Deconstructing Metacognition

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Abstract

Recent research on human cognition leads to a new view of how the human brain operates and points to the importance of student’s minds being actively engaged in their own learning process. While metacognition or “thinking about one’s own thinking” is increasingly recognized as an essential element of skillful thinking and learning, helping students understand and control how they think is difficult. In this paper we analyze and clarify the constituents of metacognition so that teachers may find ways of including it among their own pedagogic strategies. We provide a language and a structure to facilitate understanding of and speaking about metacognition and give examples of how to integrate this understanding into lesson planning.
“Know thyself.”
Thales, 500 BC

Why Metacognition is Important

The more our educational community learns about the human brain and how it operates the more important looms the idea that students need to think about how they are thinking, especially as they are learning. Metacognition or “thinking about one’s own thinking” emerges as a vital element of effective thought. In a draft of a forthcoming book on “Habits of Mind”, Art Costa and Bena Kallick describe students lacking metacognitive skills as follows (Costa, 2007):

Students often follow instructions or perform tasks without wondering why they are doing what they are doing. They seldom question themselves about their own learning strategies or evaluate the efficiency of their own performances. They have little or no motivation to do so. Some children virtually have no idea of what they should do when they confront a problem and are often unable to explain their strategies of decision-making. For these children learning is reduced to episodic rote learning and memorization, primarily directed at passing tests and getting through school. And many of them do, but just barely. They can do better.

When a student’s behavior is not heading in the right direction we often say “Stop and think about what you are doing.” and then help that student find an appropriate way of behaving. When a student’s intellectual activity is not on track we need to invoke a different exhortation, “Stop and think about what you are thinking.” and then help the student find an appropriate way of thinking.

Recent research from several different fields has led to a new view of the human brain and points to the importance of students being actively involved in their learning. This active involvement includes the engagement of student’s minds in the learning process. Pedagogical findings of
brain research are summarized in a report by the U. S. National Academy of Science report titled “How People Learn” (Bransford, 2000). This report provides recommendations for teachers striving to have their students learn thoughtfully and skillfully; it describes the emerging understanding that effective learning requires personal introspection – a metacognition:

A metacognitive approach to instruction can help students learn to take control of their own learning by defining learning goals and monitoring their progress in achieving them.

One specific focus of metacognition is on the organization of newly acquired knowledge and teachers are encouraged to help their students “... understand facts and ideas in a context of a conceptual framework and to organize their knowledge in ways that facilitate retrieval and application” (Bransford, 2002).

Thus each learner must make a conscious effort to think about how they are learning and work to organize the information learned so that their new knowledge becomes flexible enough to use in new or different circumstances. Without this organization, knowledge remains an inert collection of isolated facts – the “... episodic rote learning and memorization” that Costa and Kallick describe.

“How People Learn” emphasizes that experts acquire new information and organize it differently from novices. Experts (teachers) may transfer (teach) information but not their own organization of that information. That organization must take place in the student’s own mind and this means that students need to think about how they learn and how they organize the information they encounter. In a sense, the way an individual organizes knowledge is as unique as that person’s fingerprint. The process of “study” is largely about organizing new information so that it can be accessed and used efficiently.
Helping students understand and control how they think is difficult. How does one guide students to an awareness of their own mental processes? How does one talk to students about what is going on in their minds? The content of a person’s mind is, after all, known only to that person. We propose a language and a structure to formalize and facilitate the understanding of and speaking about metacognition. We intend here to analyze and clarify the constituents of metacognition so that teachers may find ways of including it among their own pedagogic strategies.

The ability to think skillfully and to reflect on our thinking is not an innate human characteristic. Some individuals develop metacognitive skills on their own, but usually in a haphazard manner. Furthermore, earlier research has shown that around 30% of the adult population never engages in metacognition (Chiabetta, 1976; Whimby, 1980). Since understanding how to perform this kind of mental activity can significantly improve one’s learning skills, teachers who can help students with this organization will increase the efficiency of their learning and thinking.

When we help students understand HOW their brains work and give them the strategies to make them work better they are more likely to think effectively and skillfully and take control of their own learning. Carol Dweck of Stanford University, working with struggling college students divided them into two groups – both groups were taught basic study skills but one group was given a series of classes explaining the ‘growth’ nature of intelligence. At the end of the semester the students with study skills alone had not applied what they had learned and their grades had continued to decline. The other group showed significant rebound in their grades and other teachers were able to identify the students who had had the ‘growth’ model lessons from those who had not (Dweck, 2008).

It is important for teachers and students to become aware of these emerging viewpoints about intelligence because when individuals realize they can improve their processes of learning and thinking they most often choose to do so. Skillful thinking and learning make knowledge more useful and transportable and can initiate a lifelong process of continual development of the brain.
What is Cognition?

In order to understand metacognition – thinking about one’s own thinking – we must first have a clear notion of cognition – thinking. Edward de Bono has defined thinking as

the deliberate exploration of experience for a purpose.

It is useful to elaborate on this definition by scrutinizing each of the important words in it. The action of thinking is an *exploration*, so when one thinks one investigates, studies, examines or analyzes. The object explored when thinking is one’s *experience*, that is, the collection of events that make up one’s conscious life. The domain of an individual’s thought is the entire content of that person’s conscious mind. Furthermore, this exploration of experience is *deliberate* which implies that the action is performed carefully and thoroughly. And finally the action is carried out for a *purpose* so there is some goal or aspiration to attain. Thus thinking is a careful and thorough investigation one’s conscious mind in order to achieve a specific objective.

Thinking may be as simple as trying to recollect who was present at your 16th birthday party or as complex as your reflections on finding meaning in your life. In thinking (cognition), we function in two different but inter-related modes. One mode deals with a cognitive skill, the type of thinking being used. How we think depends on the purpose of our thinking. We think differently when trying to remember a friend’s birth date (When is Sally’s birthday?) than when we speculate on the outcome of our action (What will happen if I forget Sally’s birthday?). We may be thinking by sorting through a list and trying to classify the items in it or we may be working through a deductive reasoning process (if ... then ...) to decide on a course of action.

There are many descriptions of cognitive skills and lists of the different types of thinking. Perhaps the most familiar to educators is Bloom’s taxonomy and its more recent derivatives (Bloom, 1956). Table 1 describes a revision of Bloom’s Taxonomy by Richard Mayer (Mayer, 2001). This revision modifies the six primary cognitive skills originally introduced by Bloom
and adds nineteen sub-skills or cognitive processes. For example, when using the cognitive skill *evaluate*, one makes judgments based on criteria and standards; the sub-skill of checking (or coordinating, detecting, monitoring, testing) involves judgments about internal consistency and the sub-skill of critiquing (or judging) involves judgments based on external criteria. The table of this revised taxonomy provides a simple list of the ways in which we think. It is useful because it provides a structure for thinking about the cognitive process, as well as providing a language to discuss it with others. We include a more comprehensive list of cognitive skills in the appendix based on the work of Robert Swartz, Director of the National Center for Teaching Thinking (Swartz, 2001).

The other mode of thinking involves how we conduct ourselves in support of our thought or our personal behavior while thinking. It encompasses such dispositions as persistence, striving for accuracy, gathering data effectively, or thinking flexibly. How we behave while thinking is an important attribute of our thought process. Our behavior when working alone is different than when working as part of a team; it is different when we are gathering data than when we are thinking creatively. A good list of these behaviors is the “Habits of Mind” compiled by Arthur Costa and Bena Kallick. Costa and Kallick have studied the behavior patterns of successful people and distilled them into a set of 16 dispositions or habits (Costa, 2000). As educators, Costa and Kallick were motivated to offer guidance to teachers striving to provide their students with the best practices to achieve skillful thinking. Table 2 shows the Habits of Mind. Again this list describes the structure of conduct supporting thinking and provides a language to discuss it.

Thus, thinking is a careful examination of our mind to achieve a specific purpose. When thinking skillfully, we employ one or more of the cognitive tasks listed in Table 1 (or in the Appendix) and we conduct ourselves according to one of the Habits of Mind. Clearly, a skillful thinker is able to discriminate and make appropriate choices among these cognitive skills and behaviors.
What is Metacognition?

What then is metacognition – the thinking about one’s thinking? We introduce the following definition:

Metacognition is the conscious application of an individual’s thinking to their own thought processes with the specific intention of understanding, monitoring, evaluating and regulating those processes.

Metacognition is a conscious examination of one’s thinking; an individual needs to be aware that the focus of their thinking is on their own thought processes. The purpose of metacognition is for one or more of the four intentions listed in the definition.

These intentions represent increasingly more sophisticated stages of metacognition (Swartz, 2001). The first intention of metacognition is understanding which implies an awareness that one’s thinking is directed toward one’s own thought processes. The second intention, monitoring, is checking to see that the thinking is on the right track. This includes an awareness of the two modalities of thought – the type of thinking being used and the disposition of the thinker toward those thoughts and their consequences. Are the results of the thinking reasonable? Is the right type of thinking being used? Are appropriate habits of mind exercised? The third intention, evaluation, involves an assessment of how well the thinking is proceeding toward its objective. The final intention, regulation, involves adjusting the thought process to make sure the objective is attained and when the objective is attained, reviewing the thinking and modifying the thought process so that it will be even more effective the next time it is used.

Edward de Bono developed a metaphor for intelligence in order to dispel the myth that your “intelligence” limits how well you can think. As we know there are various kinds of cars, some are powerful like a Ferrari and others not so powerful like a Volkswagen. The way a particular car is driven depends not only on the power of the car but equally on the skill of the driver. An
experienced driver can maneuver a Volkswagen more skillfully than an inexperienced driver at the wheel of a Ferrari. Similarly there are various powers of the human brain. Your intelligence, de Bono says, is analogous to the power in a car; it may be a Ferrari or it may be a Volkswagen. However, its utility to you depends on how well you learn to “drive” it. According to de Bono “Thinking is the driving skill with which each individual drives his or her intelligence.” Like all metaphors, this one has flaws; human intelligence is not as static as a car’s power but, in fact, can be improved with conscious effort (deBono, 1994).

We can extend this metaphor by noting that you can be a driver of any car without knowing how that car works. However, your knowledge of how the car works can help you be a better driver. Developing your skill at thinking is like learning to be a driver who understands their car. Thinking about how you are thinking and controlling your brain is like incorporating your knowledge of how a car operates into your driving techniques. For example, a driver may be skilled at shifting gears manually under ordinary circumstances; however, understanding what happens physically when the gears are shifted can help decide how to shift in difficult terrain. Metacognition is like knowing how your brain works and incorporating that knowledge into how you think. It is particularly valuable when the “thinking terrain” gets rough – when faced with problems whose solutions are not immediately or easily discovered.

**What are the objects of Metacognition?**

So if metacognition is thinking about our own thinking, how do we go about it? First let us consider what we might be thinking about when we think about our own thinking. What does one think about when one ponders one’s thoughts?

We have seen that thinking – ordinary cognition – involves two modes, one relating to the cognitive skill being used and the other relating to our conduct in support of thinking. When we think about our thinking we can think about these two modes but in addition our thoughts can
also turn to the content of our thoughts. For example, if a student is thinking about a concept in Physics then she can think about how her brain is dealing with that concept using the language of Physics. In metacognition involving the content from an academic discipline one can think about one’s thoughts using the language of that discipline; metacognition about a sport uses the language of that sport. Thus, there are three general objects of metacognition 1) the content of our thoughts, 2) the cognitive skills being used and 3) our conduct in support of thinking. These are depicted in the Table 3 below and we will examine them individually.

The Content of Thought

When we think about our thinking we sometimes need to focus on the content of our thought; that is just what we are thinking about right now. It might be knowledge we already possess as we try to recall some specific information; it might be a concept we are trying to understand; it might be a problem we are trying to solve; it might be plans we are trying to formulate. We can think about our thoughts as we are thinking of them. The reason for metacognition about the content of our thought is to monitor our own understanding of concepts involved or to track the progress of thinking toward the objective of thought or to check for consistency with other knowledge.

The Cognitive Skill Being Used

Sometimes we may need to think about the cognitive skill being used; that is the type of thinking we are engaged in to achieve our goal. The objective of metacognition about the cognitive skill being used is to ensure that the right thinking skills are brought to bear on the problem at hand and to sharpen these skills for future use. We may also need to seek alternative means of reaching or justifying our conclusions.
Personal behavior supporting thinking

In addition to the thoughts running through one’s mind we may also reflect on specific behaviors supporting the thinking. How diligent is the thinker? Is the thinker using all available resources? The objective of metacognition about one’s behavior is to develop these behaviors into the habits of a successful thinker. Table 4 summarizes the objectives and intentions of metacognition.

Strategies for Incorporating Metacognition into Practice

A) In order to develop the ability to use metacognition effectively students need to understand it and be able to speak about it. Young children, even preschoolers, have demonstrated the ability to perform simple metacognitive tasks (Flavel, 1970; Butterfield, 1987). Furthermore, as they grow, children’s knowledge base increases and so does their ability to monitor that knowledge (Schneider, 1985). There is growing evidence that young children can learn metacognition and that this ability facilitates subsequent learning (Bransford, 2000).

For effective, lasting learning to take place students must also understand the levels of metacognitive thought. These levels were first introduced by David Perkins and Robert Swartz (Swartz, 2001). They correspond closely to the intentions of metacognition (as one grows in ability to think about thinking, one’s metacognition grows in sophistication). These require that metacognitive thinkers:

1) be aware of the kinds of thinking they are doing (Understand),
2) know the strategies they are using to do the thinking (Monitor),
3) reflectively evaluate the effectiveness of their thinking (Evaluate) and
4) plan how they would do some similar kind thinking in the future (Regulate).
B) Opportunities for metacognition can be interwoven into every lesson. One effective technique for this is Think Aloud Problem Solving (TAPS) (Costa, 2000) where students are invited to:

1) describe their plans and strategies for solving the problem.
2) share their thinking as they are implementing their plan.
3) reflect on/evaluate the effectiveness of their strategy.
4) plan the best strategy for the next similar thinking task.

Metacognition is engaged and sustained in teaching when the teacher (Costa, 2000):

- encourages students to check for accuracy by asking students questions such as “How do you know you are right?”
  “What other ways can you prove that you are correct?”

- creates opportunities for students to clarify –
  “Explain what you mean when you said ‘you just figured it out’.”
  “When you said you started at the beginning, how did you know where to begin?”

- provides data not answers when students are on the wrong track or confused –
  “I think you heard it wrong; let me repeat the question.”
  “You need to check your observations or data”

- resists making judgments –
  “So, your hypothesis is ……?”
  “Who has a different thought?”

- makes sure students stay focused on thinking –
  “Tell us what strategies you used to solve that problem”
• encourages persistence –
  “I know you can do this. Let’s try another approach.”

C) The language of metacognition should be used to make the thinking involved in learning experiences more explicit. Instead of saying “Let’s look at these pictures.”, make the cognitive task involved explicit by saying “Let’s compare these pictures.” Instead of “What will happen if ...”, say “Let’s predict what will happen if ...” Similarly, make the behavioral aspects of Habits of Mind clear; for example by saying “As we begin to discuss our work so far let’s remember to listen to each other with empathy and understanding.”

D) It is not enough to tell students that “Today we will be comparing and contrasting.” We cannot assume that students know how to carry out the cognitive tasks if we have not taught them how. Time must be set aside to explicitly teach the skill using the content of the curriculum. Students need to understand and use the sub-skills that make up each of these cognitive tasks at level appropriate to their stage of development.

Similarly, it is not enough to tell students they should be persistent without also telling them how. Persistence is not about repeatedly banging one’s head against the wall. It requires having a range of different strategies to fall back on when the first one doesn’t work. It involves being able to change one’s point of view and look at problem from a different angle. Persistent people are aware of the range of resources available to them and they know how to make use of them. Students need to learn the sub-skills that make persistence and the other Habits of Mind possible.

E) Use metacognition in planning lessons. A simple way to integrate metacognitive exercises into existing curricula is to make sure that the start of every lesson includes a description of what content, cognition and conduct will be emphasized in the lesson. It is a common practice to spell out the content of the lesson, “Today we will review two physical characteristics of an object, its mass and volume, and then introduce the concept of density.” It is probably less common practice to describe the cognitive skills involved in the lesson. “When we do our work today we
will classify various objects by comparing and contrasting their properties and then predict their density.” This can be followed by a description of the conduct that will be useful to use during the work. “We will be working in teams so that working interdependently and thinking and communicating with accuracy and precision will be important”.

Appendix – A more comprehensive list of types of thinking

In this appendix we present a more comprehensive list of the types of thinking in Table A-1. This list is organized in three levels of cognitive abstraction. The first level involves acquiring and processing ideas, the second level entails evaluating ideas and the third level is metacognition. Within each level there are cognitive processes – thinking tools that students need to become skillful at using. These levels of abstraction describe an order of sophistication of thinking and not an order of application. In other words, when one is using a first order abstraction process, say sequencing, one may also utilize a third order abstraction by reflecting on how the sequencing is proceeding. In fact, as (Bransford, 2001) recommends, it is much more effective for students to be thinking of how they think.
Bibliography


(de Bono,1994) E. deBono, Thinking Course”, Barnes and Noble, New York.


# Table 1

## A Revision of Bloom’s Taxonomy

from (Mayer, 2000)

<table>
<thead>
<tr>
<th>Cognitive Skill</th>
<th>Description</th>
<th>Cognitive Sub-Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Remember</strong></td>
<td>retrieve relevant knowledge from long-term memory</td>
<td>Recognizing, Recalling</td>
</tr>
<tr>
<td><strong>Understand</strong></td>
<td>construct meaning, build connections between prior knowledge and new knowledge, integrating new knowledge with existing schemas and cognitive frameworks.</td>
<td>Interpreting, Exemplifying, Classifying, Summarizing, Inferring, Comparing, Explaining</td>
</tr>
<tr>
<td><strong>Apply</strong></td>
<td>use procedures to perform exercises or solve problems (use procedural knowledge)</td>
<td>Executing, Implementing</td>
</tr>
<tr>
<td><strong>Analyze</strong></td>
<td>breaking information into its constituent parts, determining how the parts are related to each other and to an overall structure.</td>
<td>Differentiating, Organizing, Attributing</td>
</tr>
<tr>
<td><strong>Evaluate</strong></td>
<td>make judgments based on criteria and standards</td>
<td>Checking, Critiquing</td>
</tr>
<tr>
<td><strong>Create</strong></td>
<td>reorganize elements into a new pattern or structure</td>
<td>Generating, Planning, Producing</td>
</tr>
</tbody>
</table>
### Table 2.
**Habits of Mind**

<table>
<thead>
<tr>
<th>Personal Traits</th>
<th>Acquiring Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Persisting</td>
<td>Gathering data through all senses</td>
</tr>
<tr>
<td>Managing impulsivity</td>
<td>Listening with understanding and empathy</td>
</tr>
<tr>
<td>Striving for accuracy</td>
<td>Questioning and posing problems</td>
</tr>
<tr>
<td>Finding humor</td>
<td>Remaining open to continuous learning</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Thinking Tools</th>
<th>Response to Thought</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thinking flexibly</td>
<td>Creating, imagining, innovating</td>
</tr>
<tr>
<td>Thinking and communicating with clarity and precision</td>
<td>Responding with wonderment and awe</td>
</tr>
<tr>
<td>Thinking interdependently</td>
<td>Thinking about thinking (metacognition)</td>
</tr>
<tr>
<td>Applying past knowledge to new situations</td>
<td>Taking responsible risks</td>
</tr>
</tbody>
</table>
## Table 3
### Objects of Metacognition

<table>
<thead>
<tr>
<th>Objects of Metacognition</th>
<th>Objectives (reasons to meta-cogitate)</th>
<th>Language</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Content</strong> – what one is thinking about</td>
<td>to monitor understanding of concepts or track progress in problem solving or formulating plans</td>
<td>Discipline</td>
</tr>
<tr>
<td><strong>Cognition</strong> – type of thinking being used</td>
<td>to achieve the objective of one’s thinking and to sharpen thinking skills</td>
<td>Types of thinking</td>
</tr>
<tr>
<td><strong>Conduct</strong> – personal behavior supporting thinking</td>
<td>to develop the habits of a successful thinker</td>
<td>Habits of Mind</td>
</tr>
</tbody>
</table>
Table 4.
The Metacognitive Process

<table>
<thead>
<tr>
<th>Objects of Metacognition</th>
<th>Intentions of Metacognition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content of the Thought</td>
<td>Do I recognize that I am thinking about my thinking? Am I able to check the reasonableness of my ideas and the progress of my thinking? Do I understand well enough? Is the result correct and consistent with my other knowledge? Can I now use this knowledge flexibly? Can I now act on this knowledge? If not what need I do?</td>
</tr>
<tr>
<td>Types of Thinking Being Used</td>
<td>Do I recognize the type of thinking I am using? Am I using the right mix of my thinking skills? Am I using these skills effectively enough? Did I use this skill well? Can I improve on my thinking the next time I use these skills?</td>
</tr>
<tr>
<td>Personal Behavior Supporting Thinking</td>
<td>Do I recognize the behaviors that contribute to the success or failure of my thought and its consequences? Am I using the right habits of mind? What other behavior should I bring to bear? Am I using these habits well enough to achieve my objectives? In future, when facing similar problems how might I behave?</td>
</tr>
</tbody>
</table>
## Table A-1. Levels of Cognitive Abstraction
Adapted from the work of Arthur Costa and Bena Kallick, developers of “Habits of Mind” and Robert Swartz, Director of the National Center for Teaching Thinking

### First Order Abstraction
**Processing Ideas**

1. Treating facts or ideas as independent entities
   - remembering
   - accumulating facts
   - generating new ideas

2. Simple analysis of collections of facts or ideas
   - classify
   - sequence
   - compare/contrast
   - analogy/metaphor
   - parts/whole reasoning
   - reacting to intellectual input

3. More complex analysis
   - inference
     - causal reasoning
     - generalization
     - prediction
     - analogical reasoning
   - summarizing
   - deduction
     - conditional (if ... then)
     - categorical (some ... all)
   - induction

4. Complex cognitive tasks (systematic thinking)
   - decision making
   - planning
   - calculating
   - problem solving
     - making assumptions or order of magnitude
     - estimates
   - speculating (What happens if ...?)
   - modeling and simulation

### Second Order Abstraction
**Evaluating Ideas**

1. Assessing the reasonableness of ideas
   - assessing the reliability of information
   - accuracy of observation
   - reliability of sources

2. Evaluating the utility of ideas

3. Testing conclusions with reality
   - uncovering and evaluating assumptions
   - hypothesis and testing
   - identifying reasons and conclusions

4. Reformulating ideas based upon assessment

5. Evaluation of the human element in thinking
   - with others
     - consensus
     - argumentation
   - with self – intuition
     - personal feelings
     - affective domain
   - (emotions)

### Third Order Abstraction
**Metacognition**

1. **Understand** -- Being aware of the kind of thinking you are doing.

2. **Monitor** -- Knowing the thinking strategy you are using.

3. **Evaluate** -- Evaluating the effectiveness of your thinking.

4. **Regulate** -- Planning how you will do the same kind of thinking the next time it is needed.

6. Self-directed inquiry
   - curiosity based learning