Taxonomies of Educational Objectives[1]

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Introduction

Learning involves acquiring knowledge, skills, attitudes, values, beliefs and behaviours. Learning can be deep (Marton and Saljo 1976) and sustainable - remembered long after and appropriately applied to various situations to solve problems, construct new hypotheses, create new principles and products. Learning can be superficial and fragile - forgotten as soon as its immediate purpose has been fulfilled. Deep and superficial learning indicates that human learning can happen at multiple levels.

Since human learning happens at multiple levels, some classification is helpful. In the 1950s, a committee headed by Prof Benjamin S. Bloom of Chicago University (USA) pioneered the classification of learning into three domains - cognitive, affective and psychomotor. The Committee further classified different levels of learning within each domain; and probably, for the first time, used the word 'Taxonomy'[3] in education. The report of the Bloom Committee, *Taxonomy of Educational Objectives: The Classification of Educational Goals,* published in 1956, brought this new term into the lexicon of education.

Several other scholars later enriched the classification of human learning into a structured hierarchy. In this Learning Resource (LR), we will provide an overview of Bloom's and Revised Bloom's Taxonomy Gagne's Hierarchy of Learning, David Merrill's Component Display Theory, and Biggs and Collis' SOLO Taxonomy. Before I conclude, I shall briefly explain (Mukhopadhyay's) eclectic model - classifying educational objectives and creating a logical synthesis of taxonomy-related learning.

Learning Outcomes

On completion of this chapter, you will be able to:

a. Recall and state various taxonomies of educational objectives.
b. Explain Gagne's, Merrill's, and Biggs and Collis' classification of educational objectives.
c. Explain Bloom's original and revised taxonomy of educational objectives.
d. Compare and contrast Bloom's original and revised taxonomies of educational objectives.
e. Compare and contrast Bloom's revised taxonomy with Merrill's, Biggs and Collis' and Mukhopadhyay's taxonomies.
f. Critically analyse the implications of taxonomies of educational objectives for improving students learning outcomes.
g. Formulate learning outcomes at different levels of cognition.

[2] This learning resource is an abridged version of Chapter 5 Taxonomies of Educational Objectives in author's book, Educational Technology for Teachers: Technology Enabled Education published in 2022.

[3] Taxonomy is the science of classification. Taxonomy originated in biological sciences and was born out of the need to classify living organisms - animals and plants. The taxonomy then became popular as a useful way to organize information.

Gagne's Learning Hierarchy[4]

The Learning Hierarchy is associated with levels of learning outcomes. Robert Gagne's taxonomy comprises five categories of learning outcomes: verbal information, intellectual skills, cognitive strategies, attitudes and motor skills. Intellectual skills are further subdivided into stimulus recognition, response generation, procedure following, terminology, discrimination, concrete and defined concepts and rules[5].

Gagne's taxonomy is based on the assumptions of information processing under external and internal learning conditions. Internal conditions are the learner's previous knowledge and previously learned capabilities, and external conditions are new knowledge, either presented to the learner or discovered by the learner. Gagne further defined eight instructional events linked to different levels of learning (Figure 1)

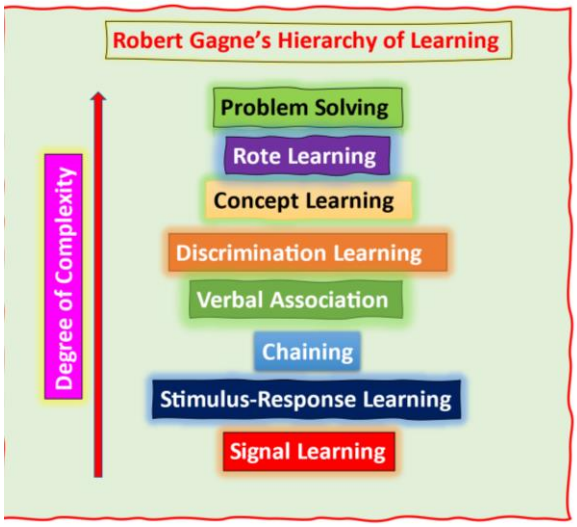

Figure 1. Gagne's Hierarchy of Learning
Source: Authors

1. **Signal learning** is the simplest form of learning derived from Pavlovian classical conditioning. By combining the sound of a bell preceding the food, Pavlov's dog learnt that sound precedes food. It started salivating at the sound of the bell. The learner learns to respond to an unrelated stimulus. Signal learning is derived from the behaviourist school of learning. The cognitivist school of psychologists do not see its relevance in human learning.
2. **Stimulus-response learning** is a more sophisticated form of conditioning. The sequence of events is stimulus-response-feedback. A well-planned scheme of reinforcement follows the acceptable response to a stimulus. This sequence follows the simple reward-punishment principle. The desirable behaviour gets strengthened with reward, and undesirable behaviour gets weakened with negative reinforcement or punishment. This is derived from the behaviourist, B. F. Skinner's Operant Conditioning.
3. **Chaining** is when a learner can connect two or more previously learnt stimulus-response bonds in the form of a chain. A 'chained' sequence is based on task analysis where each task is related to the following Action. It is commonly exemplified in certain forms of psychomotor activities like

[4] https://twurobertgagne.weebly.com/eight-conditions-of-learning.html

[5] https://www2.le.ac.uk/departments/doctoralcollege/training/eresources/teaching/theories/gagne

cycling, playing a musical instrument, or washing hands. For instance, washing hands comprises opening the faucet, wetting the hands, picking up the soap, rubbing it on the hand, rinsing with water, and mopping with the towel. Although each activity is separately identifiable, the activity is completed together with a chain of actions.

4. **Verbal association** is another kind of chaining where a learner connects two items through words or language. It is essential for developing language skills. It's often used in memorising technical terms and their meanings, pieces of prose and poetry and other similar activities.
5. **Discrimination learning** is the ability to differentiate between similar stimuli and respond differently to different stimuli. Discrimination learning is more complex due to the possibility of learning interference – one learning may interfere with another. This interference leads to conflict and confusion and may even cause to forget.
6. **Concept learning** is indicated by providing a consistent response to a series of stimuli that have certain similarities, though not the same, but also have opportunities for divergences. The learners learn to interpret the nature of the stimuli and consistently formulate their responses.
7. **Rule learning,** according to Gagne, "is a very high-level cognitive process that learns to relate and apply concepts to different situations, including situations not previously encountered"[6]. This process is the basis of learning rules and procedures.
8. **Problem-solving** is the ability to solve problems by applying previously-learnt concepts and rules. This also implies extending the skill of solving problems in unfamiliar situations by inventing new ways using the algorithm and rule learning.

Gagne proposed these eight stages of learning spanning from simple classical conditioning to high levels of cognition for problem-solving in 1956, the same year Bloom's Taxonomy of Educational Objectives was published. Interestingly, the first three stages of Gagne's eight stages are associated with the behavioural school of learning, and the last five stages are linked with the cognitivist school of learning.

David Merrill's Component Display Theory (CDT)

David Merrill offered a two-dimensional matrix model in his Component Display Theory (1983). The horizontal axis is about the types of content, namely, facts, concepts, procedures and principles. On the vertical axis are the performance (cognition) levels comprising remember, use, and find. Content and performance levels have been classified from easier to complex learning (Figure 2).

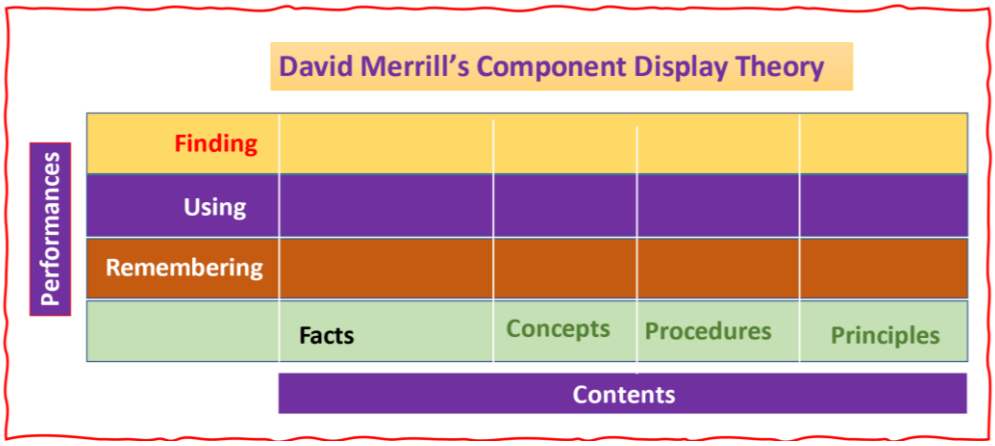

Figure 2. Merrill's Component Display Theory
Source: Author

[6] Gagne's hierarchy of learning, Robert Gordon University, Aberdeen, http://www2.rgu.ac.uk/celt/pgcerttlt/how/how4a.htm

For example, remembering facts, concepts, procedures, and principles is easier than using the facts, concepts, procedures and principles appropriately at the right time and on the right occasion. It is still more difficult to find a trend from the information set and derive new implications for generalisation[7].

The theory also identifies four primary forms of presentation, namely, Rules, Examples, Recall, and Practice: and some secondary presentation forms, like Prerequisites, Objectives, Helps, Mnemonics and Feedback[8].

Biggs and Collis' SOLO Taxonomy

John Biggs and Kevin Collis described SOLO Taxonomy in their book, *Evaluating Quality of Learning in 1982*. SOLO stands for **S**tructure of the **O**bserved **L**earning **O**utcomes. The emphasis is on learning outcome that is observable or verifiable. This relates to the evaluation of learning.

According to Biggs, "As learning progresses, it becomes more complex. SOLO ….. is a means of classifying learning outcomes in terms of their complexity, enabling us to assess students' work in terms of its *quality, not* how many bits of this and of that they have got right. Initially, a learner picks up only a few aspects of a task (uni-structural) and then several unrelated aspects (multi-structural). Then, the learner learns how to integrate them into a whole (relational), and finally, the learner can generalise that whole to untaught applications (*extended abstract*). The diagram lists verbs typical of each such level."[9] Biggs presented SOLO through the following visuals (Figure 3).

The common features of taxonomy start with simpler pre-structural elements and then move through uni-structural, multi-structural, relational finally onto complex extended abstraction. Easier forms of learning that occur at the lower end are surface learning or fragile learning. Higher levels of rational and extended abstraction are sustainable and create deep learning.

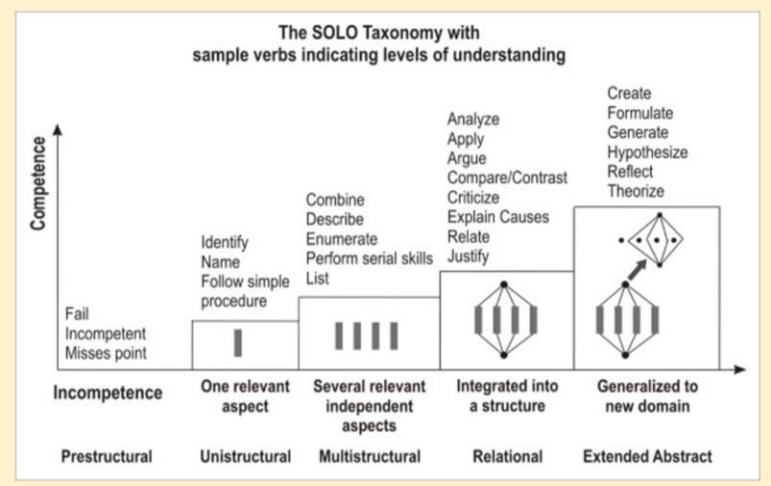

Figure 3. Biggs and Collis' SOLO Taxonomy
Source: John Biggs at https://www.johnbiggs.com.au/wp-ontent/uploads/2013/01/solo_taxonomy.jpg

[7] http://www.nwlink.com/~donclark/hrd/learning/id/component_display.html

[8] http://www.nwlink.com/~donclark/hrd/learning/id/component_display.html

[9] https://www.johnbiggs.com.au/academic/solo-taxonomy/

Simply,

- A learner may miss points and fail to learn at the pre-structural level.
- At the uni-structural level, the learner may pick up one or two aspects of the task without connecting with other variables operating within the system. For example, they may identify components, name them, and follow a simple procedure.
- At the multi-structural level, the learner picks up many more variables but continues to establish the relationships among the system elements. The action verbs indicating multi-structural learning are 'combine', 'describe', 'enumerate', 'list', 'perform serial skills.
- At the relational stage, learners can use their sense of algorithm to connect (relate) the bits and pieces of information collected at the previous levels. The evidence of relational learning is the learner's ability to 'analyse', 'apply', 'argue', 'compare', 'criticise', 'explain causes', 'relate' and 'justify'.
- The highest form of learning is extended abstraction, whereby learners can provide evidence of their learning through 'creating', 'formulating', 'generating hypotheses', 'reflecting and theorising'.

Biggs and Collis spelt out the indicative behaviour or evidence of learning with action verbs. Biggs and Collis' concept of action verb later found expression in Anderson and Krathwohl's Revised Bloom's Taxonomy.

In SOLO taxonomy, quality of learning has been mapped in a continuum from uni-structural to extended abstraction. But Biggs claims that the SOLO Taxonomic framework can also be used in 'designing the curriculum in terms of the level of learning outcomes intended, which helps implement the constructive alignment[10].' Thus, constructive alignment is an important concept implying the alignment of curriculum design with the learning outcome (Figure 4).

Figure 4. Constructive Alignment
Source: Author

Biggs and Collis's five levels of learning can be related to David Hunt's four levels of Cognitive Conceptual Complexity – low complexity (pre-structural and uni-structural), moderate complexity (multi-structural),

[10] "In constructive alignment, we start with the outcomes we intend students to learn and align teaching and assessment to those outcomes. The outcome statements contain a learning activity, a verb, that students need to perform to best achieve the outcome, such as "apply expectancy-value theory of motivation", or explaining the concept of …." That verb says what the relevant learning activities are that the students need to undertake to attain the intended learning outcome. Learning is constructed by what activities the students carry out; learning is about what they do, not about what we teachers do. Likewise, assessment is about how well they achieve the intended outcomes, not about how well they report back to us what we have told them or what they have read. The SOLO Taxonomy helps map levels of understanding that can be built into the intended learning outcomes and create the assessment criteria or rubrics. Constructive alignment can be used for individual courses, for degree programmes, and at the institutional level, for aligning all teaching to graduate attributes".
Source: John Biggs, Constructive Alignment, retrieved from https://www.johnbiggs.com.au/contact-me/

moderately high complexity (relational) and high complexity (extended abstraction) (Harvey, Hunt and Schroeder 1961).

Bloom's and Revised Bloom's Taxonomy

Bloom's Taxonomy is the contribution of the committee of educators comprising M. D. Engelhart, E. J. Furst, W.H. Hill, and D. R. Krathwohl chaired by Prof. Benjamin S. Bloom. The committee decided to name the taxonomy in the chairman's name[11]. Prof Bloom also edited the book, *Taxonomy of educational objectives: The classification of educational goals*. Vol. Handbook I: Cognitive domain published in 1956.

The derivation of Bloom's Taxonomy went through several iterations. A series of conferences were held from 1949 to 1953 to 'improve communication between educators on the design of curricula and examination'[12].

Initially, the Committee classified learning into three domains: cognitive, affective, and **psychomotor**. Learning activities that occur in the cognitive domain involve thinking, problem-solving etc. The affective domain deals with the emotive aspect of learning, while the psychomotor domain deals with 'physical skills in combination with psychological skills' (Figure 5).

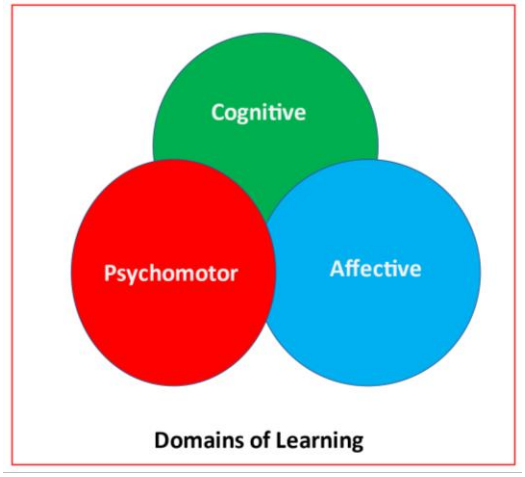

Figure 5. Three Domains of Learning
Source: Authors

Each domain was further elaborated into a set of learning outcomes arranged from simpler to more complex forms of learning (Table 1). Given the hierarchic learning organisation, the Bloom Committee termed it a Taxonomy.

[11] [https://en.wikipedia.org/wiki/Bloom%27s_taxonomy] accessed on 3 November, 2018.

[12] https://en.wikipedia.org/wiki/Bloom%2527s_taxonomy

Table 1. Components of Cognitive, Affective and Psychomotor Domains

	Cognitive	Affective	Psychomotor
Simple ↓ Complex	1. Knowledge 2. Comprehension 3. Application 4. Analysis 5. Synthesis 6. Evaluation	1. Receiving 2. Responding 3. Valuing 4. Organising 5. Characterising	1. Imitation 2. Manipulation 3. Precision 4. Articulation 5. Naturalising

Note: The Bloom Committee did not elaborate on the psychomotor domain. Later, R H Dave (1967), EJ Simpson (1972), A J Harrow (1972), and A Romiszowaski (1999) deconstructed the Psychomotor domain. Dave's classification was the simplest and the first one, given in the table above.

Bloom's cognitive domain taxonomy comprises six levels - knowledge, comprehension, application, analysis, synthesis, and evaluation - organised in a pyramidal structure from lower-order to higher-order objectives (figure 6).

Bloom's Revised Taxonomy

Bloom's taxonomy was revised by Anderson and Krathwohl and published in 2001. The revised taxonomy also comprises six levels, with some modifications. The revised terminologies are 'remember', 'understand', 'apply', 'analyse', 'evaluate', and 'create'. Also, it is a change from noun to action verbs. In the revised taxonomy, synthesis was removed; evaluation was placed at the fifth level and create at the highest level (Figure 6).

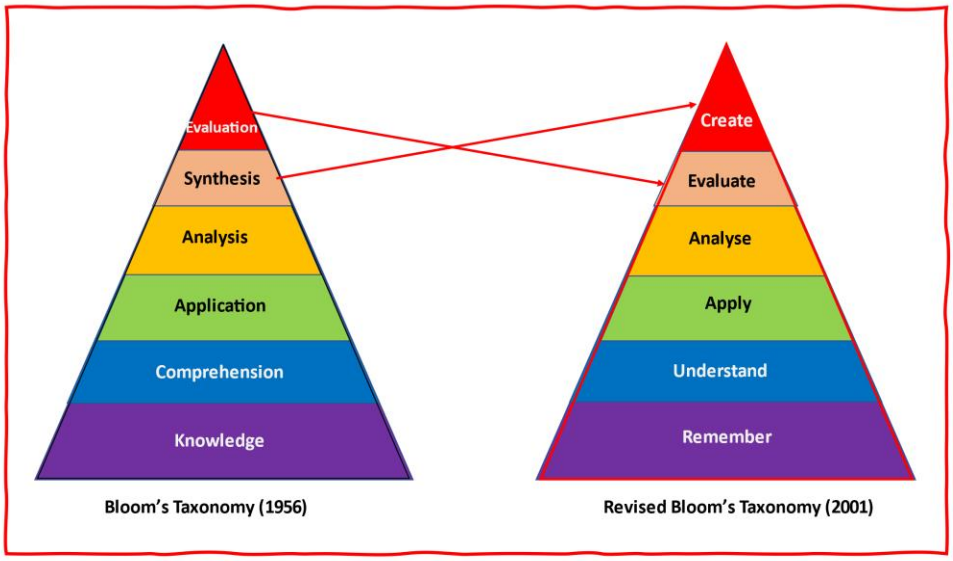

Figure 6. Comparative study of original and revised Bloom's Taxonomy
Source: Authors

The major change in the revised version is the addition of the Knowledge Dimension. The knowledge component has also been broken down into four levels - facts, concepts, procedures and Metacognition. Anderson and Krathwohl interpreted metacognition as strategic knowledge. Thus, the revised taxonomy provides an improved framework for understanding the cognitive processes in the context of knowledge (Figure 7).

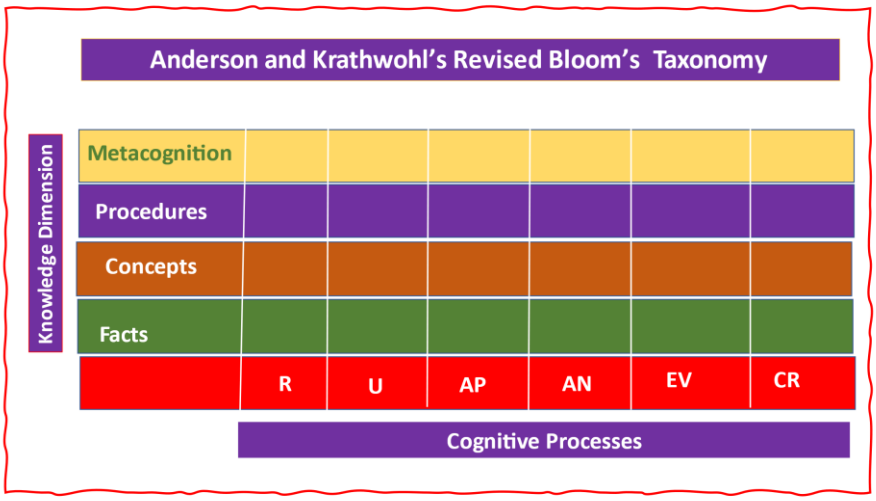

Figure 7. Revised Bloom's Taxonomy as proposed by Anderson and Krathwohl (2001)
Source: Author

David Merrill's Component Display Theory of 1983 pioneered the two-dimensional concept of a taxonomy of educational objectives. Merrill's influence and impact on the revised Bloom's taxonomy are visible in the conceptualisation and visual structuralising.

In the revised taxonomy, Anderson and Krathwohl (2001) created a "separate taxonomy of the types of knowledge used in cognition:

Factual Knowledge • Knowledge of terminology • Knowledge of specific details and elements	**Conceptual Knowledge** • Knowledge of classifications and categories • Knowledge of principles and generalisations • Knowledge of theories, models, and structures
Procedural Knowledge • Knowledge of subject-specific skills and algorithms • Knowledge of subject-specific techniques and methods • Knowledge of criteria for determining when to use appropriate procedures	**Metacognitive Knowledge** ▪ Strategic Knowledge • Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge • Self-knowledge" (Armstrong Undated)

Metacognition is "cognition about cognition", "thinking about thinking", "knowing about knowing", becoming "aware of one's awareness", and higher-order thinking skills. As metacognition implies cognition of cognition, it should naturally belong to the Cognitive Domain. Anderson and Krathwohl explained metacognition as strategic knowledge, self-knowledge, and classified under contents.

Action Verbs

Learning occurs through the covert process. The covert behaviour has to be evidenced by overt behaviour. That brings the ***Action Verbs*** into the discourse on the taxonomy of educational objectives. Action Verbs help achieve and evaluate the evidence of learning or learning outcomes. The concept of 'outcome' also figured in Bloom's Taxonomy. Educational objectives were recommended to be stated in terms of

behavioural *outcomes* of the learner. Anderson and Krathwohl (2001) provided a list of Action Verbs for the revised Bloom's Taxonomy (Appendix)[13].

Table 5.2. Revised Bloom's Taxonomy Action Verbs

Definitions	I. Remembering	II. Understanding	III. Applying	IV. Analysing	V. Evaluating	VI. Creating
Bloom's Definition	"Exhibit memory of previously learned material by recalling facts, terms, basic concepts, and answers".	"Demonstrate understanding of facts and ideas by organising, comparing, translating, interpreting, giving descriptions, and stating main ideas".	"Solve problems to new situations by applying acquired knowledge, facts, techniques and rules in a different way".	"Examine and break information into parts by identifying motives or causes. Make inferences and find evidence to support generalisations"	"Present and defend opinions by making judgments about information, validity of ideas, or quality of work based on a set of criteria".	"Compile information together in a different way by combining elements in a new pattern or proposing alternative solutions".
Verbs	• Choose • Define • Find • How • Label • List • Match • Name • Omit • Recall • Relate • Select • Show • Spell • Tell • What • When • Where • Which • Who • Why	• Classify • Compare • Contrast • Demonstrate • Explain • Extend • Illustrate • Infer • Interpret • Outline • Relate • Rephrase • Show • Summarise • Translate	• Apply • Build • Choose • Construct • Develop • Experiment with • Identify • Interview • Make use of • Model • Organise • Plan • Select • Solve • Utilise	• Analyse • Assume • Categorise • Classify • Compare • Conclusion • Contrast • Discover • Dissect • Distinguish • Divide • Examine • Function • Inference • Inspect • List • Motive • Relationships • Simplify • Survey • Take part in • Test for • Theme	• Agree • Appraise • Assess • Award • Choose • Compare • Conclude • Criteria • Criticise • Decide • Deduct • Defend • Determine • Disprove • Estimate • Evaluate • Explain • Importance • Influence • Interpret • Judge • Justify • Mark • Measure • Opinion • Perceive • Prioritise • Prove • Rate • Recommend • Rule on • Select • Support • Value	• Adapt • Build • Change • Choose • Combine • Compile • Compose • Construct • Create • Delete • Design • Develop • Discuss • Elaborate • Estimate • Formulate • Happen • Imagine • Improve • Invent • Makeup • Maximise • Minimise • Modify • Original • Originate • Plan • Predict • Propose • Solution • Solve • Suppose • Test • Theory

Source: Anderson, L.W.& Krathwohl, D.R. (2001).
Online Source: https://www.apu.edu/live_data/files/333/blooms_taxonomy_action_verbs.pdf

[13] ttps://ce.icep.wisc.edu/sites/default/files/Guidelines%20For%20Writing%20Learning%20Objectives%20v.%209-28-21.pdf

There are a few important features of the table.

- Firstly, each level of cognition is explained with descriptive statements.
- Secondly, each such descriptive statement is supported by a set of action verbs that can be used to frame the expected learning outcome. Depending upon the learning tasks and content, one has to choose a few action verbs from the extensive list provided by Anderson and Krathwohl. For example, Define, List, Identify, Recall, Recognise, etc., are for Remembering.
- It should be noticed that certain verbs appear under more than one level of cognition because these actions depict more than one level of cognition.

There are a few missing components:

a. The content classification has included facts, concepts and procedures in the revised taxonomy. Principles and theories still occupy a higher order in the content organisation hierarchy. The taxonomy of knowledge or content would logically be complete with the inclusion of principles and theories.
b. Generalisation or Extended Abstraction (SOLO) is the important higher-order cognition. This should find a place in the taxonomy – between Evaluate and 'Create'.
c. Further, since 'Create' should include even intuitive thinking, logically, there should be a pre-create stage, e.g. 'Construct'.

The taxonomy of educational objectives have been equated with Bloom's and revised Bloom's taxonomy. The teachers miss out on the significant contributions by David Merrill, Robert Gagne, Biggs and Collis (SOLO Taxonomy) and David Hunt (Conceptual Complexity). There are serious implications of the other taxonomies. For example, extended abstraction or generalisation of SOLO Taxonomy is an important higher-order cognition[14]. David Hunt's simple to complex conceptual complexity strengthens Biggs and Collis' proposition of cognition from uni-structural to extended abstraction via relational and multi-structural levels. There is a scope for constructing an Eclectic taxonomy of educational objectives by bridging the cognitive and content hierarchy gaps.

Eclectic Model of Taxonomy of Educational Objectives

This eclectic model is not an alternative or another taxonomy. It draws the best of all the taxonomies to make a more comprehensive taxonomy of educational objectives. The Eclectic Taxonomy includes constructing and generalising (Extended Abstraction of SOLO taxonomy); and 'principles' from David Merrill's CDT. Further, research on creativity indicates that there are several layers of creativity. Creativity itself spreads over a range of lower to higher-order activities.

Drawing the best from all the taxonomies, an Eclectic Taxonomy can be constructed (Figure 9).

[14] In 2001, I tried to project demand for secondary education based on the primary schooling data and transition rates warning that India does not have enough capacity to accommodate the demand for secondary education with the success of primary schooling. Government of India, Ministry of Human Resource Development constituted a committee of the Central Advisory Board of Education to recommend on Universalization of Secondary Education. The CABE Committee was provided copy of my paper. I was invited by the CABE Committee to chair the subcommittee for Universalization of Secondary Education. This policy document led to the formulation of a Centrally Sponsored Scheme, National Mission on Secondary Education (Rashtriya Madhyamik Shiksha Abhiyan- RMSA). https://www.educationforallinindia.com/universalisation%20of%20secondary%20education%20report%20of%20CABE%20Commuitee.pdf

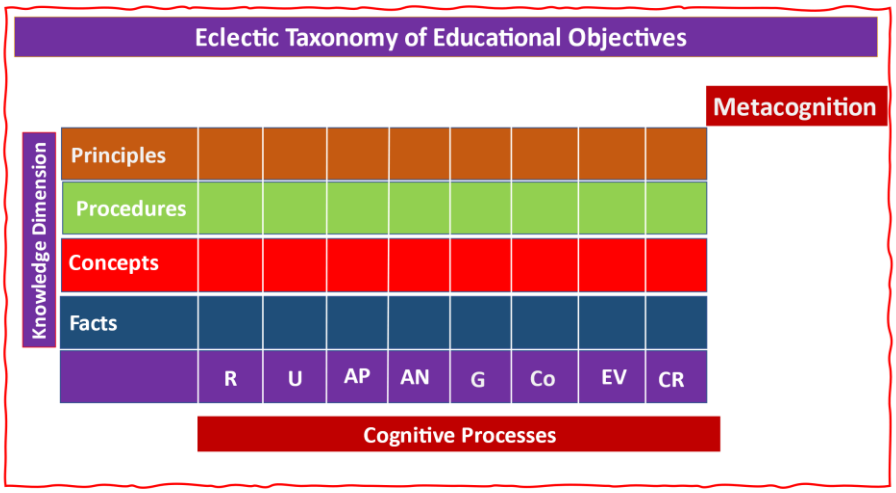

Figure 9. Eclectic Taxonomy of Educational Objectives
Source: Author

- The cognitive component should comprise Remember, Understand, Apply, Analyse, Evaluate, Generalise, Construct (Synthesis or pre-creation), and Create.
- Create should be seen at Lateral and Vertical Thinking, Divergent Thinking, Heuristic Thinking and Intuitive Thinking.
- The Content dimension should comprise Facts, Concepts, Procedures and Principles.
- Metacognition should find a place in the taxonomy located as the highest form of cognition and beyond the cognitive and content interpreted as strategic knowledge.
- Create needs to be considered as multilayer cognition comprising lateral, vertical, divergent, heuristic and intuitive thinking.

Key Takeaways

1. Learning is hierarchic. The lowest level can be just memorising and remembering a set of facts. It can learn at higher levels and create new concepts, principles, and products.
2. This hierarchic learning organisation is the subject of the taxonomy of educational objectives. The concept of taxonomy is mainly derived from biological sciences. But it is extensively utilised in library science, websites, and education.
3. There are several taxonomies of human learning. These contributions are from Robert Gagne, David Merrill, Biggs and Collis, Benjamin Bloom (Committee), Anderson and Krathwohl. Mukhopadhyay proposed an eclectic model, drawing on the best features of all the other taxonomies of educational objectives.
4. Bloom's Taxonomy, the first developed in 1956, has the most significant single influence on educational thinking.
5. The Benjamin Bloom Committee classified human learning into three domains - cognitive, affective and psychomotor. Different levels of learning were identified in each domain and classified from simple to more complex learning.
6. The Bloom Committee recommended six levels of learning. These are knowledge, comprehension, application, analysis, synthesis and evaluation.
7. Gagne proposed eight stages of learning. These stages consist of signal learning, stimulus-response learning, chaining, verbal association, discrimination learning, concept learning, rule learning and problem-solving.

8. Biggs and Collis mentioned four levels of learning. These are uni-structural, multi-structural, relational, and extended abstractions preceded by pre-structural, indicating almost no learning. Biggs and Collis also provided an important concept of Constructive Alignment.
9. David Merrill brought in the two-dimensional concept of taxonomy, with cognition and contents as the two dimensions. The cognitive hierarchy was explained as remembering, using and finding. The content taxonomy was explained as facts, concepts, procedures, and principles.
10. Anderson and Krathwohl, while revising Bloom's taxonomy, drew from David Merrill's two-dimensional structure of taxonomy. They added knowledge of content as the second dimension. In the revised taxonomy, they changed the sequence of cognition to remember, understand, apply, analyse, evaluate and create. The taxonomy of the content comprises facts, concepts, procedures and meta-cognition. Anderson and Krathwohl provided a comprehensive list of action verbs that can be used to define the learning outcomes.
11. Drawing on the best from previous taxonomies, Mukhopadhyay proposed remembering, understanding, applying, analysing, evaluating, generalising, constructing, and creating the cognitive domain hierarchy. The content knowledge domain comprises facts, concepts, procedures, principles, and theories. He located meta-cognition beyond cognition and content but at a junction point.
12. Lower order learning, namely, remembering and understanding, are necessary. Lower order learning is fragile and liable to be forgotten. Higher-order learning is sustainable and can be achieved by students' direct involvement with learning activities.

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