	No creditworthy material. Do not credit arguments, simply lifted or paraphrased from the passage.

This rubric is then transformed into an analytic rubric where each of the criteria is separately assessed. This is then used as a marking scheme.

Standard/ Level	Conclusion	Reasons	Intermediate Conclusion	Argument elements	Assumptions	Convincing
4	Precise and correctly stated	3 or more relevant reasons	Achieved and Well supported	May contain evidence, example , counter-example, analogy	May rely on reasonable assumptions only	Convincing
3	Clearly stated, may have minor paraphrase	3 or more relevant reasons	Achieved	May contain these but they give weaker support to the argument	Relies on some-so link between Reasons and Conclusion is weakened	Convincing but general
2	Stated, may have different wording, meaning but right	1 or more relevant reasons	Attempted		Relies on several and/or questionable assumptions	Basic, generally not convincing
1	May be unstated or different but related to that required (e.g., opposite to what was asked for)	1 or more relevant reasons	No intermediate conclusion			Limited

It is clear that this rubric demands that students show an advanced understanding of the nature of argument together with some knowledge of the technical vocabulary associated with critical thinking, which they will gain from the courses that they study in preparation for this public examination. The main point of including it here is to show that it is possible to design reliable and

widely-used rubrics for evaluating some elements of skillful critical thinking in an education system where there is a tradition of extended writing in national public examinations, and of extensive cross-moderation of exam scripts, as is the case with A-level examining in the United Kingdom.

5.4 Lessons from Multiple Choice Tests of Critical Thinking

There is a tradition in testing in which multiple-choice testing is used to assess critical thinking. The structure of multiple choice items involves three components: a description of a provocative situation (called "the stem"), a prompting question using terminology that prompts the kind of thinking being assessed, and the range of possible answers. It is important to note that in multiple-choice assessment of thinking it is acknowledged that the assessment is *indirect*: choosing a "right" answer from a number of possibilities is, at best, the *product* of thinking, hence the judgment that choosing the "right" answer shows that a specific kind of critical thinking took place that manifests skill is an inference.

As in all multiple choice test writing, the success of a critical thinking test item in eliciting the desired skill from the student is the judicious writing of the stem to provoke the thinking, and generating alternative choices so that one choice (the so- called right choice) supports the conclusion that skill at critical thinking was used to make the choice. It is often thought that to get the right answer such skill must be used, hence the claim that such testing is reliable. This means that stems that are not clear, vague or confusing make such test items unreliable. And unclear or vague prompts likewise limit the reliability of the item. And, of course, there needs to be one and only one correct answer. We can call these "reliability conditions".

For example, in one much-used commercially available critical thinking test, *The Cornell Test of Critical Thinking Abilities*, *Level Z* (Ennis & Millman, 2005) an experiment is described in which certain conclusions about the cause of a certain phenomenon are drawn from the experimental data. The students are then given descriptions of additional data and asked, for each one, whether it supports the conclusion, counts against it, or is neutral.

However, are the reliability conditions for the use of such tests correct? For example, is it correct to say that in a well-crafted multiple-choice item "to get the right answer the skill in question must be used"? All multiple-choice test designers recognise that this is incorrect. Test takers can get the right answer by guessing. But this can be corrected by using a battery of items requiring the same thinking skill. The more there are, to get them all, or most of them correct, makes it unlikely that the test

taker guessed correctly on all of them. This, however, inevitably makes such testing extremely cumbersome.

An easier way to deal with this problem is very instructive from our point of view. This solution was suggested, in fact, by Robert Ennis himself in the 1980s as a way to get a more reliable indication that a test-taker's correct response was based on the skill at critical thinking it was designed to elicit. It is simply to ask "Why did you make this choice?" as an extension of a multiple choice item.

Following Ennis' lead, many items that are multiple choice or indeed ask only for yes/no answers, go on to ask the student to explain their answers or to produce their 'workings out', and give additional credit for correct or partially correct explanations. Here is a modified example from Halpern's *Critical Thinking Assessment Test* (2010) which included several different response formats. The item is intended to assess the student's inductive reasoning and capacity to generalise from samples.

The **STEM**

After a televised debate on capital punishment, viewers were encouraged to log on to the station's web site and vote online to indicate if they were "for" or "opposed to" capital punishment. Within the first hour, almost 1000 people "voted" at the website, with close to half voting for each position. The news anchor for this station announced the results the next day. He concluded that the people in this state were evenly divided on the issue of capital punishment.

The **PROMPT**

Given these data, do you agree with the announcer's conclusion?

CLOSED RESPONSE FORMAT

YES or NO

SUPPLEMENTARY **EXTENDED RESPONSE FORMAT**

If you answered "yes" explain why. If you answered "No" explain why and provide two suggestions for improving this study.

Sample student constructed response:

This practice of using an extended response format following a closed response was used frequently in the PISA 2003 Problem Solving Test (OECD, 2004), where the proficiency level of responding credited to the student depended not only on their ability to solve the problem correctly but also to explain and reflect on their problem solving strategies. The most proficient problem solvers were characterised as 'reflective and communicative problem solvers'.

While multiple choice assessment of thinking can be constructed to elevate its reliability, and while it can generate scores in a fraction of the time it takes to read student essays, the dominant view now is that at the classroom level, especially when the assessment that is undertaken is formative,

extended-response assessment of thinking is preferable. We, too, strongly endorse the use of extended response assessment as a superior way of gathering data about the quality of students' thinking. So let us make some comments about the construction of effective and reliable extended response assessment prompting.

5.5 Structuring Well-Crafted Extended Response Prompts to Assess Student Thinking

The same three types of components as one finds in multiple-choice assessment items of thinking appear in well-crafted extended response prompts, whether they are straight-forward essay prompts, prompts of oral presentations, or prompts of self-assessment tasks. There is what is analogous to a *stem*, there is the direct *thinking prompt*, and there are directions for some sort of student *performance* that will display their thinking. In this case the performance is not to choose what is thought to be the "right" answer, but rather to provide some sort of extended display of the thinking being promoted.

We have already spoken about the need to use language in extended response challenges that involves clear thinking prompts that indicate well the kind of thinking being called for and that the person who is conducting the assessment is interested in. So for decision making or problem solving, as we have seen, a teacher might ask students to make and defend a decision about something, or try to ascertain and defend a solution to a problem as the best solution. But we now return to some good practices that apply to writing *stems* in extended response assessments.

There are certain both formal and substantive guidelines for stem construction in assessment items that many who develop such assessment items abide by:

- Make sure the language used is one that the students can understand;
- Describe a situation that students have enough basic knowledge to understand, or, if they don't, that is accessible to them;
- Describe a situation that is relatively close to actual situations which call for the kind of thinking being assessed;
- Do not make the way the situation is described overly complex or technical so that it is hard for students to understand;
- Do not rely on items that reflect biases of the test designers or the readers (scorers).

Some *stems* can be extended written pieces, as the example from a diagnostic critical thinking designed by one of the authors (Swartz) illustrates.

The **STEM**

Suppose that you were studying the bottom of the ocean in your class. You went to the internet and searched on Google for the "bottom of the ocean" to try to get some additional reading material about it. You found the following items listed.

1. "Man's New Frontier" by Luis Marden, from the National Geographic Magazine, April, 1989

2. The Sea and Its Living Wonders, by Dr. G. Hartwig, London, 1860

3. Twenty Thousand Leagues Under the Sea, by Jules Verne, first translation from the French into English, 1873

4. "Monsters Under the Sea" in the book Great Science Fiction Stories, Ed. by Patrick Stewart (Jean-Luc Picard on Star Trek: The Next Generation), published in New York, 2007

5. "Incredible World of Deep Sea Rifts" by Robert Ballard and J. Frederick Grassle, from the National Geographic Magazine, November, 1979.

The **PROMPT**

Is there anything about these works that suggests that some of them might be more reliable than others? Explain.

Select one of the works that you think might be more reliable than the others.

Is there any other information you would want to get in order to make you feel more sure that it was giving you accurate and reliable information about the bottom of the ocean? Or is it ok as it stands? Explain your answer.

The "Explain" and "Explain your answer" are requests for extended responses that will show the reader to what extent the respondent is exercising skill at judging the reliability of sources of information. The level of skill will then be judged based on a rubric, whether holistic or analytical. And, if this is a formative assessment, suggestions can be made as to how the respondent can improve his or her response.

5.6 Assessment Practices for Metacognitive Thinking and Thinking Dispositions

In the previous section, the focus for assessment was on the quality of thinking skills manifested in students' work. Following the alignment principle, we now turn to assessment practices for the other thinking objectives that we argued for as important in a thinking curriculum – developing effective metacognition and positive thinking dispositions. While the fruits of pursuing these objectives should eventually be manifested in student work, they will need separate and on-going classroom assessment that filters these out in such holistic performances to provide feedback to students about their current standard of performance, to support their continued development, and

to help the teacher plan what the next steps are to promote this development. So the specificity principle is as important with regard to setting criteria and standards for assessment in these domains as it is for assessing thinking skills.

Many different types of assessment tools are appropriate for these kinds of objectives, ranging from teachers' informal observations, observations using critical incidents, checklists, rubrics, self-ratings, growth charts, and reflective logs (see Carr & Claxton, 2002; Costa & Kallick, 2000d; Swartz et al, 2007, chap 6). We shall illustrate these assessment practices with examples of rubrics and self-ratings, as these are specific about criteria, standards, or both.

5.6.1 Assessing Metacognitive Thinking : The first example is an analytic rubric from Swartz et al., (2007). The criteria are derived from the steps in the Swartz/Perkins *Ladder of Metacognition* which was outlined in Section 2 of this report. Students "going up this ladder" represent movement towards self-regulation, a key objective in most programmes aimed at improving thinking. The standards are rated as 'excellent', 'acceptable', 'limited' and 'unacceptable', and are expressed in terms of degree of explicitness, use of precise thinking language, level of detail in descriptions, ability to evaluate and explain criteria of effectiveness, and to see contexts for future use. Knowledge of these levels of skill with regard to metacognitive abilities then set out a growth pattern for this kind of metacognitive thinking. The benefit of such an analytic rubric is that it specifies separate criteria for each step of the ladder against which the metacognitive growth can be judged. For example, a student may be advancing well with regard to looking back and evaluating her thinking after completing a task, but may be less adept at looking forward and developing a plan for future use. Giving a student feedback at this level of detail can help her see what still needs be achieved. If a general pattern emerges in a class, then the teacher has information on which to adapt her teaching, perhaps recognizing that some steps in the ladder (criteria) are not sufficiently clear to the students and need extra explanation, practice and scaffolding.

This is the Analytic Rubric for Assessing Metacognitive Thinking from Swartz et al. (2007, p. 155)

	Standard **----------** **Criteria**	**Excellent**	**Acceptable**	**Limited**	**Unacceptable**
L o o k I n g B a c k	*Identifies* the type of thinking done	Explicitly identifies the thinking done using appropriate and precise language	Explicitly identifies the thinking done using vague thinking language	Explicitly identifies the thinking done but does not use appropriate language	Does not explicitly identify the thinking done
	Describes how type of thinking was done	Describes explicitly how the thinking was done, using appropriate and precise language, distinguishes the steps in the process	Describes explicitly how the thinking was done, using thinking language, but does not clearly distinguish the steps in the process	Describes how the thinking was done but does not use appropriate thinking language and does not clearly distinguish the steps in the process	Describes only vaguely or not at all how the thinking was done and does not use thinking language to do so
	Evaluates how well the type of thinking was done	Provides detailed and significant information about the effectiveness of the thinking judged against explicit and appropriate criteria	Provides some information about the effectiveness of the thinking and shows some judged against explicit and appropriate criteria	Judges effectiveness but does not provide information about why or articulate appropriate criteria	Affirms effectiveness or not without explaining why or articulating criteria, or just fails to make any judgment about effectiveness
T h I n k I n G A h e a d	*Plans ahead* for doing type of thinking next time	Articulates a specific and explicit plan for using the same kind of thinking in future, identifies contexts in which it would be called for, and explains why the plan is a good plan	Articulates a specific plan for using the same kind of thinking in the future, but mentions only some reasons why, and/or identifies only a few contexts in which it would be called for, is vague about why it is a good plan	Articulates a vague or general plan for using the same kind of thinking in the future, but does not identify contexts in which it would be called for or explains why the plan is a good plan	At most only articulates a value or general for using the same kind of thinking in the future and nothing else

Notice how this rubric emphasizes the difference from one "rung" in the ladder to another. Answering the question "What kind of thinking are you doing?" is a descriptive classification of the kind of thinking; going to the next rung involves again describing, but this time the steps gone through or the focal points of the thinking being done, but then shifting on to the next "rung" to evaluating the process, and then, based on this evaluation, planning ahead. One of these cognitive

moves might be done quite well whereas another might not be, and that will be revealed using this kind of rubric to observe a student's current metacognitive performance.

An analytic rubric such as this can be very daunting for teachers/students who are beginning a metacognitive mode of assessment. The next example from Costa and Kallick (2000d, p.38) is also based on the "ladder of metacognition" as a technique for planning and executing a strategy for guiding one's thinking, but the rubric is a more holistic assessment of metacognitive ability. It is written in the language of exemplary overall behavioral performances for each standard, called "Expert", "Practitioner", "Apprentice", and "Novice". This version was used in primary school in the US where the teacher used it both for sharing the criteria to be used to evaluate growth in metacognitive thinking, and to give feedback to students.

Compared to an analytic rubric, an holistic rubric will provide less specific information about exactly what needs to be improved. In this example however the teacher underlined the criteria that needed special attention, essentially using it more like an analytic rubric for the purposes of feedback. One of the benefits of holistic rubrics is that they provide a more integrated picture of the performance characteristics of the phenomenon to be evaluated, which can sometimes get lost in the specificity of analytic rubrics. This is why it can be useful to write the rubric both ways, as in the A-Level example on Critical Thinking.

This is the rubric for Thinking about Thinking, slightly adapted (from Costa & Kallick, 2000d, p.38, from Tamalpais Elementary School, Mill Valley, California)

Level of Work	**Criteria**
Expert	Describes in detail the steps in thinking when doing mental tasks. Explains in detail how thinking about thinking helps to improve work and how it helps to develop a better learner. Describes a plan before starting to solve a new mental task. Monitors steps in the plan or strategy. Reflects on the efficiency of the strategic approach.
Practitioner	Describes one's thinking while doing a mental task. Explains how thinking about thinking helps learning and helps to improve work. Planning before a task is vague and evaluation of an approach is general
Apprentice	Includes only sparse or incomplete information when describing how one is thinking when doing a mental task. Sees only small benefits gained from thinking about thinking and learning.
Novice	Is confused about the relationship between thinking about thinking in the context of doing a mental task. Sees no beneficial relationship between the two. Is unable to describe thinking when doing a mental task.

To make the criteria more explicit for students, these rubrics can also be turned into rating items for self-evaluation by the student. The wording is amended to make it more student-friendly.

Indicators of Metacognition	**Strongly Disagree Or Not at all like me**	**Disagree Or Not like me**	**Not Sure**	**Agree Or A bit like me**	**Strongly Agree Or Very Like me**
I can use the thinking words to describe the kind of thinking I do					
I can describe in detail the steps in my thinking					
I can describe a plan before starting out on a new thinking task					
I can keep track of my plan and the steps in my thinking					
I can look back on the steps in my thinking to see if I can improve them for next time					
I can explain in detail how thinking about my thinking helps me to improve my work and be a better thinker					

5.6.2 Assessing Thinking Dispositions: As we noted in Section 2, there is less consensus about what the core thinking dispositional motivators are in contrast to the consensus there is about the types of "higher order thinking skills", and, as we noted, several frameworks are available with only a small degree of overlap. Irrespective of the model adopted, from the point of view of assessment, the same principles apply – that teachers should articulate criteria against which the students' dispositions can be judged, and standards to illustrate current status, growth patterns, and next steps should be designed.

We must remember that a disposition is always a disposition *to do something* in certain circumstances. When we say that glass is fragile we are articulating one of its usual dispositions. This means that it will shatter if struck a sharp blow by a heavy object. So one way to articulate criteria that can be observed when we speak of dispositions is to describe what the person who has that disposition will do in appropriate circumstances.

Rather than dealing with dispositions one by one, a useful approach can be to develop a Thinking Dispositions Matrix to provide an overview of the performance descriptions associated with each standard, and to see linkages between them. Of course each disposition can be the focus of a specific lesson or unit and thus can also be evaluated

separately. The reader will note these are holistic rubrics where multiple criteria are evaluated at each standard. The example below shows standards and growth patterns for two dispositions as examples - Open-Mindedness (the disposition on which there is the greatest consensus) and Flexible Thinking, and leaves the remaining columns to be completed. Again we emphasise the need to have a clear grasp of the characteristics of these dispositions as they are manifested by experts, and be able to identify progression maps or pathways for standard setting and next steps.

Assessing Growth in Thinking Dispositions: A Thinking Dispositions Matrix (adapted from Swartz et al., 2007, p. 198, and Costa & Kallick (2000d, p.39)

Standard	**Open-Mindedness**	**Flexible Thinking**	**Disposition 3**	**Disposition 4 (and so on)**
Expert	Expresses appreciation and value for others' point of view. Changes mind and incorporates others' point of view in own thinking.	Consistently generates and explores as many diverse and useful alternatives as time and resources allow and analyses how the alternatives identified will affect outcomes in original ways.		
Practitioner	Describes some ways that others' point of view are found to be new and different from own point of view.	Consistently generates alternative ways of approaching tasks and analyses how the alternatives will affect outcomes. Some alternatives show originality in approach.		
Apprentice	Recognises and considers others' views but must be persuaded to change mind.	Sporadically generates alternative approaches and analyses how they will affects those tasks. Needs prompting to continue.		
Novice	Discounts others' perspectives and points of view while clinging to own point of view.	Rarely generates alternative approaches and tend to adopt the first approach that comes to mind.		

5.7 A comment on the relationship between Assessment for Learning and Teaching Thinking Skills

While assessment for learning (AfL) and teaching thinking grew from different theoretical orientations and research bases, they share a common concern about the quality of learning (in the case of AfL) and the quality of thinking (higher-order thinking in the case of teaching thinking). As they share many common strategies for classroom practices, it is not surprising that many teachers/schools/school districts wish to pursue both simultaneously in their classrooms. For example, the Welsh Assembly Government funded a five-year project on integrating both approaches, Developing Thinking Skills and Assessment, http://wales.gov.uk/dcells/publications/curriculum_and_assessment/developingthinkingassessment/developthinkinge.pdf?lang=en

In order to identify overlaps, the chart below shows core practices for teaching thinking that we have outlined in this report and the key strategies and classroom practices promoted by assessment for learning (James et al., 2006; Clarke, 2001; Wiliam, 2011). They are many similarities, yet each has distinctive features which we have highlighted in bold. Specifically, the presumed drivers for change are different; explicit thinking strategies, metacognition and teaching for transfer are the key drivers for the thinking skills approach, while explicit success criteria and feedback are the drivers in AFL. Yet they both have a shared purpose in helping students take greater charge of their learning and become more independent learners and thinkers.

Focus on Higher-Order Thinking	**Focus on Learning**
Making thinking processes explicit	**Explicitly sharing success criteria**
Challenging tasks to provoke thinking	All learning tasks
Active learning Questioning Collaborative thinking Language for thinking Talking about thinking	Active learning Questioning Collaborative learning Language of learning Talking about learning
Thinking time	**Wait time**
Metacognitive thinking	**Reflection**
Teaching for transfer	Generally making connections
Giving specific feedback and next steps	**Giving specific feedback and next steps**
Self and peer assessment	**Self and peer assessment**

5.8 **Bringing About Significant School Change**

We have tried to lay out the state of the art today with regard to the teaching and assessing of thinking. Explicit instruction with regard to specific thinking skills infused into content instruction, followed by regular and varied practice, and prompted by key thinking dispositions, represents the core of what we have described in this part of our review. We feel it important to add to this some comments on the present views about how to bring about change in schools that will lead to this objective. So we are adding a brief section here on current views about school change. Clearly, a comprehensive review of the school change literature is beyond the scope of the current project. Both Leat (1999) and Adey and Hewitt (2004) have described in some detail the barriers they have encountered when implementing thinking programmes in UK schools, as well as the positive impacts on teachers (e.g., Baumfield & Butterworth, 2005).

The first comment that we wish to make is that most educators now recognise that significant school change, especially in the direction of making a school curriculum thinking-integrated, cannot be accomplished by having teachers simply read a text, go to a lecture, or even attend a workshop. Research on school change, in fact, shows that significant change, given the state of teacher education practices today, requires three things: (1) strong leadership, (2) on-going staff development, and (3) time. We wish to make some comments about (2), especially as it applies to bringing significant instruction in thinking into a school through infusion into the regular curriculum. But first, just a few comments about (1) and (3).

How much time is needed to bring into the regular practices in a school the richness of a thinking-infused curriculum? This means how much time is needed for a school to become a school exhibiting a regular and sustained culture of thinking? Everyone with experience working in this field now acknowledges that this is a long-term enterprise. The conventional wisdom is that a regular school requires between 3 and 5 years to accomplish this.

Leadership is absolutely necessary. From the literature (see chapter on leading change in a thinking school, written by Art Costa, in Swartz et al., 2007), and in our experience, school leaders who do the following three things have the most success in bringing about significant school change: (1) they are fully informed about the kinds of change aimed at and the reasons for making these changes, (2) they direct the change-oriented program with a sensitivity to pacing and scheduling that fits the needs and abilities of their staff, and (3) they decentralise the change-oriented tasks. With regard to (1) it is often noted that principals who attend staff-development workshops with their teachers are

usually more successful in directing a movement for significant change in their schools than those who do not.

But what kind of staff-development works best to accomplish significant change? There is now a significant body of research literature, initiated by Bruce Joyce and Beverly Showers in the 1970s-80s (e.g., Joyce & Showers, 1980; Joyce & Showers, 1996; Showers & Joyce, 2002) on the key components of teacher development programs that are most likely to bring about significant change in classroom practice. Professional development programmes are most likely to succeed if they are structured to include one-on-one contact between a coach and a teacher in implementing such change, and more so if this is a regular ongoing practice in a school during the staff-development programme. Here is a paraphrase of a chart from the work of Joyce and Showers that shows the degree of implementation of new programmes initiated through a staff-development project including group workshops or lectures. Very low here means between 5% and 8%, high between 90% and 100%.

WHY COACH			
TRAINING STEPS	KNOWLEDGE/ UNDERSTANDING	SKILLS ACQUISITION	CLASSROOM APPLICATION
THEORY	Middle++	Low	Very Low
DEMOS	High	Low+	Very Low
PRACTICE	High	High-	Very Low
CURRICULUM ADAPTATION	High	High	Low+
COACHING	High	High	High
PERIODIC REVIEW	High	High	High

Research conducted by Bruce Joyce and Beverly Flowers, University of Washington

In our experience in the field of staff-development for the infusing of the teaching of thinking into a school curriculum, this chart represents an accurate picture.

There is something new in this field though that it is important to comment on: the advent of on-line staff-development programmes. No research has been conducted on the effectiveness of these programmes – they are too young for this – but many hold out promise for more efficient delivery through e-learning. To date there are some programmes in existence that focus on thinking: Harvard University sponsors a series of on-line programmes developed by Project Zero at Harvard, called "Wide World", including some on thinking-related themes; the International Habits of Mind Institute also sponsors on-line programmes for teachers on teaching habits of mind, and the SM publishing Company in Madrid is developing a Spanish language programme on thinking-based learning (projected start-up, September, 2014).

Whether such e-programmes can make school change directed at infusing the teaching of thinking into content instruction more efficient than live face-to-face programmes yet remains to be seen.

6 Conclusion

In this final section of the report we have drawn on both the research and practice literature, as well as our own experience of teaching and assessing thinking, to create an integrated framework that is suitable for use across grades, across subjects, across different curriculum units. The table below represents a summary of the framework. We will use this to evaluate the IB programmes .

An Integrated Research and Practice Informed Framework for Developing and Assessing Thinking Skills and Related Constructs				
Thinking Objectives	**Teaching**		**Assessment**	
	Principles	**Practices**	**Principles**	**Practices**
Thinking Skills Metacognitive Thinking Thinking Dispositions	Make thinking organisers explicit Advance deep thinking challenges Engage students in collaborative thinking to ensure joint meaning making, interaction, and dialogue Prompt students to adopt a strong metacognitive perspective Teach for transfer of the skillful thinking being learned Cultivate thinking dispositions and habit and minds Generalise the approach from thinking classrooms across all grades in the school	Teach explicit thinking organisers/strategies in the classroom, graphic organisers, thinking routines Give students something challenging to think about, more than routine tasks Prompt the students to make the thinking that results from their use visible and public Use collaborative groups, arrange the classroom to facilitate interaction, develop a thinking language, support sustained dialogue about thinking Teach students explicit strategies to plan, monitor and evaluate their thinking skills and thinking dispositions. Give time to do this Explicitly teaching to facilitate the transfer of learned thinking procedures to other curricular and non-curricular contexts Create classroom norms and expectations about thoughtfulness and the habitual use of thinking strategies Prioritise teachers' professional development and teachers' planning time	Align teaching and assessment practices with thinking objectives in the classroom. Be specific about the performance criteria and standards expected for the use of Thinking Skills Metacognition Thinking Dispositions Adopt assessment for learning principles	Prompt student performances that display the use of thinking skills, habits of mind, and the efficacy of thinking dispositions. Design assessment rubrics and ratings that incorporate Specific criteria Appropriate standards Next steps Growth patterns Share the criteria and standards with students Give feedback and identify next steps Use self and peer assessment to communicate and share standards, promote assessment literacy re thinking objectives

7 References

Abrami, P. C., Bernard, R. M., Borokhovski, E., Wade, A., Surkes, M. A., Tamim, R., et al. (2008). Instructional interventions affecting critical thinking skills and dispositions: A stage 1 meta-analysis. *Review of Educational Research, 78*(4), 1102-1134.

Adey, P., Shayer, M., & Yates, C. (1989). *Thinking science: The curriculum materials of the CASE project.* London: Thomas Nelson and Sons,

Adey, P., & Hewitt, G. (2004). *The professional development of teachers: Practice and theory*. Dordrecht, the Netherlands: Kluwer Academic Publications.

Adey, P., (Ed.), (2008). *Let's think handbook: A guide to cognitive acceleration in the primary school*. London: GL Assessment.

Adey, P., Shayer, M., & Shayer, M. (2002). *Really raising standards: Cognitive intervention and academic achievement* . Routledge.

Anderson, L.W, & Krathwohl, D.R. (Eds.). (2001*). A taxonomy for learning, teaching, and assessing: A revision of bloom's taxonomy of educational objectives*. New York: Addison Wesley Longman.

Alexander, R. (2008a). Culture, dialogue and learning: Notes on an emerging pedagogy. In N. Mercer, & S. Hodgkinson (Eds.), *Exploring talk in school* (pp. 91-114). London: Sage.

Alexander, R. (2008b). *Essays on pedagogy*. Abingdon, Oxon.: Routledge.

Baumfield, V., & Butterworth, A. (2005). *Systematic review of the evidence for the impact of teaching thinking skills on teachers.* In: Research Evidence in Education Library, London: EPPI-Centre, Social Science Research Unit, Institute of Education.

Biggs, J., & Tang, C. (2011). *Teaching for quality learning at university* (4th ed.). Maidenhead, England: McGraw-Hill International.

Black, B. (2012). An overview of a programme of research to support the assessment of critical thinking. *Thinking Skills and Creativity, 7*(2), 122-133.

Blatchford, P., Kutnick, P., Baines, E., & Galton, M. (2003). Toward a social pedagogy of classroom group work. *International Journal of Educational Research, 39*(1–2), 153-172.

Bloom, B. S., Engelhart, M. D., Furst, E. J., Hill, W. H., & Krathwohl, D. R. (1956). *Taxonomy of educational objectives: The classification of educational goals handbook 1: Cognitive domain*. New York, NY: David McKay. .

Brookhart, S. M. (2010). *How to assess higher-order thinking skills in your classroom*. Alexandria, VA: ASCD.

Brown, A. (1987). Metacognition, executive control, self-regulation and other more mysterious mechanisms. In E. E. Weinert, & R. H. Kluwe (Eds.), *Metacognition, motivation and understanding* (pp. 65-116). Hillsdale, NJ: Erlbaum.

Burke, K. (1994). *The mindful school: How to assess authentic learning*. Arlington Heights, Illinois: IRI/Skylight Training and Publishing.

Burke, L. A., & Williams, J. M. (2008). Developing young thinkers: An intervention aimed to enhance children's thinking skills. *Thinking Skills and Creativity, 3*(2), 104-124.

Carr, M., & Claxton, G. (2002). Tracking the development of learning dispositions. *Assessment in Education: Principles, Policy & Practice, 9*(1), 9-37.

Clarke, S. (2001). *Unlocking formative assessment*. London: Hodder & Stoughton.

Cleghorn, P., & Baudet, S. (2003). *Thinking through Philosophy* (Books 1-4). Blackburn, UK: Educational Printing Services.

Costa, A.L. (Ed.) (2001). *Developing minds: A resource book for teaching thinking. (3rd edition)*. Alexandria, VA: Association for Supervision and Curriculum Development.

Costa, A. L., & Kallick, B. (2000a). *Discovering and exploring habits of mind. A developmental series, Book 1.* Alexandria, VA: Association for Supervision and Curriculum Development.

Costa, A. L., & Kallick, B. (2000b). *Activating and engaging habits of mind. A developmental series, Book 2.* Alexandria, VA: Association for Supervision and Curriculum Development.

Costa, A. L., & Kallick, B. (2000c). *Assessing and reporting on habits of mind. A developmental series, Book 3.* Alexandria, VA: Association for Supervision and Curriculum Development.

Costa, A. L., & Kallick, B. (2000d). *Integrating and sustaining habits of mind. A developmental series, Book 4.* Alexandria, VA: Association for Supervision and Curriculum Development.

Costa, A.L., & Kallick, B. (2014). *Dispositions: Reframing teaching and learning*. Thousand Oaks, CA: Corwin.

Dawes, L., Mercer, N., & Wegerif, R. (2004). *Thinking together: A programme of activities for developing speaking, listening and thinking skills for children aged 8-11* (2nd ed.). Birmingham: Imaginative Minds.

De Acedo Lizarraga, M., De Acedo Baquedano, M., Goicoa Mangado, T., & Cardelle-Elawar, M. (2009). Enhancement of thinking skills: Effects of two intervention methods. *Thinking Skills and Creativity, 4*(1), 30-43.

DeBono, E. (1986). *CoRT (Cognitive Research Trust) program.* Elmsford, NY: Pergamon Press, Inc.

DeBono, E. (1985). *Six hats thinking*. Boston, MA: Little, Brown and Co.

DeBono, E. (1990). *The use of lateral thinking* (2nd ed.). London: Jonathan Cape.

Dewey, J. (1933). *How we think*. Boston: D.C. Heath & Co.

Dewey, J., & Bento, J. (2009). Activating children's thinking skills (ACTS): The effects of an infusion approach to teaching thinking in primary schools. *British Journal of Educational Psychology, 79*(2), 329-351.

Dochy, F., Segers, M., Van den Bossche, P., & Gijbels, D. (2003). Effects of problem-based learning: A meta-analysis. *Learning and Instruction, 13*(5), 533-568.

Ennis, R., & Millman, J. (2005). *Cornell test of critical thinking, Level Z.* Pacific Grove, CA: Midwest Publications (now the Critical Thinking Company)

Ennis, R. H. (1962). A concept of critical thinking. *Harvard Educational Review, 32*(1), 81-111.

Ennis, R. H. (1987). A taxonomy of critical thinking dispositions and abilities. In J. Baron, & R. Sternberg (Eds.), *Teaching thinking skills: Theory and practice.* (pp. 9-26). New York: WH Freeman/Times Books/Henry Holt & Co.

Ennis, R. H. (1996). Critical thinking dispositions: Their nature and assessability. *Informal Logic, 18*(2).

Ennis, R. (2009). Critical thinking: A streamlined conception. *Teaching Philosophy, 14*(1), 5-24.

Ennis, R. (2011). Critical thinking across the disciplines. *Inquiry, 26*(2), 5-19.

Ennis, R. H., & Weir, E. E. (1985). *The Ennis-Weir critical thinking essay test: An instrument for teaching and testing*. Pacific Grove, CA: Midwest Publications.

Facione, P. (1990). The Delphi Report. Critical thinking: A statement of expert consensus for purposes of educational assessment and instruction, Executive Summary. Report from the American Philosophical Association. Millbrae, California: California Academic Press.

Feuerstein, R., Ya'acov Rand, Hoffman, M. B., Miller, R., & Vig, E. (1980). *Instrumental enrichment: An intervention program for cognitive modifiability*. Baltimore, MD: University Park Press.

Fisher, R. (1998). *Teaching thinking: Philosophical enquiry in the classroom*. London: Cassell.

Flavell, J.H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. *American Psychologist*, 34(10), 906-911.

Fogarty, R. (1994). The mindful school: How to teach for metacognitive reflection. Arlington Heights, Illinois: IRI/Skylight Training and Publishing.

Gallagher, C., Hipkins, R., & Zohar, A. (2012). Positioning thinking within national curriculum and assessment systems: Perspectives from Israel, New Zealand and Northern Ireland. *Thinking Skills and Creativity, 7*(2), 134-143.

Gijbels, D., Dochy, F., Van den Bossche, P., & Segers, M. (2005). Effects of problem-based learning: A meta-analysis from the angle of assessment. *Review of Educational Research, 75*(1), 27-61.

Halpern, D. (2010). Halpern critical thinking assessment. *SCHUHFRIED (Vienna Test System): Moedling, Austria.*[*Http://www.Schuhfried.com/vienna-Test-System-vts/all-Tests-from-az/test/hcta-Halpern-Critical-Thinking-Assessment-1*](Http://www.Schuhfried.com/vienna-Test-System-vts/all-Tests-from-az/test/hcta-Halpern-Critical-Thinking-Assessment-1)*,*

Halpern, D. F. (2014). *Thought and knowledge: An introduction to critical thinking* (5th ed.). Mahwah, NJ: Erlbaum. (lst edition was published in 1984)

Halpern, D. F., & Riggio, H. R. (2003). *Thinking critically about critical thinking: A workbook to accompany Halpern's Thought and Knowledge* (4th ed.). Mahwah, NJ: Erlbaum.

Halpern, D. (1998). Teaching critical thinking for transfer across domains – Dispositions, skills, structure training, and metacognitive monitoring. *American Psychologist, 53*(4), 449-455.

Hayes, J. R. (1989). *The complete problem solver*. Hillsdale, NJ: Lawrence Erlbaum.

Higgins, S., Baumfield, V., Lin, M., Moseley, D., Butterworth, M., Downey, G., et al. (2004). *Thinking skills approaches to effective teaching and learning. what is the evidence for impact on learners?*. In Research Evidence in Education Library, London: EPPI-Centre, Social Science Research Unit, Institute of Education.

Higgins, S., Hall, E., Baumfield, V., & Moseley, D. (2005). *A meta-analysis of the impact of the implementation of thinking skills approaches on pupils.* In Research Evidence in Education Llibrary, London: EPPI-Centre, Social Science Research Unit, Institute of Education.

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review, 16*(3), 235-266.

Hyerle, D. (1996). *Visual tools for constructing knowledge.* Alexandria, VA: Association for Supervision and Curriculum Development.

Hyerle, D. (2008). *Visual tools for transforming information into knowledge*. Thousand Oaks, CA: Corwin.

Isaksen, S.G., & Treffinger, D.J. (2004). Celebrating 50 years of reflective practice: Versions of creative problem solving. *The Journal of Creative Behavior, 38*(2), 75-101.

James, M., Black, P., Carmichael, P., Conner, C., Dudley, P., Fox, A., Frost, D., et al., (2006). *Learning how to learn: Tools for schools.* Abingdon: Routledge.

Johnson, D., & Johnson, R. (1994). *Learning together and alone, cooperative, competitive, and individualistic learning*. Needham Heights, MA: Prentice-Hall.

Jonsson, A., & Svingby, G. (2007). The use of scoring rubrics: Reliability, validity and educational consequences. *Educational Research Review, 2*(2), 130-144.

Joyce, B. & Showers, B. (1980). Improving inservice training: The messages of research. *Educational Leadership*, 37(5), 379-385.

Joyce, B. & Showers, B. (1996). The evolution of peer coaching. *Educational Leadership*, 53(6), 12-16.

Kaufmann, J. & Baer, J. (Eds.) (2006). A tribute to E. Paul Torrance. *Creativity Research Journal*, 18(1). A special issue.

Ku, K. Y., & Ho, I. T. (2010). Metacognitive strategies that enhance critical thinking. *Metacognition and Learning, 5*(3), 251-267.

Kuhn, D. (2000). Metacognitive development. *Current Directions in Psychological Science, 9*(5), 178-181.

Kuhn, D. (2008). Formal operations from a twenty-first century perspective. *Human Development, 51*(1), 48-55.

Kuhn, D. (2009). The importance of learning about knowing: Creating a foundation for development of intellectual values. *Child Development Perspectives, 3*(2), 112-117.

Kuhn, D., & Dean, J.D.(2004). Metacognition: A bridge between cognitive psychology and educational practice. *Theory into Practice, 43*(4), 268-273.

Leat, D. (1999). Rolling the stone uphill: Teacher development and the implementation of thinking skills programmes. *Oxford Review of Education, 25*(3), 387-403.

Leahy, S., Lyon, C., Thompson, M., & Wiliam, D. (2005). Classroom assessment: Minute-by-minute and day-by-day. *Educational Leadership*, 63(3), 18-24.

Lipman, M. (2003). *Thinking in education.* Cambridge University Press.

Lipman, M., Sharp, A. M., & Oscanyan, F. S. (1980). *Philosophy in the classroom*. Philadelphia, PA: Temple University Press.

Lucas, B., & Claxton, G. (2010). *New kinds of smart: How the science of learnable intelligence is changing education*. Maidenhead, UK: McGraw-Hill International.

Magno, C. (2010). The role of metacognitive skills in developing critical thinking. *Metacognition and Learning, 5*(2), 137-156.

Marin, L. M., & Halpern, D. F. (2011). Pedagogy for developing critical thinking in adolescents: Explicit instruction produces greatest gains. *Thinking Skills and Creativity, 6*(1), 1-13.

McGuinness, C. (1990). Talking about thinking: the role of metacognition in teaching thinking. In Gilhooly, K. et al. (Eds.*), Lines of thinking: Reflections on the psychology of thought*. London: Wiley, pp. 301-312.

McGuinness, C. (1993). Teaching thinking: New signs for theories of cognition. *Educational Psychology*, 13(3 &4), 305-316.

McGuinness, C. (1999). *From thinking skills to thinking classrooms: A review and evaluation of approaches to developing pupils' thinking.* Norwich: HMSO. (DfEE Research Report No. 115)

McGuinness, C. (2005). Teaching thinking: Theory and practice. *British Journal of Educational Psychology*, Monograph Series II, 3, 107-127.

McGuinness, C., & Nisbet, J. (1991). Teaching thinking in Europe. *British Journal of Educational Psychology, 61*(2), 174-186.

McGuinness, C., Sheehy, N., Curry, C., Eakin, A., Evans, C., & Forbes, P. (2006). *Building thinking skills in thinking classrooms. ACTS (Activating Children's Thinking Skills) in Northern Ireland.* London, UK: ESRC's Teaching and Learning Research Programme, Research Briefing No 18.

Mercer, N. (1996). The quality of talk in children's collaborative activity in the classroom. *Learning and Instruction, 6*(4), 359-377.

Mercer, N., & Howe, C. (2012). Explaining the dialogic processes of teaching and learning: The value and potential of sociolcultural theory. *Learning, Culture and Social Interaction*, 1, 12-21.

Mercer, N., & Littleton, K. (2007). *Dialogue and the development of children's thinking: A sociocultural approach*. Abingdon, Oxon: Routledge.

Mercer, N., Wegerif, R., & Dawes, L. (1999). Children's talk and the development of reasoning in the classroom. *British Educational Research Journal, 25*(1), 95-111.

Moseley, D., Baumfiled, V., Elliott, J., Gregson, M., Higgins, S., Miller, J., & Newton, D.P. (2005). *Frameworks for thinking: A handbook for teaching and learning.* Cambridge, UK: Cambridge University Press.

Neufeld, V.R., & Barrows, H.S. (1974). The McMaster philosophy: An approach to medical education. *Journal of Medical Education*, 49, 1040-1050.

Newell, A., & Simon, H.A. (1972). *Human problem solving*. Englewood Cliffs, NJ. Prentice Hall.

Nisbett, R. E., Aronson, J., Blair, C., Dickens, W., Flynn, J., Halpern, D. F., et al. (2012). Intelligence: New findings and theoretical developments. *American Psychologist, 67*(2), 130-159.

OECD (2004*). Problem-solving for tomorrow's world: First measures of cross-curricular competences for PISA 2003*. Paris: OECD.

Pease, M. A., & Kuhn, D. (2011). Experimental analysis of the effective components of problem-based learning. *Science Education, 95*(1), 57-86.

Perkins, D. (1995). *Outsmarting IQ: The emerging science of learnable intelligence*. New York, NY: The Free Press (Simon and Schuster).

Perkins, D. (2008). *Smart schools: From training memories to educating minds* [Better Thinking and Learning for Every Child]. New York: Simon and Schuster.

Perkins, D. N., & Grotzer, T. A. (1997). Teaching intelligence. *American Psychologist, 52*, 1125-1133.

Perkins, D. N., Jay, E., & Tishman, S. (1993). Beyond abilities: A dispositional theory of thinking. *Merrill-Palmer Quarterly , 39(1)*, 1-21.

Perkins, D. N., & Salomon, G. (1989). Are cognitive skills context-bound? *Educational Researcher, 18*(1), 16-25.

Perkins, D.N., & Salomon, G. (2001). Teaching for transfer. In A. L. Costa (Ed.), *Developing minds: A resource for teaching thinking* (3rd ed., pp. 370-378). Alexandria, VA: Association for Supervision and Curriculum Development.

Perkins, D., Tishman, S., Ritchhart, R., Donis, K., & Andrade, A. (2000). Intelligence in the wild: A dispositional view of intellectual traits. *Educational Psychology Review, 12*(3), 269-293.

Perkins, D. N., & Salomon, G. (2012). Knowledge to go: A motivational and dispositional view of transfer. *Educational Psychologist, 47*(3), 248-258.

Resnick, L. B. (1987). *Education and learning to think*. Washington: National Academy Press.

Resnick, L. B., Michaels, S., & O'Connor, C. (2010). How (well structured) talk builds the mind. In R. J. Sternberg, & D. D. Preiss (Eds.), *From genes to context: New discoveries about learning from educational research and their applications* (pp. 163-194). New York, NY: Springer.

Ritchhart, R. (2002). *Intellectual character: What is it, why it matters, and how to get it*? San Francisco, CA: Jossey-Bass.

Ritchhart, R., Church, M., & Morrison, K. (2011). *Making thinking visible: How to promote engagement, understanding, and independence for all learners*. San Francisco, CA: Wiley.

Saravanan, V. (2005). 'Thinking schools, learning nations' implementation of curriculum review in Singapore. *Educational Research for Policy and Practice, 4*(2-3), 97-113.

Savery, J.R. (2006). Overview of problem-based learning: Definitions and distinctions. *Interdisciplinary Journal of Problem-Based Learning*, 1(1), 9-20.

Schraw, G., McCrudden, M. T., Lehman, S., & Hoffman, B. (2011). An overview of thinking skills. In G. Schraw, & D. H. Robinson (Eds.), *Assessment of higher order thinking skill.* (pp. 19-45). Charlotte, NC: Information Age Publishing.

Schraw, G., & Robinson, D. H. (2011). *Assessment of higher order thinking skills.* Charlotte, NC: Information Age Publishing.

Shayer, M., & Adey, P. (2002). *Learning intelligence: Cognitive acceleration across the curriculum from 5 to 15 years* . Milton Keynes, UK: Open University Press.

Shayer, M., & Adhami, M. (2007). Fostering cognitive development through the context of mathematics: Results of the CAME project. *Educational Studies in Mathematics, 64*(3), 265-291.

Showers, B. & Joyce, B. (2002). *Student achievement through staff development*, 3rd edition. Alexandria, VA: Association for Supervision & Curriculum Development.

Sternberg, R. J., & Grigorenko, E. L. (2007). *Teaching for successful intelligence: To increase student learning and achievement.* Thousand Oaks, CA: Corwin Press.

Sternberg, R. J. (1986). *Intelligence applied: Understanding and increasing your intellectual skills. New York:* Harcourt Brace Jovanovich.

Swartz, R. & Perkins, D. (1989). *Teaching thinking: Issues and approaches*. Pacific Grove, CA: Midwest Publications.

Swartz, R.J., & Parks, D. (1994). *Infusing the teaching of critical and creative thinking in elementary instruction.* Pacific Grove, CA: Critical Thinking Books & Software.

Swartz, R.J., Fischer, S.D., Parks, S. (1998). *Infusing the teaching of critical and creative thinking into secondary science.* Pacific Grove, CA: Critical Thinking Books & Software.

Swartz, R.J., Larissey, J., & Kiser, M. A. (2000a). *Teaching critical and creative thinking in language arts*. Grade 1 & 2. Pacific Grove, CA: Critical Thinking Books & Software.

Swartz, R.J., Whipple, T., BLaisdell, G., & Kiser, M. A. (2000b). *Teaching critical and creative thinking in language arts*. Grade 3 & 4. Pacific Grove, CA: Critical Thinking Books & Software.

Swartz, R., Kiser, M. A., & Reagan, R. (2000c). *Teaching critical and creative thinking in language arts*. Grade 5 & 6. Pacific Grove, CA: Critical Thinking Books & Software.

Swartz, R. (2001). Thinking about decisions. In A. L. Costa (Ed.), *Developing minds: A resource book for teaching thinking* (3rd ed., pp. 58-66). Alexandria, VA: Association for Supervision & Curriculum Development.

Swartz, R., Fisher, S.D. (2001). Teaching thinking in science. In A. L. Costa (Ed.), *Developing minds: A resource book for teaching thinking* (3rd ed., pp. 303-309). Alexandria, VA: Association for Supervision & Curriculum Development.

Swartz, R. J., Costa, A., Kallick, B., Beyer, B., & Reagan, R. (2007). *Thinking-based learning: Activating students' potential*. Norwood, MA: Christopher-Gordon Publishers.

Swartz, R.J. (2008). Energizing learning. *Educational Leadership*, 65, 26-31. (Special Issue on Teaching Students to Think)

Taggart, G., Ridley, K., Rudd, P., & Benefield, P. (2005). *Thinking skills in the early years: A literature review.* Slough, UK: National Foundation for Educational Research.

Tishman, S., & Andrade, A. (1995). Thinking dispositions: A review of current theories, practices, and issues. https://learnweb.harvard.edu/alps/thinking/docs/Dispositions.htm)

Tishman, S., Jay, E., & Perkins, D. N. (1993). Teaching thinking dispositions: From transmission to enculturation. *Theory into Practice, 32*(3), 147-153.

Tishman, S., Perkins, D., & Jay, E. (1995). *The thinking classroom: Learning and teaching in a culture of thinking.* Boston, MA: Allyn & Bacon.

Topping, K. J., & Trickey, S. (2007a). Impact of philosophical enquiry on school students' interactive behaviour. *Thinking Skills and Creativity, 2*(2), 73-84.

Topping, K.J., & Trickey, S. (2007b). Collaborative philosophical enquiry for school children: cognitive effects at 10-12 Years," *British Journal of Educational Psychology,* 77, 271-288.

Topping, K.J. & Trickey, S. (2007c) Collaborative philosophical inquiry for school children: cognitive gains at 2-Year Follow-Up," *British Journal of Educational Psychology* , 77, 787-796.

Treffinger, D. J., Solomon, M., & Woythal, D. (2012). Four decades of creative vision: Insights from an evaluation of the future problem solving program international (FPSPI). *The Journal of Creative Behavior, 46*(3), 209-219.

Trickey, S., & Topping, K. J. (2004). Philosophy for children: A systematic review. *Research Papers in Education, 19*(3), 365-380.

Venville, G., Adey, P., Larkin, S., Robertson, A., & Fulham, H. (2003). Fostering thinking through science in the early years of schooling. *International Journal of Science Education, 25*(11), 1313-1331.

Vygotsky, L.S. (1978). *Mind in society: The development of higher psychological processes.* Cambridge, Mass: Harvard University Press. (translated and abridged edition)

Wegerif, R. (2011). Towards a dialogic theory of how children learn to think. *Thinking Skills and Creativity, 6*(3), 179-190.

Wegerif, R., Mercer, N., & Dawes, L. (1999). From social interaction to individual reasoning: An empirical investigation of a possible socio-cultural model of cognitive development. *Learning and Instruction, 9*(6), 493-516.

Wells, G. (1999). *Dialogic inquiry: Toward a sociocultural practice and theory of education*. Cambridge, UK: Cambridge University Press.

Wiggins, G. P., & McTighe, J. (2005). *Understanding by design* (2nd ed.). Alexandria, VA.: Association for Supervision and Curriculum Development.

Wiliam, D. (2011). *Embedded formative assessment*. Bloomington, IN: Solution Tree Press.

Zohar, A. (2008). Teaching thinking on a national scale: Israel's pedagogical horizons. *Thinking Skills and Creativity, 3*(1), 77-81.

8 Appendices

8.1 Appendix 1: Literature review strategy

A comprehensive review of the literature was undertaken, based on seven criteria. These criteria were:

- coverage of all search terms in appropriate wide-ranging and specialist databases,
- a search of relevant specialist research journals as detailed below,
- papers citing classical authors in thinking skills research,
- a search for thinking programmes as detailed below,
- a search for instruments for assessment of non-discipline specific thinking skills as detailed below;
- a variety of search terms as detailed below, and
- all papers by certain leading researchers, as detailed below.

Except for papers related to leading thinkers and seminal papers in the discipline, most searches related to the period 2000-2013.

A huge number of publications relating to teaching thinking in specific disciplines was uncovered during searches. These papers covered disciplines as diverse as engineering, marketing, law and literature, indicating widespread appreciation of the significance of teaching thinking in the education community. For the most part, papers specific to teaching in a given discipline were not included, being considered outside the scope of the report.

Databases

The principal database used was Google Scholar, which covers all disciplines and includes peer reviewed literature, reports, books, book sections, monographs, publications by professional bodies, government publications and some other grey literature. Google Scholar was supplemented by Web of Science, Scopus, PSYCHINFO and ERIC, the US Department of Education sponsored website. Very few additional references were found on the supplementary databases.

Journal list

All papers in the following journals in the years 2005 – 2013 were considered for inclusion.

- Thinking Skills and Creativity
- Metacognition and Learning
- Cognition and Instruction
- Journal of Cognitive Education and Psychology
- Educational Research (Sri Lanka)
- The Korean Journal of Thinking and Problem Solving
- Teaching Philosophy
- Learning and Instruction
- Educational Research Review
- Journal of Critical Thinking

- Educational Research Review
- British Journal of Educational Psychology

Thinking programmes

The following programme names were used as search terms:

Instrumental Enrichment	Cognitive Acceleration in Science Education
Let's think	Activating Children's Thinking Skills
Intelligence applied	Somerset Thinking Skills Programme
Project Intelligence	Cognitive Acceleration in Mathematics Education
Philosophy for Children	Edward de Bono's Six-Hat Thinking
Visible Thinking	Thinking Routines

Instruments assessing thinking skills

The following psychometric instruments, all of which are used to assess thinking and related skills and dispositions, were used as search terms:

- The Halpern Critical Thinking Test
- The Torrance Test of Creative Thinking
- Cambridge Assessment of Critical Thinking
- Watson-Glaser Critical Thinking Appraisal
- Cornell Test of Critical Thinking
- California Critical Thinking Skills Test
- Halpern's Critical Thinking Assessment

Search terms

The following phrases were used as search terms together with permutations thereof:

Argumentation	Explicit teaching of thinking	Strategic thinking
Assessing creative thinking	Exploratory talk	Strategies for learning
Assessing collaborative thinking	Graphic organizers	Socratic dialogue
Assessing critical thinking	Habits of mind	Taxonomy of thinking
Assessing higher-order thinking	Habits of thinking	Teaching creative thinking
Assessment of thinking skills	Higher-order thinking	Teaching problem-solving
Assessing problem solving	Infusing thinking	Teaching thinking
Attitudes to learning	Inquiry-based learning	Thinking hats
Beliefs about knowledge	Learnable intelligence	Thinking dispositions
Bloom's taxonomy	Learning dispositions	Thinking routines
Critical thinking dispositions	Learner orientation	Thinking skills
Cognitive acceleration	Making thinking visible	Thinking through dialogue
Cognitive education	Mastery orientation	Transfer of thinking
Cognitive strategies	Metacognition	Visible thinking
Cooperative learning	Metamemory	Visual maps
CORT	Metacognitive strategies	
Critical thinking	Mindful thinking	
Dialogic thinking	Problem-based Learning	

Delphi report	Reflection	
Educational dialogue	Reflective thinking	
Epistemic beliefs	Self-regulation in thinking	Skilful thinking

Authors

All publications by the following authors were included in the search:

Philip Adey	Cindy Hmelo-Silver	Lauren Resnick
Lorin Anderson	Eileen Jay	Ron Ritchhart
Al Andrade	David R Krathwohl	Gavriel Salomon
John Biggs	Deanna Kuhn	John Savery
Benjamin Bloom	Matthew Lipman	Gregory Schraw
Edward de Bono	Maurice Lipman	Michael Shayer
Margaret Carr	Elizabeth Lizarraga	Harvey Siegel
Guy Claxton	Maria Lizarraga	Robert J Sternberg
Art Costa	Neil Mercer	Robert/Bob Swartz
Anna Craft	Carol McGuinness	Shari Tishman
Filip Dochy	Jay McTighe	E Paul Torrance
Carol Dweck	Sarah Michaels	Donald J Treffinger
Robert Ennis	David Moseley	Rupert Wegerif
Reuven Feuerstein	Raymond Nickerson	Gordon Wells
Peter Facione	Richard Paul	Grant Wiggins
Diane Halpern	David Perkins	Dylan Wiliam

8. 2 Appendix 2: Examples of Thinking Dispositions and related constructs

Disposition	Description/Components	Authors
Mindfulness	The disposition to adaptively respond to new constraints or contexts The ability to balance flexibility and stability in thinking Open-mindedness Awareness of multiple perspectives	Ellen Langer Langer, E. (1989). *Mindfulness*. Perseus Books
Mindfulness	Positive attitude towards ambiguous and complex situations Preference for novelty Preference for incongruity	Gavriel Salomon Salomon, G., & Globerson, T. (1987). Skill may not be enough. The role of mindfulness in learning and transfer. *International Journal of Educational Research*, 11(6), 623-637.)
Intellectual traits of critical thinking	Intellectual humility Intellectual autonomy Intellectual integrity Intellectual courage Intellectual perseverance Intellectual integrity Confidence in reason Intellectual empathy Fair-mindedness	Richard Paul and Linda Elder https://sites.google.com/site/qepcafe/modules/overview/paul-elder
Critical spirit	Objectivity Intellectual honesty Impartiality, fair-mindedness The dispositions to • value good reasoning, • seek reasons and justification, and • base beliefs and actions on good reasoning Open-mindedness	Harvey Siegel Siegel, H. (1988*). Educating reason: Rationality, critical thinking and education*. New York: Routledge.

	Independent-mindedness	
Critical thinking dispositions	Open-mindedness Inquisitiveness Systematicity Analyticity Truth-seeking Critical thinking self-confidence Maturity	Peter and Noreen Facione Facione, P., Facione, N.C., & Giancarlo, C.A. (200O). *The California Critical Thinking Disposition Inventory: Test Manual, 2000 Update.* Millbrae, C.A.: California Academic Press.
Key thinking dispositions	Seek to clarify meaning Focus on the conclusion/outcome Taking the total situation into account Seeking and offering reasons Pursuit of knowledge Search for alternatives Seek for sufficient precision Awareness of personal beliefs Open-mindedness Withhold judgement when appropriate Apply one's critical thinking abilities Be careful Awareness of others' feelings and thoughts	Robert Ennis Ennis, R. H. (1987). A taxonomy of critical thinking dispositions and abilities. In J. Baron, & R. Sternberg (Eds.), *Teaching thinking skills: Theory and practice.* (pp. 9-26). New York: WH Freeman/Times Books/Henry Holt & Co.
Habits of Mind /Dispositions	Persisting Managing impulsivity Listening with understanding and empathy Thinking flexibly Thinking about your thinking Striving for accuracy and precision Questioning and problem posing Applying past knowledge to novel situations Thinking and communicating with clarity and precision	Art Costa and Bena Kallick Costa, A.L., & Kallick, B. (2014). *Dispositions: Reframing teaching and learning*. Thousand Oaks, CA: Corwin.

	Gathering data through all the senses Creating, imagining and innovating Responding with wonderment and awe Taking responsible risks Finding humour Thinking interdependently Remaining open to continuous learning	
Thinking dispositions	Broad and adventurous Curious and oriented toward problem finding Seek understanding and build explanations Planful and strategic Intellectually careful Seek and evaluate reasons Metacognitive	David Perkins, Eileen Jay and Shari Tishman Perkins, D. N., Jay, E., & Tishman, S. (1993). Beyond abilities: A dispositional theory of thinking. *Merrill-Palmer Quarterly, 39(1)*, 1-21.

Summarise these as:

- Curiosity – embraces wondering, seeking reasons/problems, pursuit of knowledge
- Open-mindedness – embraces fair-mindedness and adventurous thinking, scepticism and openness to others' viewpoints
- Intellectual confidence
- Disposition to be systematic – embraces planning and strategy
- The disposition to be playful with ideas – embraces creativity and pleasure in new thinking
- The disposition to reflect on one's own thinking
- The disposition to argue ideas – embraces the disposition to defend and criticise ideas, working with others.
- Toleration of ambiguity – embraces suspension of judgement.

8.3 Appendix 3: Examples of Structured Programmes to Teach Thinking Skills and Thinking Dispositions

Programme ***Founder/s***	**Theoretical Orientation**	**Age range**	**Methodology**	**Further Information**
Instrumental Enrichment *Reuven Feuerstein* First implemented in the 1950s in Israel	Learnable intelligence, Cognitive modifiability	All ages	Separate programme using 14 'instruments' over 2-3 years, cognitive mediation as a teaching approach, and bridging for transfer.	http://www.icelp.info/
Somerset Thinking Skills Course *Nigel Blagg (1991)* This is a modification of Instrumental Enrichment	Learnable intelligence, Cognitive modifiability	Secondary students and further education students	Separate programme using instruments that are similar to IE but are less abstract.t	http://www.somersetthinkingskills.co.uk/
Philosophy for Children *Matthew Lipman (1974)*	Thinking philosophically, critical, creative and caring thinking	6-16 years	Separate programme, extensive use of stories and novelettes to stimulate thinking, Socratic questioning, community of enquiry	http://www.ascd.org/ASCD/pdf/journals/ed_lead/el_198809_brandt3.pdf http://www.sapere.org.uk/ http://www.teachingthinking.net/
Thinking through Philosophy *Paul Cleghorn Steve Trickey &*	Thinking philosophically, critical, creative and	6-11 years	Separate programme, use of stories for thinking, Socratic questioning, focus on dialogue , community of enquiry	http://www.zoominfo.com/p/Paul-Cleghorn/1160952716 http://depts.washington.edu/nwcenter/aboutwhyphilosophyforchildren.html

Keith Topping (2001) A derivation of Philosophy for Children	caring thinking		Increasingly used with curricular materials	
Cognitive Acceleration through Science Education (CASE) Cognitive Acceleration Through Mathematics Education (CAME) *Philip Adey, Michael Shayer,1990 and onwards*	Piaget's theory of cognitive development plus Vygotsky's theory for instruction	11-13 years	Separate science and mathematics lessons, with the focus on accelerating thinking from concrete to formal operations, pedagogical pillars include metacognition and bridging	http://www.kcl.ac.uk/sspp/departments/education/research/crestem/Research/Past-Projects/Cognaccel.aspx http://www.letsthink.org.uk/
Let's Think (Primary School Version)	Piaget's theory of cognitive development plus Vygotsky's theory for instruction	4-11 years	Separate lessons with a focus on accelerating thinking from pre-concrete to concrete operational thinking , pedagogical pillars include metacognition and bridging	Ditto
Cognitive Research Trust (CoRT) Thinking Lessons *Edward De Bono (1974)*	Focus on lateral thinking, and on thinking tools	8 years and upwards Often used in business settings	Separate programme of 60 lessons, using thinking tools such as PMI (plus, minus, interesting), CAF (consider all the factors). Also has a programme called Six Thinking Hats.	http://www.edwdebono.com/cort/index.html http://www.slideshare.net/DamianGordon1/the-cort-thinking-programme-6276905

Thinking-Based Learning (TBL) *Bob Swartz (1994)*	Focus on developing higher order thinking, particularly critical and creative thinking skills	5-18 Years	Infusion methodology, where lessons are designed to teach both thinking skills and curricular content simultaneously. Focus on explicit instruction, use of graphic organisers , metacognition and transfer	http://www.nctt.net/
Activating Children's Thinking Skills (ACTS) *Carol McGuinness 2001*	Focus on higher order thinking, with particular emphasis on metacognitive thinking	8-11years	Similar to TBL, but with specific emphasis on collaborative thinking, dialogue, metacognitive dialogue and transfer Formed the basis for the Thinking Skills and Personal Capabilities Framework in the Northern Ireland Curriculum	http://www.tlrp.org/pub/documents/McGuinness_RB_18.pdf http://www.nicurriculum.org.uk/TSPC/what_are_tspc/
Designs for Thinking/ Thinking Maps *David Hyerle 1996*	Focus on a thinkers' toolkit particularly visual tools	Pre-school upwards	Infusion into curricular materials, using visual tools/graphic organisers and software to aid thinking	http://www.thinkingfoundation.org/david/books/habits_of_mind.pdf
Thinking Together Interthinking *Neil Mercer and Lynne Dawes 1999*	Relationship between language and thinking from a socio-cultural perspective	9-10 years originally, later 6-14 years	Focus on developing thinking through improving dialogic skill, conversations in groups, specific kinds of classroom talk in the context of curricular materials	http://thinkingtogether.educ.cam.ac.uk/projects/ http://www.open.ac.uk/creet/main/sites/www.open.ac.uk.creet.main/files/08%20Thinking%20Together.pdf
Habits of Mind *Art Costa and*	Focus on intelligent	All ages	16 habits of mind that are the focus for cultivation and direct	http://www.habitsofmind.co.uk/teaching-habits.html

Bena Kallick 2000	behaviours that build habits of mind and thinking dispositions		instruction in curricular contexts	
Visible Thinking *David Perkins Ron Ritchhart Karin Morrison* 2009	Focus on thinking dispositions	5-18 years	Focus on developing thinking routines in the curricular contexts and making thinking visible through various forms of documentation	http://www.visiblethinkingpz.org/VisibleThinking_html_files/VisibleThinking1.html
Building Learning Power *Guy Claxton 2002*	Focus is on the broader goals of learning dispositions, rather than specific thinking dispositions	All ages	Focus is on four learning dispositions – resilience, resourceful, reflectiveness and reciprocity. Methods include redesigning timetable, classroom climate, outdoor learning	http://www.buildinglearningpower.co.uk/

8. 4 Appendix 4: Psychometric Tests for assessing different kinds of thinking (illustrative rather than comprehensive list)

Test (Author, Date)	Age range	Type	Components	Publisher /website/source	Relevant reference
Tests of critical thinking					
California Critical Thinking Skills Test (Facione, 1990)	College students or advanced high school students	Multiple choice	Induction Deduction Analysis Inference Evaluation	California Academic Press: Millbrae, CA. http://www.insightassessment.com/Products/Products-Summary/Critical-Thinking-Skills-Tests/California-Critical-Thinking-Skills-Test-CCTST/(language)/eng-US	Fawkes, D.et al., (2005). Examining the exam: A critical look at the California Critical Thinking Skills Test. *Science & Education* 14. 117-135. Ross, D. et al., (2013). Do scores on three commonly used measures of critical thinking correlate with academic success in health professions trainees? A systematic review and meta-analysis. *Academic Medicine,* 88(5), 724-734.
Thinking Skills Assessment (TSA) (Cambridge Admissions Testing Service, 2001)	Adults Admissions test for university Entrance	Multiple choice	Critical thinking and problem solving	http://www.admissionstestingservice.org/our-services/thinking-skills/	Emery, J.L. & Shannon, M. (2007). The predictive validity of the Thinking Skills Assessment: A combined analysis of three cohorts. Available from http://www.admissionstestingservice.org/images/37863-tsa_predictive_validity_combined_analysis_03_10_07.pdf Black, B. (2012). An overview of a programme of research to support the assessment of Critical Thinking. Thinking

					Skills and Creativity, 7(2), 122-133.
Cornell Critical Thinking Test, 5th edition (Ennis & Millman, 2005)	Level X: 11-18 years Level Z: adults	Multiple choice	Induction Credibility Observation Deduction Assumption identification	The Critical Thinking Company: Seaside, CA. http://www.criticalthinking.com/cornell-critical-thinking-test-level-x.html	Frisby, (1992).Construct validity and psychometric qualities of the Cornell Critical Thinking Test (Level Z): A Contrasted groups analysis. *Psychological Reports* 71 (1), 291-303.
Ennis-Weir Critical Thinking Essay Test (Ennis & Weir, 1985)	13 years upwards	Essay	Designed to assess seeing reasons and assumptions, stating one's point, offering good reasons, seeing other possibilities, avoiding equivocation, overgeneralisation, credibility problems and the use of emotive language	The Critical Thinking Company: Seaside, CA. Marking manual available at: http://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CDMQFjAA&url=http%3A%2F%2Ffaculty.education.illinois.edu%2Frhennis%2Ftewctet%2FEnnis-Weir_Merged.pdf&ei=qUYgU6rQD-aL7AawlYHQBg&usg=AFQjCNHDvFJSUHhhcCJZFO2Mt7cboFXz6g&sig2=p-YXQVgeV-6ZrmlPnqZ8BQ	Werner, P.H. (1991). Test Review: The Ennis-Weir Critical Thinking Essay Test: An Instrument for Testing and Teaching. *Journal of Reading*. 494-495.
Halpern Critical Thinking Assessment	15 years upwards	Multiple choice And open-	Verbal reasoning Argument analysis Thinking as hypothesis testing Likelihood and uncertainty	Schuhfried Co. : Moedling, Austria https://sites.google.com/	Butler, H. A. (2012). Halpern Critical Thinking Assessment predicts real-world outcomes of critical thinking. *Applied Cognitive Psychology* 26 (5), 721-729.

(Halpern, 2006)		ended questions	Decision making & problem solving	site/dianehalperncmc//home/research/halpern-critical-thinking-assessment	
ICAT Critical Thinking Essay Test (Paul and team, 1996)	College and university students	Essay	Summarising Identifying the focus Commenting on strengths and weaknesses	http://www.criticalthinking.org/pages/international-critical-thinking-test/619	No peer reviewed reference available.
Watson-Glaser Critical Thinking Appraisal (Watson and Glaser, 1980)	Adults	Multiple choice	Inference Recognition of assumptions Deduction Interpretation Evaluation of arguments	http://www.talentlens.co.uk/select/watson-glaser-unsupervised-and-supervised-uk-edition?gclid=CL2NhJ6aiL0CFSETwwodqxMALA	Bernard, R.M. et al. (2008). Exploring the structure of the Watson–Glaser Critical Thinking Appraisal: One scale or many subscales? Thinking Skills and Creativity, 2008, 3, 1, 15-22.
Tests of creative thinking					
Torrance Test of Creative Thinking, 4th edition (Torrance, 1998) This test was first published in the 1960s	Kindergarten -adult		*Figural:* Fluency Elaboration Originality Resistance to premature closure Abstractness of titles *Verbal:* Emotional expressiveness Storytelling articulateness Movement or action Expressiveness of titles	Scholastic Testing Service Inc.: Bensenville, IL. http://ststesting.com/2005giftttct.html	Almeida, Leandro S., et al. (2008). Torrance Test of Creative Thinking: The question of its construct validity. *Thinking Skills and Creativity* , 3(1), 53-58. Runco, M. A., et al.,. (2011) Torrance Tests of creative thinking as predictors of personal and public Achievement: A fifty year follow-up. *Creativity Research Journal*, 22 (4).

			Synthesis of incomplete figures Synthesis of lines or circles Unusual visualization internal visualization Extending or breaking boundaries Humor Richness of imagery Colorfulness of imagery Fantasy		
Tests of problem solving					
Thinking Skills Assessment (TSA) (Cambridge Admissions Testing Service, 2001)	Adults Admissions test for university entrance	Multiple choice	Critical thinking and problem solving	http://www.admissionstestingservice.org/our-services/thinking-skills/	Emery, J.L. & Shannon, M. (2007) The predictive validity of the Thinking Skills Assessment: A combined analysis of three cohorts. Available from http://www.admissionstestingservice.org/images/37863-tsa_predictive_validity_combined_analysis_03_10_07.pdf Black, B. (2012). An overview of a programme of research to support the assessment of Critical Thinking. Thinking Skills and Creativity, 7(2), 122-133.
PISA problem solving test	15 years	Various	Problem solving	http://www.oecd.org/pisa/keyfindings/pisa-2012-results-volume-v.htm	OECD (2004). *Problem Solving for Tomorrow's World: First Measures of Cross-Curricular Competencies from PISA 2003.* OECD Publishing: Paris, France.

					Dossey, J. A., et.a., (2006). Problem Solving in the PISA and TIMSS 2003 Assessments. US Dept of Education Technical Report.
Inventories assessing Thinking Dispositions					
California Critical Thinking Disposition Inventory	11 years and upwards	Self report: Response on a Likert scale to 39 items	Truth seeking Open-mindedness Analyticity Systematicity Confidence in reasoning Intellectual curiosity Maturity of reasoned judgement	http://www.insightassessment.com/Products/Products-Summary/Critical-Thinking-Attributes-Tests/California-Critical-Thinking-Disposition-Inventory-CCTDI	Walsh, C. M., Seldomridge, L. A. & Badros. K. K. (2007). California Critical Thinking Disposition Inventory: Further factor analytic examination. *Perceptual and Motor Skills* 104 (1), 141-151. Ross, D. et al., (2013). Do scores on three commonly used measures of critical thinking correlate with academic success in health professions trainees? A systematic review and meta-analysis. *Academic Medicine,* 88(5), 724-734.
Need for Cognition Scale (Cacioppo, Petty & Kao, 1982)	Middle school upwards	Self report: Response on a Likert scale to 34 items and short-form with	The tendency for an individual to engage and enjoy thinking	http://www.liberalarts.wabash.edu/ncs/	Coutinho, S. et al., (2005) Metacognition, need for cognition and use of explanations during ongoing learning and problem solving. *Learning and Individual Differences* 15(4), 321-337. Carnevale, J. J., Yoel, I., & Lerner, J.S. (2011). Individual differences in need for cognition and decision-making competence among leaders. *Personality and Individual*

		18 items			*Differences* 51(3), 274-278.
Critical Thinking Disposition Scale (Sosu, 2013)	Adult	Self report: Response on a Likert scale to 11 items	2 factor structure: Reflective scepticism Critical openness	Available in Sosu, 2013.	Sosu, E.M. (2013). The development and psychometric validation of a Critical Thinking Disposition Scale. *Thinking Skills and Creativity* 9, 107-119.