Ignite Student Intellect and Imagination in Science

Sandra L. Schurr and Kathy L. LaMorte

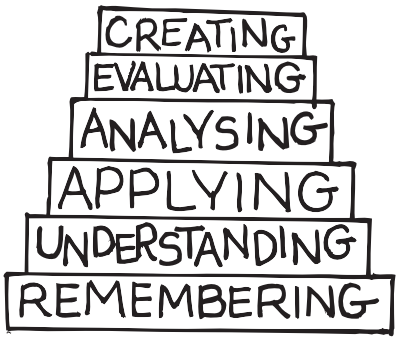
Hawker Brownlow
EDUCATION

Contents

Introduction: Discover Bloom's Revised Taxonomy

Discover Bloom's Revised Taxonomy—and how its use will ignite students' intellect and imagination in mastering the skills and concepts required to meet educational standards.

In the 1950s, Benjamin Bloom and his colleagues at the University of Chicago created the Taxonomy of Educational Objectives as a tool for identifying, classifying and qualitatively expressing different kinds of thinking. For decades, it has been one of the most universally applied models across all levels of schooling and in all areas of study. Interestingly, Bloom's Taxonomy has been translated into 22 languages and is one of the most often cited references in the history of education.



During the late 1990s, a former student of Benjamin Bloom, Lorin Anderson, working with one of his partners in the original work on cognition, David Krathwohl, headed a team of cognitive psychologists to re-examine and update the taxonomy for the emerging 21st century. As a result of their work, a number of significant improvements were made, which included changes in terminology, changes in structure and changes in emphasis. Let's look at each of these changes in more detail.

Changes in terminology

The original taxonomy of 1956 had six levels of thinking arranged in a hierarchy and stated as nouns. These were, in order from lowest level to highest level: *knowledge, comprehension, application, analysis, synthesis* and *evaluation*. In the revised 2000 Taxonomy by Anderson and Krathwohl, there are still six levels but both the names and the order differ from the original. The names of each level are now "ing" verbs rather than nouns, because thinking is an active process. Likewise, knowledge was replaced with the word *remembering*, comprehension with the word *understanding* and synthesis with the word *creating,* to better reflect the nature of the thinking defined in each category.

Changes in structure

Anderson and Krathwohl made two structural changes to the original Bloom's Taxonomy. The order of synthesis (creating) and evaluation (evaluating) has been reversed, because today scholars feel that if the taxonomy is indeed a hierarchy reflecting increasing complexity, then creative thinking is a more complex form of thought than critical or evaluative thinking. In short, one can be critical without being creative, but creative thinking often requires a form of critical thinking through the process of accepting and rejecting ideas as part of the creative process.

Another major structural change to the one-dimensional Bloom's Taxonomy was to add a second dimension in the Anderson/Krathwohl model that identifies and describes the various forms of *knowledge: factual, conceptual, procedural* and *metacognitive*. The chart below illustrates the new two-dimensional model.

The Cognitive Process Dimension

The Knowledge Dimension	Remembering	Understanding	Applying	Analysing	Evaluating	Creating
Factual Knowledge						
Conceptual Knowledge						
Procedural Knowledge						
Metacognitive Knowledge						

Changes in emphasis

The revised taxonomy is more universal today because it is easily applicable at primary, secondary and even tertiary levels. The revision emphasises explanation and description of subcategories for each of the six levels as follows: *remembering*, with subcategories of recognising and recalling; *understanding*, with subcategories of interpreting, exemplifying, classifying, summarising, inferring, comparing and explaining; *applying*, with subcategories of executing and implementing; analysing, with subcategories of differentiating, organising and attributing; *evaluating*, with subcategories of checking and critiquing; and *creating*, with subcategories of generating, planning and producing.

In essence, the revision emphasises explanation and description of subcategories through the selection of appropriate verbs, questions and tasks that are used within each level itself. These verbs or behaviours, along with the context of the assigned activities, can be classified as one of the four dimensions of knowledge and as belonging to one of the above subcategories if the teacher so desires.

It should be noted that Bloom's Revised Taxonomy, like the original version, is a useful tool for curriculum planning, instructional delivery and assessment because it ensures that learning will go beyond the mere acquisition of information. In the United States, testing now correlates with subject-area standards that use the revised taxonomy as a primary model for designing specific items in middle years reading, mathematics, science and humanities tests. In fact, 50 per cent of the test items for Year 6, 60 per cent of test items for Year 7 and 70 per cent of test items for Year 8 students focus on the taxonomy's four higher-order thinking skill levels: *applying, analysing, evaluating* and *creating*. Using the revised taxonomy as an organising structure while teaching skills and content in all of the major subject areas is a sound way to help ensure student success.

On pages 5 and 6, the Six Levels of Learning in the Revised Taxonomy are defined with a list of the most common verbs or behaviours assigned to each level. These two pages should be photocopied and distributed to all students as ready reminders about the types of tasks and thinking that are required as they move from one level of learning to the next. In addition, an enlarged copy of these pages might well be made into a poster for permanent display in the classroom where they will serve as a visible reminder for both students and teachers of the need to always take learning to the higher levels.

Part I—Bloom Sheets

The Bloom Sheets, single pages that contain an activity at each level of learning, are organised in eight sections. Each section includes a number of Bloom Sheets that address and describe what teachers of science at all year levels should know and be able to do. Interestingly, the broad categories of science standards are essentially the same for P–12;

but the individual topics, terms or vocabulary, concepts, procedures, scientific questions or problems, processes and experiments are specific to primary or secondary school science courses. The Bloom Sheets included here are specifically designed to cover general science instruction in Years 6–8.

It is important to recognise that all of the Bloom Sheets in this book reflect the 2000 Revised Taxonomy of Cognitive Levels. Each Bloom Sheet incorporates the terminology changes, the structural changes and the emphasis changes suggested by Anderson and Krathwohl. One will also find the four forms of knowledge (factual, conceptual, procedural and metacognitive) and the subcategories for each of the six levels (*remembering, understanding, applying, analysing, evaluating* and *creating*) embedded in the set of tasks or questions outlined on the Bloom Sheets themselves. For example, if one were to chart the first Bloom Sheet in this book on the Cognitive Dimension Chart, the result would be as follows:

Aids in Understanding Scientific Terms
The Cognitive Process Dimension

The Knowledge Dimension	Remembering	Understanding	Applying	Analysing	Evaluating	Creating
Factual Knowledge	X		X			X
Conceptual Knowledge	X	X	X	X		
Procedural Knowledge						X
Metacognitive Knowledge		X		X	X	

The Bloom Sheets have proven to be very popular with teachers because they

- Include both lower and higher levels of thinking skills.
- Present the information and assigned tasks in a straightforward manner.
- Are a built-in tool for differentiating instruction.

The layout and design of the Bloom Sheets are the result of considerable experimentation with middle years students. The typeface selected and the hand-created graphics by Kathy LaMorte have been demonstrated to immediately attract students and engage them in a positive way.

Classroom teachers by the hundreds have been delighted with the Bloom Sheets because they can be used in so many ways. They can be the basis for independent study assignments, classroom work by individuals or small groups, or out-of-school assignments that students can complete with the active involvement of their parents. They can also be used as the organising structure for learning stations, a multidisciplinary unit or a research paper, or as special assignments or enrichment tasks.

Part I contains 76 Bloom Sheets organised in groups that relate to standards for science.

Part II—Imaginative Assessment Options and Real-Life Applications.

This section is chock-full of interesting ideas that will motivate students and lead to their mastering various concepts. First, there are four lists of ways to assess learning in science. These lists offer ideas for including artefacts in students' portfolios, creating products, putting on performances and conducting research on various topics, all related to science. There are enough possibilities here to whet students' imaginations and get them actively involved in demonstrating their learning in ways other than a paper-and-pencil test.

The eight real-life applications that follow offer action-oriented investigations in ways science applies to real life. Individuals or small groups could complete these, but any way they are used will bring relevance to science.

Part III—More Instructional Tools and Techniques.

The last section contains a potpourri of suggestions for ways to enhance the teaching of science in the middle years classroom. It starts off with "Ten Smart Ways to Use Bloom's Taxonomy in the Science Classroom", which is a goldmine of great ideas. The other lists provide more imaginative tools and techniques, which will bring new life and vigour to science classes.

Take time in the beginning to get acquainted with the abundant and rich resources found in these pages. Browse and sample a bit to discover the wealth of engaging ideas contained in this book. You will recognise that this is a resource you will turn to time after time as you help youngsters understand and enjoy the world of science. The book's spiral binding makes the Bloom Sheets and other reproducible materials easy to copy.

Bloom's Revised Taxonomy

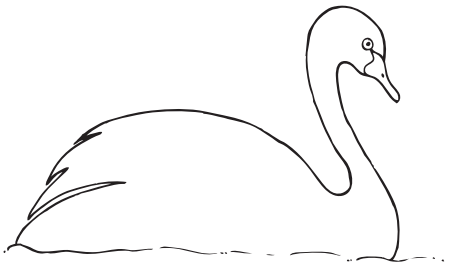
Essential Levels of Learning	Most Common Verbs or Behaviours at This Level
1. Remembering Retrieving, recognising and recalling relevant knowledge from long-term memory. This level focuses on the act of remembering when memory is used to produce definitions, facts or lists, and on the act of reciting or retrieving material.	*choose, count, define, distinguish, draw, find, know, label, list, locate, match, memorise, name, pick, point, read, recall, recite, recognise, record, reproduce, select, state, trace, underline*
2. Understanding Constructing meaning from oral, written and graphic messages through interpreting, exemplifying, classifying, summarising, inferring, comparing and explaining. This level emphasises one's ability to understand uses and implications of terms, facts, methods, procedures and concepts.	*associate, classify, conclude, demonstrate, describe, determine, differentiate, expand, explain, extend, find, generalise, give examples, give in own words, illustrate, interpret, measure, paraphrase, prepare, recognise, reorder, restate, retell, reword, rewrite, show, suggest, summarise, translate*
3. Applying Carrying out or using a procedure through executing or implementing. This level refers to new situations where one makes use of learned material through products like models, presentations, interviews or simulations.	*apply, calculate, carry out, collect information, complete, compute, construct, convert, demonstrate, derive, develop, discover, discuss, dramatise, employ, examine, execute, experiment, find, graph, illustrate, implement, interpret, interview, investigate, locate, make, model, operate, organise, perform, plan, prepare, present, produce, prove, record, relate, schedule, show, sketch, solve, use, write*

4. Analysing Breaking material or concepts into constituent parts, determining how the parts relate or interrelate to one another or to an overall structure through differentiating, organising and attributing. This level encourages one to analyse structure, recognise assumptions and poor logic, and evaluate relevancy by creating spreadsheets, surveys, charts, diagrams, or other graphic representations.	*analyse, appraise, attribute, categorise, compare, contrast, criticise, debate, deconstruct, deduce, diagram, differentiate, discover, discriminate, distinguish, divide, draw conclusions, examine, experiment, find coherence, focus, form generalisations, group, implement, infer, integrate, organise, outline, point out, question, relate, sort, structure, subdivide, survey, take apart, test, uncover*
5. Evaluating Making judgments based on criteria and standards through checking and critiquing. This level involves the act of setting standards, judging or using standards, producing evidence, and accepting or rejecting evidence on the basis of sound criteria through products such as critiques, recommendations and reports.	*appraise, argue, assess, award, check, choose, consider, critique, defend, detect, discriminate, evaluate, hypothesise, judge, justify, measure, rank, rate, recommend, support, test, validate, value, verify*
6. Creating Putting elements together to form a coherent or functional whole; reorganising elements into a new pattern or structure through generating, planning or producing. This level requires users to put parts together in a new way or synthesise parts into something different, resulting in a unique form, original product, functional whole, or coherent work such as a speech, experiment, essay or drama.	*arrange, assemble, build, combine, compose, construct, create, derive, design, develop, devise, formulate, generate, hypothesise, imagine, integrate, invent, make up, organise, originate, perform, plan, prepare, present, produce, propose, rearrange, revise, rewrite, synthesise, write*

THE AMAZING ANIMAL WORLD

REMEMBERING

Identify an animal that goes with each of these family names: herd, flock, pack, brood, mob, pride, gaggle, swarm, pod and ballet.



UNDERSTANDING

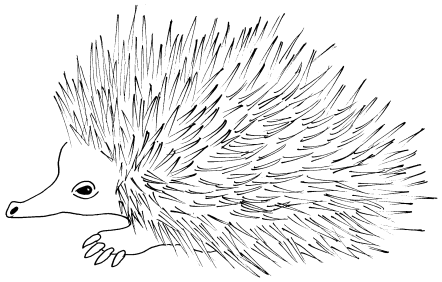
Describe each of these unusual creatures with misleading common names: tawny frogmouth, killer whale, galliwasp, glass snake, mudpuppy, roach, sandfish, seahorse, and slowworm. Keep in mind that they are very different creatures than their names would indicate. Why do you think this is true?

APPLYING

In the animal world there are a wide variety of survival techniques, including the ability to "play possum". Research one or more of the following animals who, like the possum, plays dead when in trouble. Consider: echidna, grass snake, bullfrog and rabbits.

ANALYSING

Distinguish between these two true hibernators who adapt to the shortage of food and low temperatures in winter by lowering their body temperature to near freezing and entering a near comatose state—the bat and the echidna.



EVALUATING

Determine which of the following creatures is most ingenious when it comes to using their special adaptations or behaviours in creative ways to survive: Koalas, kangaroos, possums, octopuses and spiders.

CREATING

Invent a new animal creature that blends in with its surroundings using a form of protective colouring that helps it survive as a species.

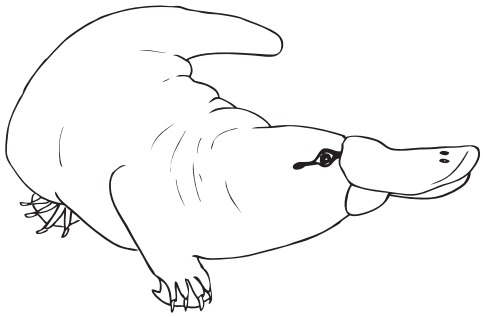
ENDANGERED SPECIES OF THE WORLD

REMEMBERING

Make a list of endangered species and their primary locations in the world.

UNDERSTANDING

Describe the characteristics that are commonly associated with those creatures that are most in danger of becoming extinct.



APPLYING

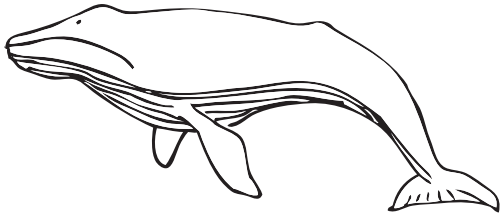
Research some of the various organisations and agencies that are aiding the effort to save endangered species. Record information about your findings.

ANALYSING

Determine the importance and effectiveness of current laws and penalties that have been passed to help eliminate the problem of endangered species.

EVALUATING

Assume the role of someone who is putting an animal or bird on the endangered species list. Defend your reasoning and include detailed information about this creature's current situation.



CREATING

Design a series of commemorative stamps highlighting those endangered species you find most interesting.