CHAPTER II

THEORETICAL OVERVIEW

2.1 McCormack and Yager Taxonomy
2.2 Bloom's Taxonomy
2.3 Revised Bloom's Taxonomy
2.4 Other Taxonomies of Educational Objectives
"It appears that by our very nature we are classifying creatures that is we categorize our observations based on patterns of similarities"

-Langenheim

Educational objectives describe the goals towards which the education process is directed. When drawn up by an educational authority or professional organization, objectives are usually called standards. Taxonomy is a classification scheme for developing objectives and it involves categories that are arranged in hierarchical order. They are classification systems based on an organizational scheme. In this instance, a set of carefully defined terms, organized from simple to complex and from concrete to abstract, provide a framework of categories into which one may classify educational goals. Such schemes can:

- Provide a common language about educational goals that can bridge subject matter and grade levels.
- Serve as a touchstone for specifying the meaning of broad educational goals for the classroom.
- Help to determine the congruence of goals, classroom activities and assessments.
- Provide a panorama of the range of possible educational goals against which the limited breadth and depth of any particular educational curriculum may be contrasted.

Educators often use taxonomies while developing objectives for lessons, units of study and even in the individual educational programs of students. Reviews of the research on educational objectives induct that students learn more when their teachers provide instructions to them with clearly written objectives, and when the objectives were at the correct level of difficulty.

There are various taxonomies of educational objectives and some of the relevant among them are given as follows.

2.1 **McCormack and Yager Taxonomy**

2.2 **Bloom's Taxonomy**

2.3 **Revised Bloom's Taxonomy (RBT)**

2.4 **Other Taxonomies of Educational Objectives**

**2.1 McCormack and Yager Taxonomy**

When humans use scientific knowledge and technology, global awareness becomes critical for environmental protection. As the American Association for the Advancement of science (1990) stated in science for All Americans,

“What the future holds in store for individual human beings, the nation and the world depends largely on the wisdom with which humans
use science and technology. But that in turn depends on the character, distribution and effectiveness of the education that people receive”.

Accordingly, scientific literacy has become a major goal of science education. Although there is no consensus regarding what kinds of science content are necessary for scientific literacy, a scientifically literate person is believed to be one who appreciates the strengths and limitations of science and who knows how to use scientific knowledge and scientific ways of thinking in order to live a better life and make rational social decisions.

Learning that fosters scientific literacy should promote development in the following areas:

- Student’s inquiry skills and abilities.
- Student’s abilities to apply what is learned to new contexts.
- Student’s content and conceptual understanding.
- Student's understanding of the nature of science.

McCormack and Yager (1989) proposed that science had been viewed as a body of knowledge consisting of facts, figures and theories and this led to science instruction characterized by presentation of factual information. They believed that science education that stressed what they called the “knowing and understanding” domain limited students in developing the level of scientific literacy demanded by the needs of society and the world. They proposed that science education might be
viewed in the context of five domains.

**The Five Domains of Science**

The five domains of science according to McCormack and Yager Taxonomy are

1. Knowledge Domain
2. Process Domain
3. Creativity Domain
4. Application Domain and
5. Attitude Domain

The five domains of science given by McCormack and Yager Taxonomy is illustrated in the following figure

![Five Domains of Science](#)

**Figure 2.1**

**The five domains of Science given by McCormack and Yager Taxonomy**

McCormack and Yager say that too often science education is limited to the first two domains, knowing and understanding and exploring and discovering, which relate primarily to the product and
process of science. They content that the other three domains must be included in these times of global environmental problems, complex social and political issues, and general concerns about the future.

To address these concerns, the domain of imaginary and creating emphasizes the creative dimension of using science for the benefit of people. The domain of feeling and valuing looks at human values, feelings and decision making skills. How to use information gained from school science studies in everyday life falls under the domain of using and applying. Characteristics of five domains of McCormack and Yager Taxonomy are given in the following table.

<table>
<thead>
<tr>
<th>Science Domain</th>
<th>Domain Foci</th>
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<tbody>
<tr>
<td>I. Knowledge (knowing and understanding)</td>
<td>Scientific information-facts, concepts, laws, hypothesis and theories accepted by the scientific community.</td>
</tr>
<tr>
<td>II. Processes (exploring and discovering)</td>
<td>Processes of science, how scientists work and think</td>
</tr>
<tr>
<td>III. Creativity (imaging and creating)</td>
<td>Idea generation, designing, problem solving</td>
</tr>
<tr>
<td>IV. Applications (using and applying)</td>
<td>Applications of what is learned to do science, connections to everyday life, informed decision making.</td>
</tr>
<tr>
<td>V. Attitudes (feeling and valuing)</td>
<td>Attitudes, sensitivity, societal issues and impacts</td>
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A science education programme, especially, one that is science/technology/society oriented, must focus on all of the interrelated
five domains, but it should stress the vital importance of these domains: imaging and creating, feeling and valuing and using and applying. It is in these domains that students use their acquired science knowledge and skills to clarify and strengthen their values and then apply and act upon them as responsible citizens. The five domains of Science according to McCormack and Yager Taxonomy is explained as follows.

1. **Knowledge Domain**

   Science in the classroom has been viewed and practiced for decades as a body of knowledge or facts to be learned or absorbed by students. Classically this occurs through the memorization of facts and concepts from text book. Science facts are clearly important, but to memorize facts as if their acquisition is the sole purpose of science education violates the spirit and nature of science.

   Science concepts are central to science instruction and student's understanding of these concepts is crucial to successful teaching and learning. Millar (1989) noted that without an understanding of science concepts it would be nearly impossible for students to follow much of the public discussion of scientific results or public policy issues pertaining to science and technology. According to Thagard (1992), conceptual systems are primarily structured through either kind hierarchies or part whole hierarchies. If a basic goal of science education is to help students
construct an understanding of the natural world, then student’s prior knowledge should be the starting point for instruction.

Students should have concrete experience with concepts before moving to abstractions, and they need opportunities to try and to do, not just to read about science. The evidence that science concepts have been learned can be seen most clearly when students can use concepts in a real-life or real world situation (National Science Teachers Association, NSTA, 1982).

Facts, laws or principles, theories and the internalized knowledge held by students all fall under the umbrella of the concept domain. These are the currently accepted scientific constructs related to all of the sciences and students may best learn these concepts through a curriculum that is conceptually sequenced for developing student understanding. Students must also experience the curriculum from conceptually sound models of assessment and instruction. Science learning should promote conceptual linkage instead of concepts in isolation approach.

The specific objectives which comes under this domain are

- learns specific information (facts, concepts, theories and laws)
- investigates knowledge of science’s history and philosophy

Classroom Activity: - Assumptions Vs Observed facts

A teacher presents a test tube containing a red liquid. She asks the students to predict what will happen when the liquid is heated. They
predict it will boil and it will make steam. The teacher heats the liquid over a flame, and it turns to a solid! A discussion ensures in which students become aware that they assumed the liquid was water or water like substance in making their predictions and understanding of the terms, assumption, observation and facts are clarified. Finally it is revealed that the liquid heated was red colored 'egg white'.

2. Process Domain

Science processes, often designated as inquiry skills, are embodied in the terms exploring and investigating. In science, the investigative processes require hands on and minds on activities, laboratory inquiries and experiments that provide approaches for helping students understand scientific concepts. A study conducted by Shavelson and Pinc (1992) found that students with experience in hands on activities could reliably note their own progress in laboratory activities. More important, these kinds of inquiry skills are also necessary for dealing with everyday life and play a role in the development of an understanding of the natural world (Aikenhead, 1979). The contexts in which the inquiries are set are important in helping students connect the inquiry skills to their personal experiences so that students do not see the processes used in doing science as entities used only in science. The application of process skills in a variety of contexts also supports the development of an understanding of the nature of science. Knowledge of the process of
constructing and communicating new scientific representations has the potential to yield important insights for science education (Nersessian, 1989).

The process domain includes the 13 processes identified by the American Association for the Advancement of science (1968). These are the generally accepted processes that scientists use as they accomplish their work. The abilities to use these process skills can be the target for instruction and assessment, but the identification of separate and distinct processes does not mean that they always occur in definable or identifiable ways. Scientists and students may use several of the science process skills in concert and these skills may be employed during scientific investigations in ways not expected or predicted by anyone observing the investigative process. These processes and skills are embedded in knowing, doing and thinking in science.

Process skills used in science are

- Observing
- Using space and time relationships
- Classifying, grouping and organizing
- Using numbers and quantifying
- Measuring
- Communicating
The specific objectives which comes under this domain are

1. Uses processes of science to learn how real scientists think and work (observe and describe, classify and organize, measure and chart, communicate, predict and infer, hypothesize, test hypotheses, identify and control variables, interpret data and construct instruments, simple devices and physical models).

2. Use manipulative (psychomotor) skills as well as cognitive skills.

Class room Activity: - Measuring: students are given a sugar cube (though not told what it is), a metric ruler, a balance scale, a steel pin and a prescribed amount of water. They are challenged to make as many observations and measurements as they can of the cube, and to use as many of their senses as they can in doing so.
3. Creativity Domain

Creativity is integral to science and the scientific process and is used in generating problems and hypotheses and in developing plans of action. Torrance (1969) defined creativity as the process of becoming sensitive to problems, deficiencies, gap in knowledge missing elements and disharmonies. He also included in his description the identification of the difficulties, the search for solutions, making guesses, or formulating hypotheses about the deficiencies. The testing and retesting of these hypotheses, possibly modifying and retesting them and finally communicating the results all relate to and rely on the creative process.

Creativity plays an integral role in the many processes of science and in doing science. If a science educator wishes to foster a classroom that enhances student’s creativity, the classroom should probably become more students centered. Creativity is fostered and nurtured through richness in experiences. Creativity calls for openness in the classroom, acceptance of ideas, thinking outside of the box, try new things approach, and a so called go with the flow approach.

Studies have suggested that the work done in the laboratory rests on the ability to manipulate the objects and the instruments used. Three features of laboratory practice make the need for creative abilities paramount. First, scientists and students do not work with the natural world as it is, rather they manipulate the objects of study to make them
more accessible for experimentation. Secondly investigators do not work with the natural world where it is, but are instead able to bring those natural objects into an artificial or vicarious setting. Third, scientists and students do not need to study an event only when it happens but, rather, can cause the event to occur unnaturally when the situation demands it. These three characteristics of a laboratory require an imaginative, inventive mind capable of performing these investigations. These aspects of the scientific enterprise are often ignored in the traditional classroom, yet they are integral to science instruction.

The creative domain is likely to have some of the following attributes.

**Creative domain Attributes**

The creative domain calls for experience that promote.

- visualization - production of mental images.
- generation of metaphors
- divergent thinking
- imagination
- novelty – combining objects and ideas in new ways
- open-ended questioning
- solving problems and puzzles
- consideration of alternative viewpoints
• designing devices and machines.
• generation of unusual ideas
• multiple modes of communicating results and
• representations in various ways and modes

Classroom Activity: The Water-Expanding Machine

A science teacher claims to have invented a machine that expands the volume of water by a factor of three. She points to a box that has an input funnel on top and an outlet tube at its base. She has a volunteer measuring 500ml of water and pours it into the funnel. In a short time, 1500ml of water pours out of the outlet. Since the teacher has presented this in a tongue in-cheek fashion, students are suspicious. She asks “How many of you believe the water really expanded?” very few do. “You did see the water appear to be expanded. See if you can draw an idea of what could be inside the box to create this illusion. Try to come up with an idea that no one else will think of” As kids create their models, they are thinking creatively.

4. Application Domain

A key element in the application domain is the determination of the extent to which students can transfer and effectively use what they have learned to a new situation, especially one in their own daily lives. Students must demonstrate that they not only grasp the meaning of the information and processes but that they can also make applications to
concrete situations that are new to them. The application domain is important because it involves students using concepts and processes not only in a familiar context but in addressing new problems. Students who can apply what they have learned to new situations provide evidence that they have an understanding of a concept.

Two major arenas where students use applications are in school and daily life. In school, application often involves problem solving or learning new material by using knowledge and skills acquired in previous studies. In daily life, the crucial factor appears to be the ability to choose the concepts and skills pertinent and relevant for dealing with novel situations. In helping students make applications and connections among science, technology and their personal lives, the use of current social and technological issues can assist students in seeing the need for the integration of knowledge and skills. Beginning science learning based on student’s concerns in the so called real world may be a way to diminish the learning gap between the world of school science experiences and their personal societal and technological experiences (McCormack and Yager, 1989). An issue based approach to science learning can serve as a vehicle for engaging students in learning that is local, personal and relevant.

**Attributes of the Application Domain**

- Use of critical thinking
• Use of open-ended questions.

• Use of scientific process in solving problems that occur in daily life.

• Abilities to make interdisciplinary connections – integration of the sciences.

• Abilities to make interdisciplinary connections – integration of science with other subjects.

• Decision making related to personal health, nutrition and life style based on knowledge of scientific concepts rather than on near say or emotions.

• Understanding and evaluation of mass media reports on scientific developments.

• Application of science concepts and skills to technological problems.

• Understanding of scientific and technological principles involved in common technological devices.

Class room Activity: -Over a period of time, students are encouraged to collect and bring to school “dead” household appliances (old fosters, electric mixers, blenders etc) These are in abundance in garages, and students are also asked to bring in borrowed screwdrivers, wrenches and pliers. As part of an invention or technology unit, they take apart the old
appliances and try to learn or infer as much as they can about how they operate. Much can be learned about gears, motors, switches and solenoids through this experience, and students gain some appreciation and respect for engineering and inventiveness.

5. Attitude Domain

Many times we have heard people say that they were never good at science, mathematics or some other area of study. Felker (1974) found that when students were induced to make positive statements about themselves, they attained more positive attitudes about themselves. Page (1958) indicated that teachers who reflected an active and personal interest in their student's progress were more likely to be successful in enhancing the personal confidence levels of students.

Attitude is very broadly used in discussing issues in science education and is often used in various contexts. Two general categories that are distinguishable are

a. Attitude towards science (ie. interest in science, attitude toward scientists and attitude toward social responsibility in science)

and

b. Scientific attitude (ie, open-mindedness, honesty or skepticism) Interest in science tends to decline as students experience more science classes and progress through school. This is especially true in the middle schools. When enrollment
in science classes declines, science educators need to work to retain student interest in science and need to consider changing both instruction and assessment practices to be more students centered in order to promote ongoing interest (Gardner, 1975).

The positive “I can” attitude and “I enjoy” feelings may enhance student’s efforts to seek answers for their own problems and lessen their reliance on others. Students should be able to solve problems with greater independence without parent or teacher intervention. Statements such as “Don’t tell me the answer” or “I can figure it out all by myself”, indicate a growing autonomy. The end result of this self directed growth could very well be self acceptance and responsibility for lifelong learning.

**Attitude Domain Attributes**

The attitude domain calls for experiences that support

- exploration of human emotions.
- expression of personal feelings in constructive ways.
- decision making about social and environmental issues.
- development of more positive student attitude towards science in general.
- development of positive attitude towards oneself and
• development of sensitivity to and respect for feeling of other people.

Although this attitude may seem beyond the scope of a science classroom, consider the words of Charles Swindoll (1994):

“The longer I live the more I realize the impact of attitude on life. Attitude to me is more important than facts ... I am convinced that life is 10% what happens to me and 90% how I react to it. And so it is with you ... we are in charge of our Attitudes.”

Class room Activity: - Students are presented with a problem: A drawing of an odd ogg is shown, it is half human and half animal. This individual is the last of its kind. Some people think it should be destroyed. Some would display it in a 200 curies. Others say it should be used for horror films. What should be done?

Students work on this dilemma in co operative discussion groups, considering pros and cons and the ethics of this discussion. In doing so, they become aware of some of their personal attitudes and those of classmates.

2.2 Bloom's Taxonomy

Taxonomy of educational objectives is intended to provide classification of the goals of our educational system. It helps in the discussion of curricular and evaluation problems. The initiative in developing Taxonomy of educational objectives gained momentum in 1948
at the American Psychological Association Convention (APAC) at Boston. During 1948-1956, several meetings were held to develop a Taxonomy popularly known as Bloom's Taxonomy of Educational Objectives.

Bloom's Taxonomy was first presented in 1956 through the publication "The Taxonomy of Educational Objectives, The Classification of Educational Goals, Handbook I: Cognitive Domain" by Dr. Benjamin S. Bloom, M. D. Englehart, E. J. Furst, W. H. Hill, and David Krathwohl. Bloom himself considered the Handbook, "one of the most widely cited yet least read books in American education."

According to Bloom's Taxonomy of educational objectives, the behavioural changes of individuals resulting from instruction can be classified into three domains namely,

I. Cognitive Domain

II. Affective Domain

III. Psychomotor Domain

The classification can be represented in the following figure
I. Cognitive Domain

Cognitive domain includes those objectives which deal with recall and recognition of knowledge and development of intellectual abilities. Bloom's Taxonomy classifies cognitive behaviour into six categories starting from the simple to the most complex. The categories can be thought of as degrees of difficulties, that is the lower levels must be mastered before the next one can take place. The categories coming under cognitive domain are

1. Knowledge

Knowledge is defined as the remembering of previously learned material by recalling terms, facts, basic concepts etc. It represents the lowest level of learning outcomes in the cognitive domain. It involves

1.1. Knowledge of specifics
1.2. Knowledge of ways and means of dealing with specifics
1.3. Knowledge of universals and abstractions in a field

2. Comprehension

Comprehension is defined as the ability to grasp the meaning of material. It includes the understanding of facts and ideas by organizing, comparing, translating, interpreting, giving descriptions, and stating main ideas. It involves

2.1. Translation
2.2. Interpretation
2.3. Extrapolation
3. **Application**

It refers to the ability to use learned material in new and concrete situations. It involves the application of the acquired knowledge, facts, concepts, and rules in a different way to new situations.

4. **Analysis**

Analysis refers to the ability to break down material into its component parts so that its organizational structure can be understood. It involves

4.1. Analysis of elements

4.2. Analysis of relationships

4.3. Analysis of organizational principles

5. **Synthesis**

Synthesis refers to the ability to put parts together so as to form a whole or a new pattern. It involves

5.1. Production of a unique communication

5.2. Production of a plan, or proposed set of operations

5.3. Derivation of a set of abstract relations

6. **Evaluation**

It is the highest level of cognitive domain. It enables an individual to present and defend opinions by making judgments about information, validity of ideas or quality of work based on a set of criteria and to establish the worth of it. It involves
6.1. Evaluation in terms of internal evidence

6.2. Judgments in terms of external criteria

The categories were designed to range from simple to complex and from concrete to abstract. Further, it was assumed that the taxonomy represented a cumulative hierarchy, so that mastery of each simpler category was a prerequisite to mastery of the next, more complex one.

II. Affective Domain

The Affective domain deals with the interests, attitudes, opinions, appreciations, values, and emotional sets. It describes the way people react emotionally and their ability to feel another living things pain or joy. Affective objectives target the awareness and growth in attitudes, emotion, and feelings. There are five levels in the affective domain moving through the lowest order processes to the highest

1. Receiving

It is the lowest level of learning outcome in the affective domain. It refers to the student's willingness to attend to particular phenomena or stimuli. The teacher's concern is that the student's attention is focused. Without this level no learning can occur. It involves

1.1. Awareness

1.2. Willingness to receive

1.3. Controlled or selected attention
2. Responding

The student actively participates in the learning process, not only attends to a stimulus; the student also reacts in some way. It involves

2.1. Acquiescence in responding

2.2. Willingness to respond

2.3. Satisfaction in response

3. Valuing

The worth or value a student attaches to a particular object, phenomenon, or behaviour. It ranges from the simple acceptance of a value to the more complex level of commitment. It involves

3.1. Acceptance of a value

3.2. Preference for a value

3.3. Commitment

4. Organization

The student can put together different values, information and ideas, resolve conflicts among them and start to build an internally consistent value system by comparing, relating, and synthesizing values and there by develops a philosophy of life. It involves

4.1. Conceptualization of a value

4.2. Organization of a value system
5. Characterization by a value or value complex

At this level, the student holds a particular value or belief that exerts influence on his/her behaviour so that it becomes a characteristic “life style”. Thus the behaviour is pervasive, consistent and predictable. It involves

5.1. Generalized set

5.2. Characterization

III. Psychomotor Domain

The psychomotor domain includes physical and motor (or muscular) skills. This means much more than the gaining of skills in games and physical education. Every act has a psychomotor component. For instance, writing and talking are psychomotor skills which must be acquired if the child is to function successfully in our society. In the learning situation there is a progression from mere physical experience - seeing, touching, moving etc. - through the carrying out of complex skills under guidance, to the performance of skilled activities independently.

There are three primary taxonomies of the psychomotor domain:

1. Simpsons Taxonomy

2. Dave's Taxonomy

3. Harrows Taxonomy

1. Simpsons Taxonomy

The psychomotor domain (Simpson, 1972) includes physical
movement, coordination, and use of the motor-skill areas. Development of these skills requires practice and is measured in terms of speed, precision, distance, procedures, or techniques in execution. The seven major categories of this Taxonomy are listed from the simplest behavior to the most complex as

**Perception:** The ability to use sensory cues to guide motor activity. This ranges from sensory stimulation, through cue selection, to translation.

**Set:** Readiness to act. It includes mental, physical, and emotional sets. These three sets are dispositions that predetermine a person's response to different situations (sometimes called mindsets).

**Guided Response:** The early stages in learning a complex skill that includes imitation and trial and error. Adequacy of performance is achieved by practicing.

**Mechanism:** This is the intermediate stage in learning a complex skill. Learned responses have become habitual and the movements can be performed with some confidence and proficiency.

**Complex Overt Response:** The skillful performance of motor acts involves complex movement patterns. Proficiency is indicated by a quick, accurate, and highly coordinated performance, requiring a minimum of energy. This category includes performing without hesitation, and automatic performance.
2. Dave's Taxonomy

Dave's Taxonomy includes the following:

**Imitation** – Observing and patterning behavior after someone else. Performance may be of low quality. Example: Copying a work of art.

**Manipulation** – Being able to perform certain actions by following instructions and practicing. Example: Creating work on one's own, after taking lessons, or reading about it.

**Precision** – Refining, becoming more exact. Few errors are apparent. Example: Working and reworking something, so it will be “just right.”

**Articulation** – Coordinating a series of actions, achieving harmony and internal consistency. Example: Producing a video that involves music, drama, colour, sound, etc.

**Naturalization** – Having high level performance becomes natural, without needing to think much about it. Examples: Michael Jordan playing basketball, Nancy Lopez hitting golf ball, etc.

3. Harrows Taxonomy

Anita Harrow's Taxonomy for the psychomotor domain is organized according to the degree of coordination including involuntary responses as well as learned capabilities. Simple reflexes begin at the lowest level of the Taxonomy, while complex neuromuscular
coordination makes up the highest levels (Seels & Glasgow, 1990). It involves the following categories

**Reflex movements**- are actions elicited without learning in response to some stimuli. Examples include: flexion, extension, stretch, postural adjustments.

**Basic fundamental movements**- are inherent movement patterns which are formed by combining of reflex movements and are the basis for complex skilled movements. Examples are: walking, running, pushing, twisting, gripping, grasping, manipulating.

**Perceptual**- refers to interpretation of various stimuli that enable one to make adjustments to the environment. It involves visual, auditory, kinesthetic, or tactile discrimination. Examples include: coordinated movements such as jumping rope, punting, or catching.

**Physical activities**- require endurance, strength, vigor, and agility which produce a sound, efficiently functioning body. Examples are: all activities which require a) strenuous effort for long periods of time; b) muscular exertion; c) a quick, wide range of motion at the hip joints; and d) quick, precise movements.

**Skilled movements**- are the result of the acquisition of a degree of efficiency when performing a complex task. Examples are: all skilled activities obvious in sports, recreation, and dance.
Non-discursive communication -is communication through bodily movements ranging from facial expressions through sophisticated choreographics. Examples include: body postures, gestures, and facial expressions efficiently executed in skilled dance movement and choreographics.

Clearly, Bloom's Taxonomy has stood the test of time. Due to its long history and popularity, it has been condensed, expanded, and reinterpreted in a variety of ways. Research findings have led to the discovery of a veritable smorgasbord of interpretations and applications falling on a continuum ranging from tight overviews to expanded explanations. Nonetheless, one recent revision (designed by one of the co-editors of the original taxonomy along with a former Bloom student) merits particular attention.

2.3 Revised Bloom's Taxonomy (RBT)

During the 1990's, a former student of Bloom's, Lorin Anderson, led a new assembly which met for the purpose of updating the Taxonomy, hoping to add relevance for 21st century students and teachers. Like the original group, representatives of cognitive psychologists, curriculum theorists and instructional researchers, and testing and assessment specialists were also arduous and diligent in their pursuit of learning, spending six years to finalize their work. The revision which published in 2001 includes several seemingly minor yet actually quite significant
changes.

Anderson and Krathwohl (2001) revised Bloom's taxonomy to fit the more outcome-focused modern educational objectives, including switching the names of the levels from nouns to active verbs, and reversing the order of the highest two levels. The lowest-order level (Knowledge) became remembering, in which the student is asked to recall or remember information. Comprehension became Understanding, in which the student would explain or describe concepts. Application became Applying, or using the information in some new way, such as choosing, writing, or interpreting. Analysis was revised to become Analyzing, requiring the student to differentiate between different components or relationships, demonstrating the ability to compare and contrast. These four levels remain the same as Bloom et al.'s (1956) original well-known and accepted hierarchy.

In general, research over the last 40 years has confirmed the Taxonomy as a hierarchy with the exception of the last two levels. It is uncertain at this time whether synthesis and evaluation should be reversed or whether synthesis and evaluation are at the same level of difficulty but use different cognitive processes. The two highest, most complex levels of Synthesis and Evaluation were reversed in the revised model, and were renamed Evaluating and Creating by Anderson and Krathwohl (2001). As they did not provide empirical evidence for this reversal, these two highest levels are essentially equal in level of complexity. Both depend
on analysis as a foundational process. However, synthesis or creating requires rearranging the parts in a new, original way whereas evaluation or evaluating requires a comparison to a standard with a judgment as to good, better or best. This is similar to the distinction between creative thinking and critical thinking. Both are valuable while neither is superior.

The visual comparison of the two Taxonomies is given in the following figure.

**Figure 2.3**
Visual comparison of the two Taxonomies
The revised Taxonomy incorporates both the kind of knowledge to be learned (knowledge dimension) and the process used to learn (cognitive process), allowing for the instructional designer to efficiently align objectives to assessment techniques. Both dimensions are illustrated in the following table that can be used to write clear and focused objectives. Using a simple cross impact grid or table like the one below, one can match easily activities and objectives to the types of knowledge and to the cognitive processes as well. It is a very useful tool to use in assessing how instruction is actually impacting levels of learning.

**Table 2.2**

The Revised Taxonomy Table

<table>
<thead>
<tr>
<th>Cognitive process Dimension</th>
<th>Remember</th>
<th>Understand</th>
<th>Apply</th>
<th>Analyze</th>
<th>Evaluate</th>
<th>Create</th>
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<tr>
<td><strong>The Knowledge Dimensions</strong></td>
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**Knowledge Dimensions Defined:**

**Factual Knowledge** is knowledge that is basic to specific disciplines. This dimension refers to essential facts, terminology, details or elements students must know or be familiar with in order to understand a discipline or solve a problem in it.
**Conceptual Knowledge** is knowledge of classifications, principles, generalizations, theories, models, or structures pertinent to a particular disciplinary area.

**Procedural Knowledge** refers to information or knowledge that helps students to do something specific to a discipline, subject, and area of study. It also refers to methods of the inquiry, very specific or finite skills, algorithms, techniques, and particular methodologies.

**Metacognitive Knowledge** is the awareness of one’s own cognition and particular cognitive processes. It is strategic or reflective knowledge about how to go about solving problems, cognitive tasks, to include contextual and conditional knowledge and knowledge of self.

For teachers, the objectives for an entire unit can be plotted out on the Taxonomy table, ensuring that all levels of the cognitive process are used and that students learn different types of knowledge. For example, if a math teacher were planning a comprehensive unit, he or she could use the Taxonomy table to make sure that students not only learned different mathematical procedures, but also learned how to think (meta-cognition) about the best way to solve math's problems.

Teachers may also use the new Taxonomy dimensions to examine current objectives in units, and to revise the objectives so that they will align with one another, and with assessments. Using the revised Taxonomy by referring to the charted dimensions, may give teachers a
place to start when revising units to better align with new standards-based requirements as well.

2.4 Other Taxonomies of Educational Objectives

In addition to McCormack and Yager Taxonomy, Bloom's Taxonomy and Revised Bloom's Taxonomy there were also other Taxonomies of educational objectives. They were

2.4.1 Feisel-Schmitz Technical Taxonomy of learning outcomes

2.4.2 Marzano’s New Taxonomy

2.4.3 Romiszowski Taxonomy

2.4.4 SOLO Taxonomy

Details of each of the above taxonomies is given below.

2.4.1 Feisel-Schmitz Technical Taxonomy of learning outcomes

This includes the following categories of objectives.

**Judge:** To be able to critically evaluate multiple solutions and select an optimum solution.

**Solve:** Characterize, analyze, and synthesize to model a system (provide appropriate assumptions).

**Explain:** Be able to state the outcome/concept in their own words.

**Compute:** Follow rules and procedures (substitute quantities correctly into equations and arrive at a correct result, Plug & Chug).
Define: State the definition of the concept or is able to describe in a qualitative or quantitative manner.

2.4.2 Marzano’s New Taxonomy

Robert Marzano (2000) a respected educational researcher, has proposed 'A New Taxonomy of Educational Objectives'. Developed to respond to the shortcomings of the widely used Bloom’s Taxonomy and the current environment of syllabus guidelines-based instruction, Marzano’s model of thinking skills incorporates a wide range of factors that affect how students think and provides a more research-based theory to help teachers improve their student's thinking.

Marzano’s New Taxonomy is made up of three systems and the Knowledge Domain, all of which are important for thinking and learning. The three systems are the Self-System, the Metacognitive System, and the Cognitive System. When faced with the option of starting a new task, the Self-System decides whether to continue the current behavior or engage in the new activity; the Metacognitive System sets goals and keeps track of how well they are being achieved; the Cognitive System processes all the necessary information, and the Knowledge Domain provides the content.
Knowledge Domain

Traditionally, the focus of most instruction has been in the component of knowledge, students were assumed to need a significant amount of knowledge before they could think seriously about a subject. Unfortunately, in traditional classrooms, instruction rarely moved beyond the accumulation of knowledge, leaving students with a mental file cabinet full of facts, most of which were quickly-forgotten after the final test.

Knowledge is a critical factor in thinking. Without sufficient information about the subject being learned, the other systems have very little to work with and are unable to fulfill the learning process successfully. A high-powered automobile with all the latest technological features still needs some kind of fuel to make it fulfill its purpose. Knowledge is the fuel that powers the thinking process. Marzano identifies three categories of knowledge: *information*, *mental procedures*, and *physical procedures*.

Information

Information consists of organizing ideas, such as principles, generalizations, and details, such as vocabulary terms and facts. Principles and generalizations are important because they allow us to store more information with less effort by placing concepts into categories. For example, a person may never have heard of an *akbash*,
but once someone knows that the animal is a dog, he knows quite a bit about it.

**Mental Procedures**

Mental procedures can range from complex processes, such as writing a term paper to simpler tasks such as tactics, algorithms, and single rules. Tactics, like reading a map, consist of a set of activities which do not need to be performed in any particular order. Algorithms, like computing long division, follow a strict order which does not vary by situation. Single rules, such as those covering capitalization, are applied individually to specific instances.

**Physical Procedures**

The degree to which physical procedures figure into learning varies greatly by subject area. The physical requirements necessary for reading may consist of no more than left-to-right eye movement and the minimal coordination needed to turn a page. On the other hand, physical and vocational education requires extensive and sophisticated physical processes, such as playing tennis or building a piece of furniture. Contributing factors to effective physical processing include strength, balance, manual dexterity, and overall speed of movement. Many of the activities which students enjoy in their leisure time such as sports or electronic game-playing require refined physical procedures.
**Classroom Example**

Most curriculum syllabus guidelines are organized around concepts which are usually labeled by one or two words. A concept such as “triangles” would include all the information components:

- Vocabulary (information): isosceles, equilateral, hypotenuse
- Generalization (information): All right triangles have one angle of 90 degrees.
- Mental procedures: Conducting proofs and figuring the length of the side of a right triangle.
- Physical procedures: Constructing triangles with a compass and ruler.

**Cognitive System**

The mental processes in the Cognitive System take action from the knowledge domain. These processes give people access to the information and procedures in their memory and help them manipulate and use this knowledge. Marzano breaks the Cognitive System down into four components: *knowledge retrieval, comprehension, analysis, and knowledge utilization*. Each process is composed of all the previous processes. Comprehension, for example, requires knowledge retrieval; analysis requires comprehension, and so on.

**Knowledge Retrieval**

Like the knowledge component of Bloom’s Taxonomy, Knowledge Retrieval involves recalling information from permanent
memory. At this level of understanding, students are merely calling up facts, sequences, or processes exactly as they have been stored.

**Comprehension**

At a higher level, Comprehension requires identifying what is important to remember and placing that information into appropriate categories. Therefore, the first skill of comprehension, synthesis, requires the identification of the most important components of the concept and the deletion of any that are insignificant or extraneous.

**Analysis**

More complex than simple comprehension, the five cognitive processes in Analysis are *matching, classifying, error analysis, generalizing,* and *specifying.* By engaging in these processes, learners can use what they are learning to create new insights and invent ways of using what they have learned in new situations.

**Knowledge Utilization**

The final level of cognitive processes addresses the use of knowledge. Marzano calls these processes Knowledge Utilization, or Using Knowledge. The processes of using knowledge are especially important components of thinking for project-based learning since they include processes used by people when they want to accomplish a specific task. Decision-making, a cognitive process involves the weighing of options to determine the most appropriate course of action. Problem-
solving occurs when an obstacle is encountered on the way to achieving a goal. Sub-skills for this process include identification and analysis of the problem. Experimental inquiry involves generating hypotheses about physical or psychological phenomena, creating experiments, and analyzing the results.

**Metacognitive System**

The metacognitive system is the “mission control” of the thinking process and regulates all the other systems. This system sets goals and makes decisions about which information is necessary and which cognitive processes best suit the goal. It then monitors the processes and makes changes as necessary.

**Self-System**

As any teacher knows, providing students with instruction in cognitive strategies, even with metacognitive skills, is not always enough to ensure that they will learn. Teachers also are often pleasantly surprised to discover that a student has accomplished a task that they considered to be far too difficult. These situations occur because at the root of all learning is the Self-System. This system is comprised of the attitudes, beliefs and feelings that determine an individual’s motivation to complete a task. The factors that contribute to motivation are: importance, efficacy, and emotion.
2.4.3 Romiszowski taxonomy

In Romiszowski's Taxonomy a distinction is made between knowledge and skills. Knowledge is divided into:

**Facts**: details concerning concrete events, situations, people or matters. One (part of a) lesson can be focused on the student memorizing factual knowledge with the aid of what the teacher tells or shows. An example of a factual objective: a student should be able to quote the percentage of undernourished African children under two years of age.

**Procedures**: assignments that consist of a step plan.

**Concepts**: definitions of abstract matters (for example, freedom, intelligence) or grouping of perceptible objects or matters. A learning aim could be to provide the students with insight so that they are able to fit new examples, objects, etc. into a particular concept system. An example of an objective with regard to the learning of concepts: a student is able to name the characteristics of viral diseases and indicate which illness in a given list of syndromes is caused by a virus.

**Principles**: rules or patterns (if ... then ... statements). An example of an objective with regard to the learning of principles: a student is able to explain which preventative measures must be taken when the tsetse-fly prevails in livestock areas.

These categories of knowledge are characterized by a gliding scale of difficulty. Each category is more difficult to understand, apply and, for
Theoretical Overview

the trainer, transfer than its predecessor. Romiszowski's Taxonomy draws
trainer's and teacher's attention to the fact that the transfer of knowledge
is a complex matter.

The transfer of skills is much more important to Romiszowski than
just the transfer of knowledge. Romiszowski subdivides skills into:
1. Cognitive skills, such as decision-making, problem-solving and logical
thinking.
2. Psychomotor skills, such as the performance of actions and techniques.
3. Reactive skills, such as being conscious of and acting in accordance
with a value system.
4. Interactive skills in the fields of social intercourse, communication and
leadership.

Romiszowski emphasizes that a person can learn to master these
skills in a reproductive and in a productive manner. A reproductive
command of skills means the performance of a skill following a
previously set out procedure.

The taxonomy has been used for the analysis of a course objective,
an entire curriculum, or a test in order to determine the relative emphasis
on each major category. The unceasing growth of knowledge exerts
constant pressure on educators to pack more and more into each course.
Along these same lines is the Taxonomy's use to assure that objectives,
instructional activities, and assessment are congruent (aligned) with one
another. The Taxonomy has also commonly been used in developing a test's blueprint, providing the details for guiding item development to assure adequate and appropriate curriculum coverage.

2.4.4 SOLO Taxonomy

The SOLO taxonomy stands for:

Structure of

Observed

Learning

Outcomes

It was developed by Biggs and Collis (1982). It describes level of increasing complexity in a student's understanding of a subject, through five stages, and it is claimed to be applicable to any subject area. The five stages in SOLO Taxonomy are

1 **Pre-structural**: here students are simply acquiring bits of unconnected information, which have no organisation and make no sense.

2 **Unistructural**: simple and obvious connections are made, but their significance is not grasped

3 **Multistructural**: a number of connections may be made, but the meta-connections between them are missed, as is their significance for the whole.

4 **Relational** level: the student is now able to appreciate the significance of the parts in relation to the whole.
At the extended abstract level, the student is making connections not only within the given subject area, but also beyond it, and are able to generalise and transfer the principles and ideas underlying the specific instance. The figure showing SOLO Taxonomy is as follows.

![SOLO Taxonomy Diagram]

**Figure 2.4**  
Figure showing SOLO Taxonomy

**Conclusion**

The theoretical overview enabled the investigator to understand the origin and roots of development of McCormack and Yager Taxonomy. The investigator also examined Bloom's Taxonomy, Revised Bloom's Taxonomy and other Taxonomies of educational objectives. This helped the investigator to frame the topic of study and to adopt a suitable procedure to carry out.