REVISED EDITION

HANDBOOK

OUTCOME BASED EDUCATION

GENERAL

Prof. N.J. Rao

KERALA STATE HIGHER EDUCATION COUNCIL

2023

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Revised Edition

(Material presented here was liberally borrowed from the references given)

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Preface

Higher Education in India is undergoing major changes since 2015. One important change is shifting the focus from what is taught to what is learned. This is formally known as Outcome Based Education (OBE). OBE is an approach to education in which decisions about the curriculum and instruction are driven by the exit learning outcomes that the students should display at the end of a program or a course. A system based on outcomes gives priority to ends, purposes, learning, accomplishments, and results. While this shift to student centricity appears to be the right way, it calls for important changes to the existing beliefs and practices of teaching and learning. These include how the syllabus of course is communicated to the learners, the way instruction needs to be done, how the assessment of learning is done, and how the attainment of educational goals (learning outcomes) is determined.

All institutions offering higher education programs in India need to be accredited by the National Assessment and Accreditation Council (NAAC). OBE and some criteria of the NAAC can serve as excellent framework for design and conduct of courses in general higher education programs without curtailing the academic freedom of the teachers in any way. This booklet presents why and what of OBE, features of Revised Bloom's taxonomy of learning, teaching, and assessment, and how to write Outcomes of a Course in higher education programs as per the criteria of the NAAC. This document evolved through many Faculty Development Programs (FDPs) conducted across the country over the last seven years, and inputs from the participating faculty. I am particularly thankful to the FLAIR programs and the FDPs organized by the Kerala State Higher Education Council. I hope this and other companion booklets become pedagogical associates to the practicing and aspiring faculty of higher education institutions.

N. J. Rao

November 2022

Towards Outcome-Based Education[1]

Science and technology have caused the appearance of a variety of pedagogic strategies that have acquired presence in almost all educational systems. Although this has opened enormous possibilities for students and teachers to make use of, some important questions continue to haunt educational systems everywhere. Hardly any breakthrough has been achieved regarding teaching or how to learn. Slightly altered versions of earlier rote-learning, which compel students to reproduce whatever is conveyed to them by their teachers, remain still valid. Students must learn what the system or teachers as representatives of the system, chooses to teach them and at the end of such educational transactions they must face a test set by the very same system.

There is no scope for students to frame their questions or exercise freedom to ask questions in their own way. Portions of the syllabus for any academic programme require rethinking against the background of changes occurring in society as well as at the level of knowledge attained in the domain concerned. Often many things already learnt recur at higher stages not only adding to the tedium of familiarity but also rendering the obsolete plausible again, rather than letting students unlearn them. Same lessons indiscriminately passed on to higher levels impede the process of learning by turning it into mere memorizing.

Understanding ceases with the precedence of remembrance over it. Such aberrations should never happen in a very serious and sensitive area of human endeavour like education. That such a situation prevails, despite technological advances providing for effective ways of teaching how to learn systematically by unlearning, is an issue quite frustrating. This is one of the most important problems that the world higher education encounters in the wake of the techno-economic globalization that shakes the core of the production of knowledge. It is a fact that the exponential rate of the so-called knowledge production has shot up amazingly high, but a majorKerala State Higher Education Council (2022) Outcomes are presented as items which should inevitably be attained by every student at the end of his or her educational experiencepart of such knowledge is mere information. As a result, transmission of knowledge has become even more mechanical and alienating. Naturally, the quality of teaching and learning has become abysmally poor. Naming this kind of inappropriate production and transaction of knowledge as education is being questioned very seriously. Teaching how to learn and deepening learning through systematic unlearning must be resuscitated as inevitable constituents of quality assurance. In the context, Outcome-based Education (OBE) has been gaining obsessive emphasis to achieve quality. OBE is based upon an educational theory which integrates every aspect of educational system with a set of avowed outcomes.

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Outcomes are presented as items which should inevitably be attained by every student at the end of his or her educational experience. OBE insists upon determination of learning outcomes as the first step in course designing. Outcomes which are decided upon should evolve out of the contents, instructional strategies, learning experiences, methods of evaluation and the assessment. At different levels of higher education, each course should have its own expected outcomes, explained logically through a linked process which can be defended as to its ability to produce graduates with predetermined outcomes. The worthiness or desirability of the whole course can be prejudged before its implementation, by the defensibility of its objectives, namely the outcomes, and how they can be achieved through the several steps contained in the process.

Outcomes are presented as items which should inevitably be attained by every student at the end of his or her educational experience

Precisely drawn specific outcomes provide clarity of purpose in teaching/learning. They act as a running thread of quality control across the planning of curriculum, selection of instructional strategies, choice of learning experience and preparation of tests. Informing learners about the outcome well in advance, OBE enables ongoing concurrent self-assessment of learners for making sure of their progress towards attaining the outcome. It provides them with chances to demand new learning experiences that ensure outcome. Since the outcomes are stated, the teachers alsoget to know the progress, and they enjoy the legitimate right to test whether the learners have attained the goal. In such a system, teachers become lucid about teaching how to learn and students, clear about learning how to create. If in the earlier system, teaching was defined as a task to be carried out within the syllabus–curriculum set framework; under OBE, it becomes a definite responsibility to be carried out in such a way as to meet the objectives or outcomes. Similarly, students under the new system get opportunity as well as reasons to chart out their own innovative ways of learning. Transcending the stereotypical, OBE provides opportunities to learn differently, naturally, and creatively. It is mastery learning but with criticality and creativity. Once OBE is accepted, the differences between types of institutions do not matter so much, as between distance learning or campus-based learning. What matters is whether the graduate has attained the objectives set for the course. It is true that within the prevalent pedagogic or andragogic process, there are several gaps, both in terms of curriculum objectives and in terms of syllabus-based transaction, which make the final test itself superfluous. On the contrary, OBE provides a tightly spelt-out process, the internal parts of which are logically linked to one another. Obviously, OBE is a very transparent system right from curriculum planning to the declaration of the assessment result. However, we cannot uncritically accept OBE and hail it as a panacea. There are several factors that hold us sceptical about it. For instance, who or what combination of forces will be instrumental in setting the objectives or outcomes is a crucial question. In a techno-economically globalized world the general objectives may be set globally based on the requirements of reproducing such a universal system.

OBE may also be biased in producing and reproducing the techno-economic system that is already predominant. Insistence upon determining the outcomes beforehand is logically the same that we see in any of the projects in the economy, which rigorously spell out their deliverables in advance. Just as the earlier system/systems demandeduncritically recreating the main features that were already predominant, OBE may also in a more efficient manner be doing the same. Therefore, it is extremely important to be cautious about such lurking dangers of the system and evolve strategies to counter them.

OBE may also be biased in producing and reproducing the techno-economic system that is already predominant. It is extremely important to be cautious about such lurking dangers of the system and evolve strategies to counter them.

A crucial step is to ensure that specific internal features of OBE are set forth as fool proof. The internal logic which leads the system towards outcomes and the way in which creative and innovative methods are encouraged to be adopted, will reduce the possibilities of deadpan repetition as could be doubted. Nevertheless, a reason for favouring OBE is that hardly can we escape the global strategies of standardization, classification, and ranking. Whether we wish it or not, international accreditation agreement for professional courses is mandatory. Powerful motives of economies of scale and advantages for use for further processing are behind it. In such a situation, professional courses will be expected to be part of a standardized world-wide system.

Courses and Credits in the General Stream too must be precisely defined in alignment with international standards. Strengthening teaching/learning system in higher education institutions today means a package of curriculum design, course design, instruction design, and test design following global standards. Re-articulation of higher education in tune with OBE is no more a matter of choice today. Such discussions are to be encouraged in educational planning.

Prof. (Dr) Rajan Gurukkal is Chief Editor of Higher Education for the Future and Vice Chairman of Kerala State Higher Education Council

Foreword

The Higher Education Institutions (HEIs) in the State are in the threshold of amajor transformation especially in the realm of curricular reforms. This is inline with the global and national development in the structure and content ofhigher education. Major changes are being implemented in teaching -learningat the undergraduate level involving a thorough transformation in the teaching-learning process. Outcome Based Education (OBE) forms an integral part ofthe curricular reforms. The emergence of new areas of knowledge andtechnological changes are to be integrated in to the whole system of higher education. There are several liberal arts, humanities and social sciences ofgreat relevance not appropriately promoted in the Higher EducationInstitutions of Kerala. The technological adoption must be sophisticatedenough to be in perfect alignment with Outcome Based Education (OBE).

Assessment methods have to be based on Blooms action verbs or stem wordsfor ascertaining the knowledge categories and cognitive levels. Institutionsespecially universities and colleges have to bring about necessary changes inthe organizational structure for facilitating the OBE based evaluation as newnormal in higher education institutions. In this context, Faculty Development Centre (FDC) of the Kerala State Higher Education Council has been organizing

several training programmes on OBE for the benefit of teachers ingovernment/ aided/ self-financing colleges. The universities in the state aretaking all out efforts to define the Graduate Attributes of programmes andcurriculum /syllabi are being restructured to integrate OBE at all levels ofteaching and evaluation.

I congratulate Dr. Manulal P. Ram, Research Officer and the academic staff ofthe Faculty Development Centre for their excellent work and pain stakingefforts under the leadership of Prof Rajan Gurukkal, Vice Chairman, KSHEC inbringing out this Handbook on Outcome Based Education for both general andengineering streams. I also appreciate the wholehearted efforts of Prof N. J.Rao, (IISc, Bangalore) and his team in this important endeavour. I also thank thefaculty of various universities/ colleges for their enthusiastic participation andsuggestions in the Faculty Development Programmes which really improvedthe content of this book.

28.02.2023
Thiruvananthapuram

Dr. Rajan Varughese
Member Secretary

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CHAPTER 1

Introduction

1. What is Outcome Based Education?

Learning is supposed to have occurred when we can do something that we could not do earlier. Learning leads to acquiring new knowledge, behaviors, skills, values, preferences, or understanding and sometimes involves synthesizing different information types. According to Kolb, learning is the process whereby knowledge is created (knowledge production) through the transformation of experience. Outcomes of Learning or 'learning outcomes' are what the student should do at the end of a learning experience. Learning experiences in formal higher education programs can be identified as learning units. A unit of learning maybe a few hours of self/classroom learning activity, a one-semester course, or a formal program of two to four years.

The outcomes of learning are also referred to as Outcomes, Learning Outcomes, Intended Learning Outcomes, Instructional Objectives, Educational Objectives, Behavioural Objectives, Performance Objectives, Terminal Objectives, Subordinate Skills, Subordinate Objectives, General Instructional Objectives, Specific Learning Outcomes, and Competencies.

An outcome of education is what the student should do at the end of a program/course/ instructional unit. An outcome is a functional ability, including attributes, skills, and knowledge.

William Spady introduced Outcome Based Education (OBE) in the early 90s for the American School system. Higher education systems adopted OBE eventually by shifting the focus from what is taught to what is learned. OBE is an approach to education in which decisions about the curriculum and instruction are driven by the exit learning outcomes that the students should display at the end of a program or a course. It facilitates establishing the conditions and opportunities within the system that enable all students to achieve those essential outcomes. A system based on outcomes gives priority to ends, purposes, learning, accomplishments, and results.

There are several advantages to working with Outcome-Based Education.

- **Clarity**: An explicit statement of what the educational process aims to achieve clarifies the curriculum to both students and teachers and focuses on teaching and learning.
- **Provision of a Framework**: Outcome-based education provides a robust framework for integration of the curriculum.
- **Guide for Assessment**: The outcomes provide the framework for student examinations.

- **Facilitates Curriculum Evaluation**: The outcomes provide benchmarks against which the curriculum can be judged.

Conducting teaching-learning processes in any framework is not acceptable to some teachers and is taken against the spirit of education. Any framework presented is immediately branded as a straitjacket. If the teacher is a 'subject expert sage' and the students are highly cognitively competent, there is no need for any framework. Such a combination of sages and students is scarce in higher education institutions of India. Even the top-ranked institutions must follow the procedures related to positive discrimination and be concerned with equity and access issues. OBE merely asks the teacher to communicate at the beginning of the semester what students are expected to do at the end of a semester (course outcomes) rather than the mere list of topics. It has been established through systematic research and field studies. Communicating the course outcomes to students at the beginning of the semester makes a significant difference to students' performance. Outcome-based education does not interfere with the academic freedom of the teacher. It merely asks the teacher to follow a process in offering a course. The process consists of writing course outcomes (what the students should be able to do), designing assessment (how to measure the ability of students to do what they are expected to do), and instruction (how the teacher proposes to facilitate the students to acquire the ability to do what they are supposed to do). The teacher makes all the decisions in all three steps of the process. That is certainly not a definition of a straitjacket. The accreditation agencies require that all institutions write the outcomes, communicate them to stakeholders, particularly to students, and determine the attainment of these outcomes.

Outcome based education does not interfere with the academic freedom of the teacher. It merely asks the teacher to follow a process in offering a course

It is interesting to note what Shankaracharya says about outcomes. From the introduction by Sankara to his commentary on Mandukya Upanishad and Gaudapada'sKarikas (as translated and annotated by Swamy Nikhilananda of Sri Ramakrishna Ashram, Mysore, 1949)

A Prakarana (Treatise) has four indispensable elements (अनुबन्ध) literally, "what sticks to another", namely, the determination of the fitness of the student for the study of treatise (अधिकारी), the subject-matter (विषय), the mutual relationship (सम्बन्ध) between the treatise and the subject-matter (which is that of the explainer and the explained) and the object to be attained by the study, i.e., its utility (प्रयोजन). Good teachers always implicitly acknowledged the existence of four elements of a treatise (Course) and followed

- अधिकारी- Prerequisites
- विषय - Content
- सम्बन्ध -Teacher-Student interaction through instruction
- प्रयोजन - Object to be attained by the study - Outcome

OBE expects all teachers address these four elements explicitly

This note presents a method of writing outcomes for General (Sciences, Social Sciences, Humanities, and Arts) undergraduate (3-year and 4-year) degree programs. The proposed method is in the framework of current pedagogical theories and was heavily field tested through faculty development workshops. Material from the indicated references was used liberally in preparing this document.

The accreditation agencies require that all institutions write the outcomes,communicate them to stakeholders, particularly to students, and determine the attainment levels of these outcomes.

CHAPTER 2

Outcomes

Outcomes are the abilities the students acquire and demonstrate at the end of a learning experience. The learning experience can be an instructional unit that involves a small number of hours of instructional activity, a course of one-semester duration, or a two to four-year formal undergraduate program. Outcomes serve as the basis for productive interaction among concerned stakeholders. The outcome can also be called a 'learning product' since the outcome is the product of learning. Therefore, the "product defines the process" in OBE. It is results-oriented thinking and is the opposite of input-based education, where the emphasis is on the educational process and where we are happy to accept whatever is the result. Outcome-based education is not merely producing outcomes for an existing curriculum**.**

Outcomes can be defined at two levels in the case of General undergraduate programs.

Program Outcomes: POs (Program Outcomes) are statements that describe what the students graduating from general programs should be able to do. Program Specific Outcomes: PSOs (Program Specific Outcomes) are statements that describe what the graduates of a specific program should be able to do.

Course Outcomes: COs (Course Outcomes) are statements that describe what students should do at the end of a course.

The general undergraduate degree is the terminal degree for most graduates (>80%). They get into employment not necessarily related directly to the discipline of the program they graduated from. Whatever be the profession the graduates get into, they need to have some abilities and attitudes that make them good employees and contribute to the wealth generation and service activities of the organization they work for. In any organization, the employees must work as teams arranged in some hierarchy, communicate well in verbal and written form with peers and customers, understand the impact of what they do on society, etc. Program Outcomes (POs) represent the knowledge, skills, and attitudes that all students are required to attain at the time of graduation from any program. POs need to be identified by the University/Institute offering general programs. POs are non-specific to the discipline of the program. Sometimes these are referred to as liberal education and common core competencies.Some sample POs are:

Program Outcomes (POs) students are what all students are required to attain when graduating from an engineering program

Critical Thinking: Take informed actions after identifying the assumptions that frame our thinking and actions, checking out the degree to which these assumptions are accurate and valid, and looking at our ideas and decisions (intellectual, organizational, and personal) from different perspectives.

Effective Communication: Speak, read, write, and listen clearly in person and through electronic media in English and one Indian language, and make meaning of the world by connecting people, ideas, books, media, and technology.

Program Specific Outcomes (PSOs) are outcomes that are specific to a program. They characterize the specificity of the core (core courses) of a program. PSOs of a general program can only be two to four in number. Sample PSOs for BSc (Zoology) are

PSO1. Understand the nature and basic concepts of cell biology, Biochemistry, Taxonomy, and ecology.

PSO2. Analyze the relationships among animals, plants, and microbes

PSO3. Perform procedures as per laboratory standards in the areas of Biochemistry, Bioinformatics, Taxonomy, Economic Zoology, and Ecology

PSO4. Understand the applications of biological sciences in Apiculture, Aquaculture, Agriculture, and Medicine

The PSOs need to be written by the concerned Board of Studies.

Course Outcomes (COs) represent what the students should be able to at the end of a course. They will be discipline and subject specific. Some sample COs from different courses are

- Understand human development aspects, including pregnancy, parturition, birth control, infertility, developmental defects, and miscarriage.
- Synthesize specified chemicals, characterize them, and interpret spectral data to elucidate the structure of a synthesized chemical compound.
- Write programs for one-dimensional and two-dimensional array manipulation and string handling functions

Course Outcomes are to be written by the teacher(s) offering the course or the Board of Studies of the concerned program.

CHAPTER 3

Taxonomy of Learning

3.1 What is Taxonomy of Learning

In 1956, Benjamin Bloom headed a group of educational psychologists who developed a classification of intellectual behavior levels important in learning. This classification became a taxonomy with three overlapping domains: cognitive, psychomotor, and affective. Cognitive learning is demonstrated by recalling knowledge and intellectual skills: comprehending information, organizing ideas, analyzing, and synthesizing data, applying knowledge, choosing among alternatives in problem-solving, and evaluating ideas or actions. This domain on the acquisition and use of knowledge is predominant in most courses. Bloom identified six levels within the cognitive domain, from the simple recall or recognition of facts as the lowest level, through increasingly complex and abstract mental levels, to the highest order, evaluation. The six progressive stages of cognitive thinking are identified as knowledge (recall), comprehension, application, analysis, synthesis, and evaluation. Bloom's initial work was followed up with research that resulted in a list of Action Verbs representing intellectual activity on each cognitive domain's respective level.

Krathwohl (1964) took the lead to produce a parallel taxonomy explaining the development of attitudes, principles, codes, and human values. Affective learning is demonstrated by behaviors indicating attitudes of awareness, interest, attention, concern, responsibility, ability to listen and respond in interactions with others, and the ability to demonstrate those attitudinal characteristics or values appropriate to the test situation and the field of study. This domain relates to emotions, attitudes, appreciations, and values, such as enjoying, conserving, respecting, and supporting. Six progressive stages constitute personal growth in the affective domain: affective perceiving, reacting, conforming, validating, affective judging, and affective creating. Verbs applicable to the affective domain include accept, attempt, defend, dispute, join, judge, praise, question, share, support, and volunteer.

Kibler et al. (1970) completed the trilogy of taxonomies with the physical dimensions of behavior as it develops from gross to fine movements and nonverbal to verbal activities. Psychomotor learning is demonstrated by physical skills; coordination, dexterity, manipulation, grace, strength, speed; actions that demonstrate the fine motor skills such as the use of precision instruments or tools, or actions that evidence gross motor skills such as the use of the body in dance or athletic performance. The categories include psychomotor perceiving, activating, executing, maneuvering, psychomotor judging, and psychomotor creating. Verbs applicable to the psychomotor domain include bend, grasp, handle, operate, reach, relax, shorten, stretch, write, differentiate (by touch), express (facially), perform (skilfully).

Together, these taxonomies for cognitive learning, social interaction, and physical development are the recognized building blocks for creating measurable learning outcomes, planning instruction, and measuring the attainment of outcomes.

Bloom's taxonomy has been revisited several times by educational psychologists, and several variants of the original taxonomy were proposed. L. W. Anderson, D.R. Krathwohl, and others presented a revision of Bloom's taxonomy of educational objectives in 2001 to re-establish the relevance of the ideas in Handbook (1956) and to incorporate new knowledge and thought produced since 1956. The revised Bloom's Taxonomy of cognitive domain was two-dimensional in contrast to the single dimension of the original taxonomy. The suggested two dimensions are cognitive process and knowledge. The cognitive process dimension contains six categories: Remember, Understand, Apply, Analyze, Evaluate, and Create. These cognitive processes are organized hierarchically as per cognitive complexity. For example, the process Apply is at higher cognitive complexity than Understand, which means Apply cognitive activities are likely to involve cognitive activities belonging to Understand and Remember cognitive levels. The knowledge dimension contains four categories: Factual, Conceptual, Procedural, and Metacognitive. The two-dimensional nature of the Revised Taxonomy allows a more natural expression of an outcome statement.

Revised Bloom's Taxonomy is two-dimensional with six cognitive processes and four knowledge categories

A typical outcome statement has some subject matter content (a noun or noun phrase) and a description of what is to be done with or to that content (a verb or verb phrase). Consider the statement: State Maxwell's field equations.

- Maxwell's field equations: Subject matter content (Knowledge category)
- State: What is to be done with or to that content - Recall (Cognitive Process)

There exist several other taxonomies: SOLO, Fink, Gagne, and Marzano & Kendall. All taxonomies attempt to structure the processes involved in learning based on observations of learning behaviors and the limited understanding of how the brain functions. Our focus will be on Revised Bloom's Taxonomy and Revised Bloom-Vincenti Taxonomy, which includes additional categories of knowledge specific to Engineering.

3.2 Cognitive Processes

Cognitive processes are attention, perception, comprehension, calculation, judgment, storing in memory, reasoning, retrieval from memory, learning, planning, problem-solving, self-monitoring, and speech formation. Knowledge recall and the intellectual skills: comprehending information, organizing ideas, analyzing, and synthesizing data, applying knowledge, choosing among alternatives in problem-solving, and evaluating ideas or actions demonstrate cognitive

learning. This domain on the acquisition and use of knowledge is predominant in most courses. As per the revised Bloom's taxonomy, the taxonomy of cognitive processes involved in learning are

- Remember
- Understand
- Apply
- Analyze
- Evaluate
- Create

There are several subprocesses associated with each one of these cognitive processes.

The four categories of knowledge considered by the Revised Bloom taxonomy are

- Factual
- Conceptual
- Procedural
- Metacognitive

One must use the words representing the six categories of cognitive processes with specific meanings defined by Bloom. Let us understand the cognitive processes.

3.2.1 Remember

The process category is Remember when the objective of instruction is to promote retention of the presented material in much the same form as it was presented. Remembering involves retrieving relevant knowledge from long-term memory. The two associative cognitive processes are **recognizing** and **recalling**.

The student is given recognition or recall-task under conditions very similar to those in which he or she learned the material to assess student learning in the simplest process category. Little, if any, extension beyond those conditions is expected. If, for example, a student has learned the symbols for various logical functions, then the test of remembering could involve requesting the student to match the logical functions given in one list with symbols shown in a second list. The test for recall could include asking the student to provide the symbols for specified logical functions.

Remember cognitive process has two processes: Recognize and Recall

Remembering knowledge is essential for meaningful learning and problem-solving. However, when teachers focus on meaningful learning, remembering knowledge is integrated within the more significant task of constructing new knowledge or solving new problems.

Recognizing involves retrieving relevant knowledge from long-term memory to compare it with the presented information. In recognizing, the student searches long-term memory for a piece

of identical or very similar information to the given information. Three main methods of presenting a recognition task for the purpose of assessment are verification, matching, and forced choice.

Recalling (retrieving) involves retrieving relevant knowledge from long-term memory when given a prompt to do so. The prompt is often a question. In recalling, a student searches a long-term memory for a piece of information and brings that piece of information to working memory where it can be processed.

Remembering, therefore, is retrieving relevant knowledge from long-term memory. The relevant knowledge may be factual, conceptual, procedural, or some combination of these. Remembering knowledge is essential for meaningful learning and problem-solving. Some action verbs associated with remembering activity include *recognize, recall, list, tell, locate, write, find, mention, state, draw, label, define, name, describe, prove a theorem.*

Some sample Remember activities are:

- What percentage of Kerala state income comes from foreign remittances?
- What is the occupational structure of the Kerala population?
- What is confessional poetry?
- Who gave the call "Swaraj is my birth right, and I shall have it"?

Some generic questions related to **Remember** activities are:

- What happened after...?
- How many...?
- Who was it that...?
- Can you name the...?
- Describe what happened at...?
- Who spoke to...?
- What is the meaning of...?

3.2.2 Understand

Students are said to understand when they can construct meaning from instructional messages, including oral, written, graphic communications. These messages are presented to students during lectures, in books, or on computer monitors. Examples of instructional messages include laboratory demonstrations, observations during field trips and role-playing sessions, results of computer simulations, and verbal, pictorial, and symbolic representations on paper. Students understand when they build connections between the new knowledge to be gained and their

Understand cognitive process has seven sub-processes: Interpret, Exemplify, Classify, Summarize, Infer, Compare, and Explain

prior knowledge. Since concepts are building blocks for these schemas and frameworks, conceptual knowledge provides a basis for understanding. Cognitive sub-processes in this category of Understand and the associated action verbs are:

- Interpret: Translate, paraphrase, represent and clarify
- Exemplify: Illustrate and instantiate
- Classify: Categorize and subsume
- Summarize: Generalize and abstract
- Infer: Find a pattern
- Compare: Contrast, match, and map
- Explain: Construct a model

The word "Understand" is to be used in the context of Revised-Bloom taxonomy to mean strictly to represent these seven sub-processes.

Interpretingoccurs when a student converts information from one representative form to another. Interpreting may involve converting words to words (paraphrasing), pictures to words, words to pictures, numbers to words, words to numbers, and the like. Alternative terms for interpreting are translating, paraphrasing, representing, and clarifying.

Exemplifyingoccurs when a student gives a specific example or instance of a general concept or principle. Exemplifying involves identifying the general concept or principle's defining features and using these features to select or construct a specific instance. Alternative terms are illustrating and instantiating.

Classifying occurs when a student recognizes that something belongs to a specific category (concept or principle). Classifying involves detecting relevant features or patterns that fit both the instance and concept or principle. Classifying is a complementary process to exemplifying. Alternative terms for classifying are categorizing and subsuming.

Summarizingoccurs when a student suggests a single statement that represents presented information or abstracts a general theme. Summarizing involves constructing a representation of information, such as the meaning of a scene in a play, and abstracting a summary from it, such as determining a theme or main points. Alternate terms are generalizing and abstracting.

Inferring involves finding a pattern within a series of examples or instances. Inferring occurs when a student abstracts a concept or principle that accounts for a set of examples or instances by encoding the relevant features or each instance and, most important, by noting relationships among them. A student can distinguish a pattern in the series of numbers 1, 2, 3, 5, 8, 13, 21, …. The process of inferring involves making comparisons among instances within the context of the entire set. A related process uses the pattern to create a new instance (e.g., the next number on the series is 34, the sum of 21 and 13). It is an example of executing, which is a cognitive process associated with Apply. Inferring and executing are often used together on cognitive tasks.

Comparing involves detecting similarities and differences between two or more objects, events, ideas, problems, or situations, such as determining how a 'well-known event' is like or unlike a less familiar event. Comparing includes finding a one-to-one correspondence between elements and patterns in one object, event, or idea and those in another object, event, or idea. When used in conjunction with inferring (e.g., first, abstracting a rule from the more familiar situation) and implementing (e.g., second, applying the rule to the less familiar situation), comparing can contribute to reasoning by analogy. Alternative terms are contrasting, matching, and mapping.

Explaining occurs when a student constructs and uses a cause-and-effect model of a system. The model may be derived from formal theory (as is often the case of the natural sciences) or experience. A complete explanation involves constructing a cause-and-effect model, including each significant part in the system or each major event in the chain, and using the model to determine how a change in one part of the system or one "link" in chain influences another section or the whole. An alternate term of explaining is constructing a model.

Some sample **Understand** activities are:

- Identify the characters of Phylum Annelida with its classification
- Compare the Indian Freedom Movement with other Asian and African Freedom Movements.
- Understand the agriculture commodity price fluctuations using Cobweb Theorem.
- Illustrate the exclusion of marginalized populations from the fruits of development.
- Explain financial statements using fund flow and cash flow.
- Estimate marginal utility from the total utility.

Some generic questions related to **Understand** activities are:

- Provide an example of... .?
- What was the main idea expressed in... .?
- Write in your own words...?
- Write a brief outline...?
- What do you think could happen next...?
- Who do you think...?
- Distinguish between...?
- What differences exist between...?
- Provide an example of what you mean...?

3.2.3 Apply

Apply involves using procedures to perform exercises or solve problems. Thus, apply is closely linked with *Procedural Knowledge.* An exercise is a task for which the student already knows the proper procedure to use, so the student has developed a routinized approach to it. A problem is a task for which the student initially does not know what procedure to use, so the student must locate a procedure to solve the problem. The apply process consists of two cognitive processes: *executing* – when the task is an exercise (familiar) – and *implementing* – when the task is a problem (unfamiliar).

Executeoccurs whena student routinely carries out a procedure when confronted with a familiar task (exercise). The familiarity of the situation often provides clues to guide the choice of the appropriate procedure to use. Executing is more frequently associated with the use of *skills* and *algorithms* than with the *techniques* and *methods*. Skills and algorithms have two qualities that make them particularly amenable to executing. First, 'executing' consists of a sequence of steps followed in a *fixed order*. Second, when you perform all the steps correctly, the result is a predetermined answer. An alternative term for *executing* is *carrying out*.

Implement occurs when a student selects and uses a procedure to perform an unfamiliar task. Because selection is required, the student must understand the type of problem encountered and the range of available procedures. Thus, implementing is used in conjunction with other cognitive process categories, such as *Understand* and *Create*. Because the student faces an unfamiliar problem, he or she does not immediately know which of the available procedures to use. Furthermore, no single procedure may be a "perfect fit" for the problem; some procedures may require modifications. Implementing is more frequently associated with the use of techniques and methods than with skills and algorithms. Techniques and methods have two qualities that make them particularly amenable to implementation. First, the procedure may be more like a "flow chart" than a fixed sequence; that is, the procedure may have "decision points" built into it. Second, there often is no single, fixed, and expected answer when the procedure is applied correctly. The notion of no 'single and fixed' solution is especially applicable to objectives that call for applying *conceptual knowledge* such as theories, models, and structures where no known procedures seem to exist. An alternative term for *implementing* is *using*.

Apply cognitive process has two sub-processes: Execute and Implement

Some sample **Apply** activities are:

- Trace the historical background of American Literature
- Determine the correctness of English pronunciation over a range of recognized international accents.
- Compute the Energies and Wave functions of the Hydrogen atom using Schrodinger equation.

- Prepare scripts for radio talks, newspaper articles, and television talks on health, nutrition, and family living for tribal, rural, and urban groups.
- Carry out the transcription of the given dialogue
- Compute the trend from financial statements
- Do you know another instance where . . .?

3.2.4 Analyze

Analyse involves breaking material into its constituent parts and determining how the parts are related to one another and an overall structure. This process category includes the cognitive processes of differentiating (determining the essential and vital pieces of a message), organizing (determining how the parts of the message are organized), and attributing (identifying the purpose of the message). Learning to maybe as an end itself. Educationally it is considered as an extension of Understanding or as a prelude to Evaluating and Creating. A teacher may wish to develop in his/her students the ability to:

- Distinguish fact from opinion (or reality from fantasy)
- Connect conclusions with supporting statements
- Distinguish relevant from extraneous material
- Determine how ideas are related to one another
- Ascertain the unstated assumptions involved in what is said
- Find evidence in support of the author's purposes

The processes of Understanding, Analysing, and Evaluating are interrelated and often used iteratively in performing cognitive tasks. At the same time, however, it is important to maintain them as separate process categories. A person who understands communication may not be able to do it well. Similarly, someone who is skilful in analyzing a communication may evaluate it poorly.

Differentiating involves distinguishing the parts of a whole structure in terms of their relevance or importance. *Differentiating* occurs when a student discriminates relevant from irrelevant information, important from unimportant, and then attends to relevant and essential information. *Differentiating* differs from *comparing* in using the broader context to determine what is appropriate and crucial. In 'comparing,' all factors are equal irrespective of their relevance and importance. Alternate terms for *differentiating* are *discriminating*, *selecting*, *distinguishing*, and *focusing*.

Organizing involves identifying the elements of communication or situation and recognizing how they fit together into a coherent structure. In organizing, a student builds systematic and logical connections among the pieces to the presented information. *Organizing* usually occurs in conjunction with *differentiating*. The student first identifies the relevant or essential elements and then determines the overall structure within which the components fit. *Organizing* can also occur in conjunction with *attributing*, in which the focus is on identifying the author's intention

or point of view. Alternative terms for *organizing* are *structuring*, *integrating*, *findingcoherence*, *outlining*, and *parsing*.

Attributing occurs when a student ascertains the point of view, biases, values, or intentions underlying communications. *Attributing* involves a process of deconstruction, in which a student determines the author's intentions of the presented material. In contrast to interpreting, in which the student seeks to *understand* the meaning of the submitted content, *attributing* involves extension beyond basic *understanding* to infer the intention or point of view underlying the submitted material. An alternative term is *deconstructing*.

Analyze cognitive process has three sub-processes: Differentiate, Organize and Attribute

Some sample **Analyze** activities are:

- refining generalizations and avoiding oversimplifications
- developing one's perspective: creating or exploring beliefs, arguments, or theories
- clarifying issues, conclusions, or beliefs
- developing criteria for evaluation: defining values and standards
- evaluating the credibility of sources of information
- questioning deeply: raising and pursuing root or significant questions
- clarifying arguments, interpretations, beliefs, or theories
- reading critically: clarifying or critiquing texts
- examining or evaluating assumptions
- distinguishing relevant from irrelevant facts
- making plausible inferences, predictions, or interpretations
- giving reasons and evaluating evidence and alleged facts
- recognizing contradictions
- exploring implications and consequences

Some generic questions related to **Analyze** activities are:

- Structure evidence into for and against a historical description?
- Determine the point of the author of an essay in terms of his or her political perspective?
- Identify the cause and effect of advertising in FMCG?
- Analyze given literature from feminist and post-colonial approaches?
- Identify the historical development of Sanskrit plays?
- What is the theme . . ..?
- What evidence can you find . . .?
- What motive is there . . .?
- How is … is related to . . .?

3.2.5 Evaluate

Evaluate is defined as making judgments based on criteria and standards. The criteria most often used are quality, effectiveness, efficiency, and consistency. Students or the tester will identify criteria. The standards may be quantitative or qualitative. Evaluating includes the cognitive processes of checking (judgments about internal consistency) and critiquing (judgments based on external criteria). However, all judgments are evaluative. Most cognitive processes require some form of judgment. What most differentiates Evaluate from other students' judgments is the use of standards of performance with clearly defined criteria. Is this machine or software working as efficiently as it should be? Is this method the best way to achieve the goal? Is this approach the most cost-effective than other approaches?

Checking involves testing for internal inconsistencies or fallacies in operation or a product. For example, *checking* occurs when a student tests whether a conclusion follows its premises, whether data support or disconfirm a hypothesis, or whether presented material contains parts that contradict one another. When combined with *planning* (a cognitive process in the category *Create*) and *implementing* (a cognitive process in the category *Apply*), checking involves determining how well the plan is working. Alternative terms for *checking* are testing, detecting, monitoring, and coordinating.

Critiquing involves judging a product or operation based on externally imposed criteria and standards. *Critiquing* lies at the core of what has been called critical thinking. An example of *critiquing* is judging the merits of a solution to the problem of acid rain in terms of likely effectiveness and its associated costs. An alternate name is judging.

Evaluate cognitive process has two sub-processes: Check and Critique

Some sample **Evaluate** activities are:

- Select the factor among the following that has maximum impact on climate change
    - Carbonated soft drinks like Pepsi and Coke
    - Automobiles
    - Cell phones
    - Fast food
- What would you recommend . . .?
- What would you cite to defend the actions . . .?
- What choice you would have made . . .?
- How would you rate the . . .?

3.2.6 Create

Create involves putting elements together to form a coherent or functional whole. Objectives classified as Create have students make a new product by mentally reorganizing some elements or parts into a pattern or structure not-present before. Although Create requires creative thinking on the student's part, this is not entirely free creative expression unconstrained by the demands of the learning task or situations. To some persons, creativity is the production of superior products, often due to some special skills. 'Create,' as used here, includes objectives that call for unique production, also refers to objectives calling for production that all students can and will do. If nothing else, in meeting these objectives, many students will create in the sense of producing their synthesis of information or materials to form a new whole, as in a circuit, a software unit, a mechanism, a structure, and so on.

Although the process categories of Understand, Apply, and Analyse may involve detecting relationships among the presented elements, Create is different because it also consists of constructing an original product. Unlike create, the other categories include working with a given set of elements that are part of a given whole; that is, they are part of a larger structure the student is trying to understand. In creating, on the other hand, the student must draw upon elements from many sources and put them together into a novel structure or pattern relative to his or her prior knowledge. Create results in a new product, which is more than the student's beginning materials. A task that requires Create is likely to require aspects of each of the earlier cognitive process categories to some extent, but not necessarily in a specific order.

The creative process is of three phases: problem representation, in which a student attempts to understand the task and generate possible solutions; solution planning, in which a student examines the possibilities and devices a workable plan; and solution execution, in which a student successfully carries out the plan. Therefore, the creative process can be thought of as starting with a divergent phase in which a variety of possible solutions are considered as the student attempts to understand the task (generating). This phase is followed by a convergent phase, in which the student devises a solution method and turns it into a plan of action (planning). Finally, the plan is executed as the student constructs the solution (producing). It is not surprising that the Create is associated with three cognitive processes: generating, planning, and producing.

Generating involves representing the problem and arriving at alternatives or hypotheses that meet specific criteria. Often, the way a problem is initially described suggests possible solutions; however, redefining or coming up with a new representation of the problem may suggest different solutions. When generating transcends the boundaries or constraints or prior knowledge and existing theories, it involves divergent thinking and forms the core of creative thinking. Generating is used in a restricted sense here. Understand also requires generative processes included in translating, exemplifying, summarizing, inferring, classifying, comparing, and explaining. However, the goal of Understanding is most often convergent (that is, to arrive

at a single meaning). In contrast, the purpose of generating within Create is divergent (that is, to arrive at various possibilities). An alternative term for generating is hypothesizing.

Planning involves devising a solution method that meets a problem's criteria, developing a plan for solving the problem. Planning stops short of carrying out the steps to create a real solution for a given problem. In planning, a student may establish sub-goals or break a task into subtasks to be performed when solving the problem. An alternative term is designing.

Producing involves carrying out a plan for solving a given problem that meets specifications. Objectives within the category Create may or may not include originality or uniqueness as of the specifications. So, it is with producing objectives. Producing can require the coordination of the four types of knowledge. An alternative term is construction**.**

Created cognitive process has three sub-processes: Generate, Plan and Produce

Some sample **Create** activities are:

- Design a flowchart showing the energy flow in the Western Ghats.
- Create a plan to conserve the wetland ecosystem.
- Create awareness on issues related to health, nutrition, and family using audio, visual, and audio-visual technologies.
- Design a marketing mix for fairness cream among working women in Tamil Nādu during summer.
- Produce a 30-minute movie out of a 2-hour feature film using specified techniques of editing.

3.2.7 Critical Thinking

Critical thinking involves cognitive processes including 1) identifying the assumptions that frame our thinking and determine our actions, 2) checking out the degree to which these assumptions are accurate and valid, 3) looking at our ideas and decisions (intellectual, organizational, and personal) from several different perspectives, and 4) based on all this taking informed actions. The basic typology of the assumptions that critical thinking unearths and scrutinizes includes paradigmatic, prescriptive, and causal (Brookfield 2012). Paradigmatic assumptions are the hardest of all assumptions to uncover. They are the structuring assumptions we use to order the world into fundamental categories. Usually, we do not even recognize them as assumptions, even after being pointed out to us. Prescriptive assumptions are assumptions about what we think ought to be happening in each situation. They are the assumptions that surface as we examine how we think, we/others should behave, what good learning and educational processes should look like, and what obligations students and teachers owe to each other. Inevitably they are grounded in, and extensions of, our paradigmatic assumptions. Causal assumptions are assumptions about how different parts of the world work and the conditions under which they

can be changed. Of all the assumptions we hold, causal ones are the easiest to uncover. Approximately 80% of assumptions covered in any conversation, class, course, or workshop will be causal. Causal assumptions are usually stated in two ways: when those assumptions govern future behavior, and the second ones are stated retroactively or historically. Assumptions are rarely right or wrong; they are contextually appropriate.

Critical thinking unearths and scrutinizes paradigmatic, prescriptive, and causal assumptions. Revised-Bloom's taxonomy addresses critical thinking through its core cognitive activities and Analyze and Evaluate

There are five distinct intellectual traditions shaping understandings of critical thinking.

1. Analytic philosophy and Logic: Detecting Language Tricks
2. Natural Sciences: The Hypothetico-Deductive Method
3. Pragmatism: The Experimental Pursuit of Beautiful Consequences
4. Psychoanalysis: Living an Integrated, Authentic Life
5. Critical theory: Speaking Truth to Power

These traditions are distinct but are not mutually exclusive.

We do critical thinking to take informed actions - actions that are grounded in evidence, can be explained to others, and stand a good chance of achieving the results we desire.

3.2.8 Problem Solving

The problem-solving process consists of

- Identification of the problem (Analyse)
- Explore and develop alternative solutions (Create)
- Select the best alternative (Evaluate)
- Implement (build and test the selected solution) (Apply)
- Evaluate the result (Evaluate)

The problem-solving process, therefore, involves some or all the Revised-Bloom cognitive processes. One proposed taxonomy of Problem Solving

- Routines (Apply)
- Diagnosis (Selecting a method: Apply and Analyse)
- Strategy (Order of using methods: Analyse and Evaluate)
- Interpretation (Multiple higher cognitive levels)
- Generation (Multiple higher cognitive levels)

Revised-Bloom taxonomy subsumes Critical Thinking and Problem-Solving processes. The classification of cognitive processes proposed by Revised-Bloom, or any other taxonomy of cognitive processes, should only be considered approximate. For example, it is difficult to draw a line between Understanding and Analysis. According to some neurologists, Revised-Bloom taxonomy appears to be not in contradiction with the processes taking place in the brain.

The analysis of cognitive processes presented here has implications for both teaching and assessing. On the teaching side, two of the cognitive processes help to promote retention of learning, whereas 17 of them help to foster the transfer of learning. Thus, when the goal of instruction is to facilitate the transfer, objectives should include the cognitive processes associated with Understand, Apply, Analyse, Evaluate, and Create. On the assessment side, the analysis of cognitive processes is intended to help broaden their assessment of learning. When instruction is to promote transfer, assessment tasks should tap cognitive processes that go beyond remembering.

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CHAPTER 4

Categories of Knowledge

4.1 Introduction

While the word 'knowledge' is extensively used by all, there is no single agreed definition of 'knowledge' at present, nor any prospect of one. Knowledge is a term that has been actively and continually defined. Knowledge is a complex of several related ideas. Consider some of the definitions.

Knowledge is relationships, facts, assumptions, heuristics, and models derived through the formal and informal analysis or interpretation of data. (Information Society Technologies http://cordis.europa.eu/ist/ka1/ administrations/publications/glossary.htm).

Knowledge is defined as remembering previously learned material. This may involve the recall of specific facts or complete theories, but all that is required is the rote memory of the appropriate information. Knowledge represents the lowest and most basic level of learning. www.drdan.org/Hnadout%2017.htm

Knowledge is the internalization of information, data, and experience home.earthlink.net/~ddstuhlman/defin1.htm.

Knowledge is the psychological result of the perception of learning and reasoning http://wordnetweb.princeton.edu/perl/webwn?s=knowledge.

Knowledge is accumulated external and explicit information belonging to the community, being leveraged by tacit intrinsic insights that originate within individuals who then may act alone or cooperatively to control or integrate with their environment.

http://www.pacrimcross.com/kmguidelines/ defknow.html.

Knowledge is defined (Oxford English Dictionary) variously as expertise and skills acquired by a person through experience or education; the theoretical or practical understanding of a subject what is known in a field; facts and information awareness or familiarity gained by experience of a fact or situation

A branch of philosophy, called **'**epistemology**,'** is dedicated to the study of knowledge, and its sources, varieties, and limits. In any branch of philosophy, there are at least two competing views. In epistemology, one view referred to as **'**empiricism**,'** holds that knowledge is derived from experience, whereas 'apriorism' considers that knowledge is innate. The extreme form of empiricism is referred to as 'positivism' or 'logical positivism.' It holds that nothing is innate and that only that which can be measured is worth worrying about. The extreme form of apriorism denies the very idea of knowledge existing outside the individual mind. The conventional attitude adopted by non-philosophers is a kind of truce between the two extremes.

The Second half of the twentieth century has witnessed many new turns in the epistemic scenario, the latest among which is a turn towards situated knowledge/cognition. In stark contrast to the traditional epistemology where knowledge was and still is construed as individual, rational, abstract, a perspectival, and value-neutral situated epistemology upholds knowledge to be social, not insulated from emotion, concrete, perspectival and value-endowed. More specifically, the concept of situated cognition is a cluster-concept, and its degree of situatedness depends on how many traits of 'situatedness' have been reflected in a piece of cognition. The said cluster includes three theses: (a) cognition depends not just on the mind/brain but also on the body (the embodiment thesis), (b) cognitive activities routinely exploit structures of the natural and social environment (the embedding thesis), and (c) the boundaries of cognition extend beyond the boundaries of an individual organism (the extension thesis).

The perspective of knowledge, as considered here, is based on the current perspectives in cognitive science and cognitive psychology on knowledge presentation. We do not adhere to a simple behaviorist view that knowledge is best represented as an accumulation of association between stimuli and responses or merely a quantitative increase in bits of information. Instead, our perspective reflects the idea that knowledge is organized and structured by the learner in line with a rationalist-constructivist tradition. Based on cognitive science research on the development of expertise, expert thinking, and problem-solving, our perspective is that knowledge is domain-specific and contextualized. Our understanding of knowledge should reflect this domain specificity and the role that social experiences and context play in the construction and development of knowledge.

4.2 Types of Knowledge

There are many distinct types of knowledge, and even more terms used to describe them. Some of the terms are conceptual knowledge, conditional knowledge, content knowledge, declarative knowledge, disciplinary knowledge, discourse knowledge, domain knowledge, episodic knowledge, explicit knowledge, factual knowledge, metacognitive knowledge, prior knowledge, procedural knowledge, semantic knowledge, situational knowledge, sociocultural knowledge, strategic knowledge, and tacit knowledge. Some of the different terms signify essential differences among the varieties of knowledge, whereas others are different labels for the same knowledge category. Considering several constraints to categorization and the need for simplicity and ease of use, we propose four general types of knowledge (Anderson et al., 2001) relevant across all disciplines:

- Factual Knowledge
- Conceptual Knowledge
- Procedural Knowledge
- Metacognitive Knowledge

Factual knowledge refers to specific content elements such as terms and facts (bits of information). Conceptual knowledge refers to more general concepts, principles, models, or theories. Procedural knowledge is the "knowledge of how" to do something. The "something" might range from completing routine exercises to solving novel problems. Current cognitive and social constructivist models of learning emphasize ideas such as consciousness, awareness, self-reflection, self-regulation, and thinking about and controlling one's thinking and learning, which were excluded by behaviorist psychology models. Because these activities focus on cognition itself, the prefix meta is added to reflect that metacognition is 'about' or 'above' cognition. Both cognitive and constructivist models agree on the importance of facilitating students' thinking about their thinking. Here we define "metacognitive knowledge" as "knowledge about cognition." Learners can activate the relevant situational, conditional, or cultural knowledge for solving a problem in a specific context.

These four categories of knowledge apply to all disciplines, but do not constitute a complete set. There are categories of knowledge specific to Engineering, Social Sciences, Computing, Management, Economics, etc. While categories of knowledge specific to Social Sciences, Computing, Management, and Economics are not enunciated definitively, the categories of knowledge specific to Engineering have been identified (Vincenti 1990).

The four types of knowledge and their sub-types are explored further in the following sections.

4.2.1 Factual Knowledge

Factual knowledge contains the basic elements students must know if they are to be acquainted with the discipline or solve any of the problems in it. The elements are usually symbols associated with some concrete referents, or "strings of symbols" that convey essential information. Factual Knowledge exists at a low level of abstraction. As our knowledge increases in all fields of inquiry, even experts in these fields have difficulty keeping up with all the new elements. Consequently, some selection for educational purposes is always required. The two subtypes of Factual Knowledge are knowledge of terminology and knowledge of specific details and elements.

Factual knowledge refers to specific content elements such as terms and facts (bits of information).

Knowledge of terminology includes specific verbal and nonverbal labels and symbols (e.g., words, numerals, signs, pictures). Each subject matter contains many labels and symbols, both verbal and nonverbal, that have referents. They are the basic language of the discipline – shorthand used by experts to express what they know. The novice learner must be cognizant of these labels and symbols and learn the accepted referents that are attached to them. Some examples of knowledge of terminology are

- Knowledge of the alphabet and numbers
- Knowledge of engineering or technical terms

- Knowledge of physical and chemical constants
- Knowledge of mathematical and graphic representations
- Knowledge of specific details and elements refers to knowledge of events, locations, people, dates, sources of information, and the like.

It may include exact and specific information, such as the exact date of an event or the exact magnitude of a phenomenon, which could be descriptive or prescriptive. It may also include approximate information, such as a period in which an event occurred or the general order of magnitude of the phenomenon. Specific facts are those that can be isolated as separate, discrete elements in contrast to those that can be known only in a broader context.

Knowledge of specific details and elements: The facts of a given subject belong to this category. However, the tremendous number of particular facts forces educators (curriculum specialists, textbook authors, and teachers) to make choices about what is basic and secondary importance or importance primarily to experts.

Some examples of **knowledge of specific details and elements** are:

- Knowledge of products, companies, and major stakeholders related to biochemical measuring equipment
- Knowledge of notable events and persons in the evolution of biochemistry
- Knowledge of prominent European and Indian historians
- Knowledge of currently used cinematographic equipment
- Knowledge of performance characteristics of commercially available optical microscopes

4.2.2 Conceptual Knowledge

A concept denotes all the entities, phenomena, and/or relations in each category or class by using definitions. Concepts are abstract in that they omit the differences of the things in their extension, treating the members of the extension as identical. Classical concepts are universal in that they apply equally to everything in their extension. Concepts are also the essential elements of propositions, much the same way a word is the essential semantic element of a sentence. Unlike perceptions, which are images of individual objects, concepts cannot be visualized. Because they are not themselves individual perceptions, concepts are discursive and result from reason. Concepts are bearers of meaning, as opposed to agents of meaning. A single concept can be expressed in any number of languages. The concept of DOG can be expressed as a dog in English, Hund in German, as Nayi in Kannada, and Kuttha in Hindi. The fact that concepts are, in some sense, independent of language makes translation possible - words in various languages have identical meanings because they express the same concept.

Conceptual knowledge includes knowledge of categories and classifications, and the relationships between and among them – more complex, organized knowledge forms. Conceptual knowledge includes schemas, mental models, or implicit or explicit theories in different cognitive psychological models. These schemas, models, and theories represent the knowledge an individual has about how a subject matter is organized and structured, how the various parts or bits of information are interconnected and interrelated in a more systematic manner, and how these parts function together. For example, the mental model of how a computer works may include ideas about how information can be represented in binary form, Boolean algebra, logical expressions, registers, instructions, control unit, ALU, primary memory, secondary memory, storage media, display of information, keyboards, printers, etc. This type of conceptual knowledge might be one aspect of what is termed "disciplinary knowledge."

Conceptual knowledge refers to more general concepts, principles, models, or theories.

Conceptual knowledge includes three subtypes: knowledge of classifications and categories, knowledge of principles and generalization, and knowledge of theories, models, and structures. Classification and categories form the basis for principles and generalizations. These, in turn, form the basis for theories, models, and structures. These three subtypes should capture a great deal of the knowledge that is generated within different disciplines.

Knowledge of Classification and Categories includes specific categories, classes, divisions, and arrangements that are used in different subject matters. This type of knowledge is more general and often more abstract than terminology and specific facts. Each subject matter has a set of categories that are used to discover new elements and deal with them once they are discovered. Classification and categories differ from terminology and facts in that they form the connecting links between and among specific elements. When one is concerned with realizing a logic expression, the major categories include 'binary variables' 'logic functions,' 'truth-tables,' 'hardware logic units,' 'assertion levels,' etc.

Sometimes it is challenging to distinguish knowledge of classifications and categories from factual knowledge. Primary classifications and categories can be placed into larger, more comprehensive classifications and categories. For example, binary, hex, octal, and decimal systems can be placed into number systems.

Knowledge of classifications and categories is an essential aspect of developing expertise in an academic discipline. Proper classification of information and experience into appropriate categories is a classic sign of learning and development. Some examples of knowledge of classification and categories are

- Knowledge of number systems
- Knowledge different computers

Principles and Generalizations are composed of classifications and categories. Principles and generalizations tend to dominate an academic discipline and are used to study phenomena or solve problems in the discipline. These include abstractions that summarize observations of phenomena and have the highest value in describing, predicting, explaining, or determining the most appropriate and relevant action or direction to be taken. Principles and generalizations bring together many specific facts and events, describe the processes and interrelationships among these specific details (thus forming classifications and categories, and describe processes and interrelationships and among the classifications and categories). Principles and generalizations enable us to organize the whole in an economical and coherent manner.Examples of knowledge of principles and generalizations are

- Knowledge of fundamental laws of physics
- Knowledge of Boolean algebra
- Knowledge of the principles that govern trigonometric operations

Knowledge of Theories, Models, and Structures include different paradigms and epistemologies that disciplines have for structuring inquiry. Students should know these separate ways of conceptualizing and organizing subject matter and areas of research within the subject matter.

For example, the relevant operating characteristics of electrical and electronic devices are described through currents and voltages as time functions at appropriately selected points or point pairs. An expert in a discipline knows not only the different disciplinary theories, models, and structures but also their relative strengths and weaknesses and can think "within" as one of them as well as "outside" any of them. Examples of knowledge of theories, models, and structures are

- Knowledge of social network theory
- Knowledge of field theory
- Knowledge of behavioral, cognitive, and social constructivist theories of learning
- Knowledge of systems view of organizations

4.2.3 Procedural Knowledge

Procedural knowledge is the "knowledge of how" to do something. The "something" might range from completing routine exercises to solving novel problems. Procedural knowledge often takes the form of a series or sequence of steps to be followed. It includes knowledge of skills, algorithms, techniques, and methods, collectively known as procedures. Procedural knowledge also includes knowledge of the criteria used to determine when to use the procedures.

Procedural knowledge is specific or germane to a subject matter or an academic discipline. In mathematics, for example, there are algorithms to find the local minimum value of a function to determine the determinant of a square matrix, etc. In digital systems, there are methods to

prepare a truth-table from a logic expression, to minimize a given logic expression, to do state assignment, etc. The subcategories of procedural knowledge are:

- Knowledge of subject-specific skills and algorithms
- Knowledge of subject-specific techniques and methods
- Knowledge of criteria for determining when to use appropriate procedures

Knowledge of subject-specific skills and algorithms can be expressed as a series or a sequence of steps. Sometimes the steps are followed in a fixed order; at other times, decisions must be made which step to perform next. The result is considered fixed in this type of knowledge.Examples of this category of knowledge include

- Knowledge of algorithms used with mathematical operations
- Knowledge of algorithms for minimizing logic expressions
- Knowledge of pattern-search algorithms in Artificial Intelligence

Knowledge of subject-specific techniques and methods includes knowledge that is mostly the result of consensus, agreement, or disciplinary norms rather than knowledge that is more directly an outcome of observation, experimentation, or discovery. This subtype of knowledge reflects how experts in the field or discipline think and solve problems. Examples of this category of knowledge include

- Knowledge of algorithms for minimizing logic expressions
- Knowledge of pattern-search algorithms in Artificial Intelligence
- Knowledge of behavioral, cognitive, and social constructivist theories of learning
- Knowledge of systems view of organizations

Knowledge of criteria for determining when to use appropriate procedures involves knowing the ways they have been used in the past. Systematization is used by subject matter experts as they solve problems in their field. Experts know when and where to apply their knowledge. They have criteria that help them make decisions about when and where to use diverse types of subject-specific procedural-knowledge. Their knowledge is "conditionalized" because they know the conditions under which a given procedure is to be applied. Initially, these criteria are likely to appear complex and abstract to students; they acquire meaning related to concrete situations and problems. Examples of this category of knowledge include

Procedural knowledge is the "knowledge of how" to do something. It also includes knowledge of the criteria used to determine when to use the procedures.

- Knowledge of methods of management research
- Knowledge of system dynamics methods to model complex socio-technical systems

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- Knowledge of the criteria for determining which statistical procedure to use with the data collected in an experiment
- Knowledge of the criteria for determining the performance of Industry and Service sectors in India

4.2.4 Metacognitive Knowledge

Metacognitive knowledge is knowledge about cognition in general and awareness of and knowledge about one's cognition. Regardless of their theoretical perspective, researchers agree that with development, students will become more aware of their thinking and more knowledgeable about cognition in general, and as they act on this awareness, hey will learn better (Bransford, Brown, and Cocking, 1999). The labels for this general developmental trend vary from theory to theory but include metacognitive knowledge, metacognitive awareness, self-awareness, self-reflection, and self-regulation. An essential distinction in the field is between knowledge of cognition and the monitoring, control, and regulation of cognition. Flavell (1979) suggested that metacognition included knowledge of strategy, task, and person variables. These are categorized here as

- Strategic knowledge
- Knowledge about cognitive tasks
- Self-knowledge

Strategic knowledge is knowledge of the general strategies for learning, thinking, and problem-solving. The strategies in this subtype can be used across many different tasks and subject matters. This subtype includes knowledge of the variety of strategies that students might use to memorize material, extract meaning from text, or comprehend what they hear in classrooms or read in books and other course materials. These learning strategies can be grouped into three general categories: rehearsal, elaboration, and organizational (Weinstein and Mayer, 1986).

Strategic knowledge is knowledge of the general strategies for learning, thinking, and problem-solving.

- Rehearsal strategies involve repeating words or terms to be recalled over and over to oneself; they are not the most effective strategies for deeper levels of learning and comprehension.
- Elaboration strategies include using various mnemonics for memory tasks and techniques such as summarizing, paraphrasing, and selecting the main idea from texts. Elaboration strategies foster deeper processing of the material to be learned and result in better comprehension and learning than rehearsal strategies.
- Organizational strategies include various forms of outlining, drawing "cognitive maps", mind mapping or concept mapping, and note-taking; students transform the material from one form to another. Organizational strategies usually result in better comprehension and learning than do rehearsal strategies.

In addition to these general learning strategies, students can know metacognitive strategies useful in planning, monitoring, and regulating their cognition. Students can eventually use these strategies to plan their cognition (e.g., set sub-goals), monitor their cognition (e.g., ask themselves questions as they read a piece of text, check their answer to a math problem) and regulate their cognition (e.g., re-read something they don't understand, go back and "repair" their calculating mistake in a math problem).

Self-knowledge is knowledge of one's strengths and weaknesses of cognition and learning.

This subtype of knowledge also includes general strategies for problem-solving and thinking. These strategies represent the various general heuristics students can use to solve problems, particularly ill-defined problems that have no definitive solution method. Examples of heuristics are means-ends analysis and working backward from the desired goal state. In addition to problem-solving strategies, there are general strategies for deductive and inductive thinking (including evaluating the validity of different logical statements, avoiding circularity in arguments, making appropriate inferences from various sources of data, and heuristic – making decisions from convenient instead of representative symbols).

Students need to develop self-knowledge and awareness about their motivation.

The third subtype includes knowledge about cognitive tasks, including contextual and conditional knowledge. Different cognitive tasks can be difficult, and may make differential demands on the cognitive system, and may require different cognitive strategies. For example, a recall task is more difficult than a recognition task. As students develop knowledge of different learning and thinking strategies, this knowledge reflects both general strategies and how to use them. Students also need to develop conditional knowledge for these general cognitive strategies; in other words, they need to develop some knowledge about when and why of using these strategies appropriately. All these different strategies may not be appropriate for all

situations. The learner must develop some knowledge of different conditions and tasks for which the different strategies are most appropriate. Conditional knowledge refers to knowledge of the situations in which students may use Metacognitive knowledge. If one thinks of strategies as cognitive "tools" that help students construct understanding, then different cognitive tasks require different tools. An important aspect of learning about strategies is the conditional knowledge of when and why to use them appropriately. Another important aspect of conditional knowledge is the local situational and general, conventional, and cultural norms for using different strategies. For example, the strategies used in a classroom learning situation may not be the most appropriate ones to use in a work setting.

Self-knowledge includes knowledge of one's strengths and weaknesses of cognition and learning. One hallmark of experts is that they know when they do not know something, and they then have some general strategies for finding the needed and appropriate information. Self-awareness of the breadth and depth of one's knowledge base is an important aspect of self-knowledge.

Students need to be aware of the several types of general strategies they are likely to rely on in different situations. An awareness that one tends to over-rely on one strategy, when there may be other more adaptive strategies for the task, could lead to a change in strategy use.

In addition to knowledge of one's general cognition, individuals have beliefs about their motivation. Motivation is a complicated and confusing area. A consensus has emerged, however, around general social cognitive models of motivation that propose three sets of motivational beliefs.

- Self-efficacy beliefs that are students' judgments of their capability to accomplish a specific task
- Beliefs about goals or reasons students have for pursuing a specific task (e.g., learning vs.getting a good grade)
- Students' perception of their interest (liking) for a task as well their judgments of how important and useful the task is to them

Just as students need to develop self-knowledge and awareness about their knowledge and cognition, they also need to develop self-knowledge and awareness about their motivation. Again, awareness of these different motivational beliefs may enable the learners to monitor and regulate their behavior in learning situations in a more adaptive manner.

Self-knowledge is an essential aspect of Metacognitive knowledge, but the accuracy of self-knowledge is most crucial for learning. The role of the teacher is to help students make an accurate assessment of their self-knowledge and not attempt to inflate students' academic self-esteem.

4.3 In Summary

Revised Bloom's taxonomy of learning, teaching, and assessment treats the cognitive domain as two-dimensional with six cognitive processes and four categories of knowledge. The six cognitive processes are Remember, Understand, Apply, Analyze, Evaluate, and Create and they are hierarchical in nature. Boundaries between some cognitive processes are not very sharp. Four types of knowledge are factual, conceptual, procedural, and metacognitive. Metacognitive knowledge, in simplest terms, is knowledge about cognition. However, there can be domain-specific categories of knowledge. It is believed that there are categories of knowledge specific to Engineering, Social Sciences, Management, Computing, and Humanities.

Chapter 5

Affective Domain

Many researchers believe that non-cognitive factors and skills are more important than cognitive aspects in educative processes. Grit, tenacity, curiosity, attitudes, self-concept, self-efficacy, anxiety coping strategies, motivation, perseverance, confidence are among those frequently referred to as non-cognitive factors. Many of these factors fall into the affective domain.

Every one of us develops a unique personality or self-concept in the process of interacting with and growing in the physical and social environment. We reject pain and embrace pleasure. This happens when we become autonomous, make our own decisions and choices in structuring the experiences, we become what we can become, we actualize our possibilities and potentialities, we achieve unity of personality and blend or integrate our experiences into a coherent, unified, and consistent system of feelings, ideas, and attitudes.

An individual growing in a dynamic, pluralistic, urban-industrial society encounters a fast-changing set of circumstances. Young persons are confronted by various experiences that were not part of the pre-adult experience of elders. Adults may become confused as they attempt to reconcile their past inconsistencies and contradictions. Such confusion is easily communicated to the younger generation. Such a climate is not conducive to healthy psychological development. Affective education has a significant role in resolving this problem.

The Affective Domain is most associated with feelings and emotions. It is usually displayed in positive or negative reactions to given events, objects, behaviors, policies, or situations. Affective behaviors are accompanied by varying degrees of feelings and reflect distinct "approach" or "avoidance" predispositions. A person's experience in interacting with the environment shapes the nature and scope of affective responses. (Pierce and Gray, 1981)

An "affect" is any type or degree of positive or negative feeling toward environmental circumstances, expressed through an observable display of emotive, reactive, or evaluative behavior.

Attitudes are unexamined inclinations or dispositions for or against objects, ideas, or actions. They serve as general feeling indicators that usually influence behavior.

Values are tested dispositional insights for or against objects, ideas, or actions. When someone values something, he/she assigns worth to it concerning goals and purposes. Values (enjoying, conserving, respecting, supporting, etc.) serve as specific guides for consistent behavior.

Activities in all three domains involve Sensory Inputs, Mental Processing, and Output. Pierce-Gray taxonomy recognizes this three-step process and classifies the affective domain in terms of increments in cognition.

1. Perceive

- Emotive Imprinting
- Response Setting

Sample Outcome: Listen to others' points of view on ethical issues in genetics and biotechnology.

Action verbs: ask, choose, describe, follow, give, hold, identify, locate, name, point to, select, sit, erect, reply and use

2. React

- Emoting
- Recognizing
- Controlling

Sample Outcomes:

- Discusses the nature of his/her past and present reactions to the ethical issues in genetics and biotechnology
- Discusses with classmates whether he/she should continue to react in the same way to the ethical issues in genetics and biotechnology
- Assists teammates in resolving ethical issues in genetics and biotechnology.

Action Verbs: answer, assist, aid, comply, conform, discuss, greet, help, label, perform, practice, present, read, recite, report, select, tell, and write.

3. Conform

- Artificial Attitude
- Consistent Attitude
- Rationalized Attitude

Sample Outcomes:

- Justify the position he/she has taken regarding the use of genetic experimentation from an ethical point of view.
- Display commitment to using ethical standards when resolving ethical problems in genetics and biotechnology.

Action verbs: Complete, demonstrate, differentiate, explain, follow, form, initiate, invite, join, justify, propose, read, report, select, share, study, and work.

4. Validate

- Examining Values
- Accepting Values

Sample Outcome:

- Write a two-page paper explaining why he/she intends to maintain, revise, or discard his/her present stance on the current genetic experimentation from an ethical point of view.
- Adhere to ethical standards in discussing specified issues in genetics and biotechnology.

Action verbs: Explain, follow, justify, propose, read, report, select, share, study, and work

5. Affective Judge

- Establishing Value Criteria
- Value Judging

Sample Outcome: Given multiple stands taken on ethical issues on genetics and biotechnology by separate groups, develop criteria based on which one can judge the ethical issues.

Action verbs: Adhere, alter, arrange, combine, develop, complete, defend, explain, formulate, generalize, identify, integrate, and modify.

6. Affective Create

- Integrating Values
- Inspirational Insight

Sample Outcome: Prepare a report that attempts to present his/her ethical standard on genetics and biotechnology supported by the assumptions made and data collected.

Action verbs: Act, create, influence, modify, perform, propose, revise, serve, solve, support.

Teachers can set up affective goals to be attained in their courses. These goals can be classified as

- Behavioral Goals are attitudes and values related to the rights, feelings, and property of others, including the fellow students, teachers, and the institution.
- Procedural Goals are attitudes and values concerned with demonstrating respect for critical thinking, objectivity, evidence, and logical analysis.
- Substantive Goals are attitudes and values related to economic, social, political, ethical, and aesthetic questions and importance to a pluralistic society.

In addressing the activities in the affective domain, the teacher must choose a position. Should he/she try to avoid controversy? Try to be the impartial (and neutral) observer? Try to instill acceptable values in students? It is suggested that the teacher is to take the role of "defensible partisanship" in a culturally pluralistic and democratically oriented society. Teacher's attitudes should be that values are not taught, but they are critically examined.

Chapter 6

Psychomotor Domain

Learning in the psychomotor domain involves motor, muscular activities. Psychomotor learning also occurs in combination with cognitive and affective domain learning. It is demonstrated by physical skills that are acquired through practice. The development of these skills requires practice and is measured in terms of speed, precision, distance, procedures, or techniques in execution. Riding a bicycle, driving a car, playing a musical instrument, typing, acting, and running are dominantly psychomotor activities. The psychomotor activities become important and even dominant in courses of programs in Theatre, Music, Painting, Sports, Medicine, Nursing, Dentistry, Emergency Medical Services, etc.

There are several taxonomies of the psychomotor domain due to Ragsdale, Simpson, Kibler, Barker and Miles, Hauenstein, and Harrow.

Pierce-Gray taxonomy of psychomotor domain identifies six levels: Psychomotor Perceive, Activate, Execute,Maneuvere, Psychomotor Judge, and Psychomotor Create.

Activities in all three domains involve Sensory Inputs, Mental Processing, and Output. Pierce-Gray taxonomy recognizes this three-step process and classifies the psychomotor domain in terms of increments in cognition.

1. Psychomotor Perceive

- Sensory Transmission
- Physio Functional Maintenance

The ability to use sensory cues to guide motor activity. There is the readiness to act. It includes mental, physical, and emotional sets. These three sets are dispositions that predetermine a person's response to different situations

Outcome Sample: Estimate where a ball will land after it is thrown and then moving to the correct location to catch the ball.

Action verbs: Choose, describe, detect, differentiate, distinguish, identify, isolate, relate, and select.

2. Activate

- Physical Outputs
- Mimicry
- Deliberate Modelling

Activation is a 3-stage process: Physical Outputs, Mimicry, and Deliberate Modelling. The initial stages in learning a complex skill that includes imitation and trial and error. Adequacy of performance is achieved by practicing.

Outcome Samples:

- Perform proper breathing techniques.
- Reproduce basic stances, including aramandi, sama, muzhumandi, and the related exercises.

Action verbs: Copy, trace, follow, react, reproduce, respond

3. Execute

- Task Execution
- Operational Execution
- Skilled Execution

Execute is also a 3-stage process: Task Execution, Operational Execution, and Skilled Execution. Learned responses have become habitual, and the movements can be performed with some confidence and proficiency

Outcome samples:

- Operate a computer quickly and accurately.
- Perform tha-thai-thamadavus.

Action verbs: Perform skilfully, react fast, reproduce fast, and respond fast

4. Maneuvere

- Inspecting Skills
- Selecting Skills

The maneuvere is a 2-stage process: Inspecting Skills and Selecting Skills. Skills are well developed, and the individual can modify movement patterns to fit unique requirements.

Outcome Samples:

- Perform a task with a machine that it was not originally intended to do.
- Link different movements together.
- Prioritize equipment to carry fewer loads in my backpack.

Action verbs: Adapt, alter, change, rearrange, reorganize, revise, vary, perform, link, and prioritize.

5. Psychomotor Judge

- Establishing Performance Criteria
- Performance Judging

Psychomotor Judge is a 2-stage process: Establishing Performance Criteria and Performance Judging. Skill judging involves more cognitive activity than the lower levels. Actual psychomotor activities even absent for the individual making a judgment.

Outcome Samples:

- Judge the singing performance of participants.
- Judge the quality of a dance performance.

Action verbs: Judge, critique, differentiate, mark, and select

6. Psychomotor Create

- Combining Skills
- Performance Insight

Psychomotor Create is a 2-stage process: Combining Skills and Performance Insight. Skills are combined to create a new whole.

Outcome Samples:

- Develop a new and comprehensive training program.
- Create a new gymnastic routine.
- Perform a Kuchipudi dance for a given Sanskrit poem.
- Sing a given song in a specified Raga.

Action verbs: Create, develop, perform, arrange, build, combine, compose, construct, design, initiate, make, and originate.

Cognitive, affective, and psychomotor activities are not independent of one another. Higher levels of affective and psychomotor activities involve more cognitive activities. Instruction needs to pay attention to these dependencies, especially integrating affective and psychomotor elements into cognitive activities in general courses.

For completion, we can also include Spiritual Domain as the fourth domain. The exploration of that domain is beyond the scope of this note. The four domains and their taxonomies are presented as a concept map in figure 1.

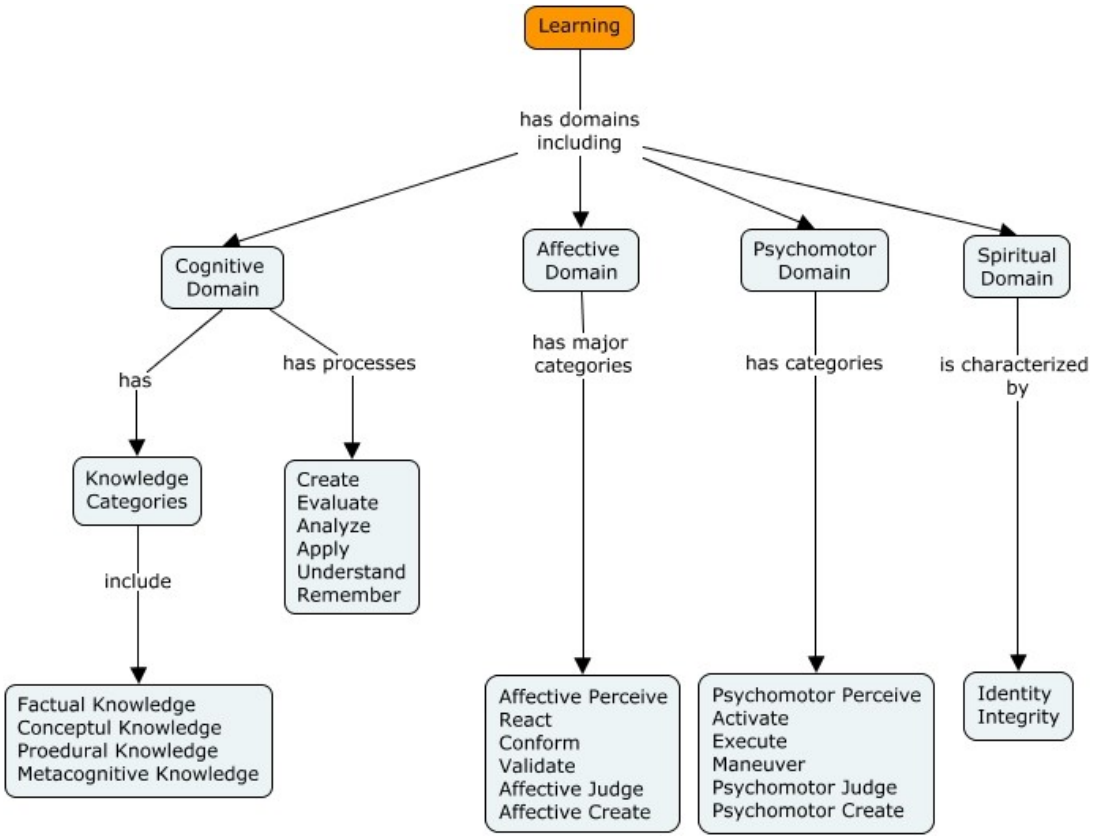

Fig. 1: Taxonomy of the four domains of learning

CHAPTER 7

Taxonomy Table

Cognitive Domain has two dimensions: Cognitive Processes (Levels) and Knowledge Categories. There are six cognitive processes and four general categories of knowledge. A table with the six rows of cognitive processes and four categories of knowledge can serve as an excellent tool to deal with several issues of teaching and learning. Such a table known as the Revised Bloom's taxonomy table is shown in figure 2.

Cognitive Processes	Knowledge Categories			
	Factual	Conceptual	Procedural	Metacognitive
Remember				
Understand				
Apply				
Analyze				
Evaluate				
Create				

Fig. 2: Revised Bloom's Taxonomy Table of the cognitive domain

A cell of the Taxonomy Table can be numbered by its cognitive process (1 to 6) and its knowledge category (1 to 4). The cell (4, 3) represents Analyse-Procedural outcome, instructional activity, and/or assessment. As there is a hierarchy among cognitive processes, the cell (4, *) represents a more complex (higher level) cognitive activity than the cell (3, *), but not a necessarily more difficult activity. The cell (4, *) implies all activities in (3, *), (2, *) and (1. *) cells.

The three elements of a Course are

- Course Outcomes (CO) representing what the students should be able to do at the end of the course
- Assessment Items (AI) of the course include assignments, tests, presentations, reports, examinations, etc.
- Instructional Activities (IA) to facilitate the learners attaining the course outcomes
- Good learning can take place when there is alignment between the three elements of a course. This would mean
- Assessment should be in alignment with the course outcomes.
- Instruction should be in alignment with the assessment.

An element of a course can be tagged by its cognitive level (action verb) and knowledge categories (can be more than one). An element can be in one or more cells of the taxonomy

table based on tagging. Alignment among the elements of a course means all the aligned elements being in the same cell of the RB taxonomy table, as shown in figure 3.

Cognitive Processes	Knowledge Categories			
	Factual	Conceptual	Procedural	Metacognitive
Remember				
Understand				
Apply			CO3, IA3, AI3	
Analyze				
Evaluate				
Create				

Fig. 3: Alignment of the three elements in the RB taxonomy table

The taxonomy table can also be used to check for alignment among the three elements of a course. Consider the taxonomy table shown in figure 4. In the table

Cognitive Processes	Knowledge Categories			
	Factual	Conceptual	Procedural	Metacognitive
Remember	AI5	IA5, AI5	IA4	
Understand		IA5, AI5	IA4	
Apply		IA5, AI5	CO4, AI4	
Analyze		CO5		
Evaluate				
Create				

Fig. 4: Partial or no alignment

- CO4 is in Apply-Procedure Cell, Instructional Activity is also in the cell (3, 3), but AI4 items are either in the cell (3, 1) or (3, 2).
- The absence of Assessment Items in the cell (3, 3) is unacceptable.
- CO5 is in the Analyze-Conceptual cell, but AI5 and IA5 are not in the cell (4, 2). This is unacceptable.
- AI5 is also in the cell (1, 1) is not related to the "Analyze" cognitive process nor to the "Conceptual" category of knowledge. It is also not acceptable.

Proper alignment requires

- Course Outcome and its related Instructional Activities should be in complete alignment (locatable in the same cells)
- While a few (small percentage) assessment items can be in cells representing cognitive levels lower than that of CO, a significant percentage of Assessment Items should be in the same cell as that of CO.

Taxonomy table can facilitate achieving a specified alignment among the three elements of a course and eliminate chance occurrences, can help in designing of well-structured Test Item Banks, and consequently, validity and reliability, two important properties of assessment can be achieved and can serve as a useful tool for organizing tutoring.

A table can be drawn for the Pierce-Gray taxonomy of the affective domain, as shown in figure 5. There is a hierarchy in affective levels as well as affective goals. Procedural affective goals are at a higher level than those of behavioral affective goals, and substantive affective goals are at a higher level than those of procedural affective goals. Attaining affective goals at higher levels can be that much more difficult.

Affective Level	Behavioral Goal	Procedural Goal	Substantial Goal
Perceive			
React			
Conform			
Validate			
Affective Judge			
Affective Create			

Fig. 5: Pierce-Gray taxonomy table of the affective domain

CHAPTER 8

Program Outcomes

Program Outcomes represent the knowledge, skills, and attitudes that all students are required to attain at the time of graduation from any general undergraduate program. Program Outcomes (POs) outcomes are non-specific to a program. No accreditation agency formally presents a set of POs for all institutions, unlike accreditation agencies associated with professional programs. General programs can significantly differ from one another. However, the NAAC requires that every University or Deemed to be University identify its own set of POs that need to be attained by all its general programs. If a university is offering a professional program, it is convenient if it used the POs identified by the corresponding accreditation agency. Every degree awarding institute around the world identifies its own POs. A comparison of POs of several institutions shows that while they are not identical, they are similar in spirit. The institutions may also differ in the number of POs. A set of POs identified in the spirit of POs proposed and identified by institutions and organizations (for example, AACU) across the world are proposed in the following.

PO1. **Critical Thinking**: Take informed actions after identifying the assumptions that frame our thinking and actions, checking out the degree to which these assumptions are accurate and valid, and looking at our ideas and decisions (intellectual, organizational, and personal) from different perspectives.

PO2. **Problem Solving**: Understand and solve problems of relevance to society to meet the specified needs using the knowledge, skills, and attitudes acquired from humanities/sciences/ mathematics/social sciences.

PO3. **Effective Communication**: Speak, read, write, listen clearly in person and through electronic media in English and one Indian language, and make meaning of the world by connecting people, ideas, books, media, and technology.

PO4. **Individual and Teamwork:** Function effectively as an individual and as a member or leader in diverse teams and a wide variety of settings.

PO5. **Ethics**: Understand multiple value systems, including your own, the moral dimensions of your decisions, and accept responsibility for them.

PO6. **Environment and sustainability**: Understand the impact of technology and business practices in societal and environmental contexts and sustainable development.

PO7. **Self-directed and life-long learning**: Demonstrate the ability to engage in independent and life-long learning in the broadest context socio-technological changes.

PO8. **Design Mindset**: Represent and develop tasks and work processes for desired outcomes.

PO9. **Computational Thinking**: Understand data-based reasoning through the translation of data into abstract concepts using computing technology-based tools.

PO10. **Effective Citizenship**: Demonstrate empathetic social concern and equity-centered national development and act with an informed awareness of issues and participate in civic life through volunteering.

PO11. **Global Perspective**: Understand the economic, social, and ecological connections that link the world's nations and people.

PO12. **Aesthetic Engagement**: Demonstrate and master the ability to engage with the arts and draw meaning and value from an artistic expression that integrates the intuitive dimensions of participation in the arts with broader social, cultural, and theoretical frameworks.

A university may consider all the twelve POs or a subset of them or even add more POs. The chosen POs may also get reworded. In the following part of the document, we assume that the first ten POs are identified for all general programs offered by a university.

Designing and conducting undergraduate programs to attain a set of POs is a new experience for Indian Universities. These POs cannot always be addressed through courses specifically designed for a PO or a set of POs. These POs need to be addressed through the core courses of the program under consideration. We need to understand the nature of elements of the POs selected and identify activities that address these elements. It should be remembered that activities planned to address POs should be amenable to the measurement of their attainment by students.

PO1.Critical Thinking

Take informed actions after identifying the assumptions that frame our thinking and actions, checking out the degree to which these assumptions are accurate and valid, and looking at our ideas and decisions (intellectual, organizational, and personal) from different perspectives.

While everyone considers critical thinking is essential, hardly any program has activities that directly address and promote critical thinking. Critical thinking is the kind of thinking—about any subject, content, or domain—that improves itself through disciplined analysis and assessment. Analysis requires knowledge of the elements of thought; assessment requires knowledge of standards for thought.

Critical Thinking entails

- identifying the assumptions that frame our thinking and determine our actions
- checking out the degree to which these assumptions are accurate and valid
- looking at our ideas and decisions (intellectual, organizational, and personal) from different perspectives
- taking informed actions based on all these

Some activities that promote critical thinking are

- Structured discussions on Newspaper articles, essays and books, speeches, policies, and movies
- Explore the relationships between different subjects.
- Taking W-GCTA (Watson- Glaser Critical Thinking Appraisal) test

PO2. Problem Solving

Understand and solve problems of relevance to society to meet the specified needs using the knowledge, skills, and attitudes acquired from humanities/sciences/ mathematics/social sciences.

Every course facilitates learners to acquire some knowledge, skills, and attitudes. There exist problems of relevance to society to meet the specified needs that will focus on the discipline of the program. It is necessary to understand the identified problem and clarify and formulate (model) the problem. Solve problems that are well defined (like the end-of-chapter) problems and ill-defined problems.

Activities that promote problem-solving

- Exercises to convert ill-defined problems to well-defined problems
- Case studies to understand problems that have their focus in the discipline of concern
- Solving end-of-the chapter problems

PO3. Effective Communication

Speak, read, write, and listen clearly in person and through electronic media in English and one Indian language, and make meaning of the world by connecting people, ideas, books, media, and technology.

All professionals need to communicate effectively with their communities in person and electronic media. She is also required to communicate with lay educated persons, including customers of one's organization and society at large in English and the local Indian language. All professionals work in groups. This requires all members to document and present their day-to-day work in commonly agreed formats. As all formal professional activities in India are conducted in English, many colleges have one course each in English and Professional Communication

PO4 can be addressed through activities such as

- Some writing exercises should be embedded in some courses with evaluation rubrics having elements related to correctness and writing skills.
- Report writing should be given adequate weightage in evaluating project reports.
- Write technical documents (reports) that get evaluated as per declared rubrics.
- Make short presentations to peers in English and laypersons in English and in an Indian language that gets evaluated as per declared rubrics.
- Give feedback on a presented activity.
- Document the feedback given on a presented activity

PO4. Individual and Teamwork

Function effectively as an individual and as a member or leader in diverse teams and a wide variety of settings.

Elicit views of others, mediate disagreements, and help reach conclusions in group settings.

All activities in an organization are group activities. A group must work as an effective team to meet the goals of a project. Organizations consider the ability to work in a team is an essential characteristic of all employees. After becoming a member of a team, and identifying of one's role, an individual should be able to work effectively to achieve the team's objectives despite personal differences with other team members.

Some activities that can address PO5

- Coaching students on becoming members of teams
- Develop rubrics to measure how good a team member is and make the evaluation count.
- Provide students with experiences as members or leaders in technical, semi-technical, and non-technical teams.
- Group assignments that involve group decision making and division of work through negotiation.
- Group projects.
- Co-curricular activities
- Activities through e-groups

PO5. Ethics

Recognize different value systems, including your own, understand the moral dimensions of your decisions, and accept responsibility for them.

The application of ethical principles requires moral autonomy. Moral autonomy means conduct and principles of action are owned, decisions and actions are based on critical reflection and not a passive adoption of some "code," and moral beliefs and attitudes are integrated into the core of one's personality and lead to committed action. Professional ethics are rules and standards governing the conduct of individuals in their roles as professionals. Every professional society will define a code of ethics for its practitioners. Students should understand the nature of ethical problems they face in professional practices. Students should understand the ethical norms of professional practice and their implications on professional decision making.

PO5 can be addressed through

- A dedicated course on professional ethics and/or case studies with a focus on ethical issues and their resolutions.
- Identifying the deviations of a proposed solution from the accepted professional practices
- Identifying the impact of a proposed solution on diverse groups of persons

- Recognizing the ethical dilemma in the case study presented.
- Proposing actions that minimize damage and synthesize solutions rather than judge the players in ethically complex situations presented as case studies.

PO6. Environment and Sustainability

Understand the impact of technology and business practices in societal and environmental contexts and sustainable development.

A student should understand the need for sustainable development. A student should understand the impact of technology and business practices in societal and environmental contexts. A student should demonstrate the knowledge of what can lead to sustainable development.

This PO can be addressed through

- Courses on technology and society, and sustainability
- Case studies can be incorporated in some courses that will bring the attention of the students to sustainability issues.

The assessment could be in terms of the student's perception of the impact of technology and business practices solutions on sustainability.

- Having some COs in a few courses
- Understand what sustainable growth is.
- Understand the impact of a given technology on the environment and sustainability.

PO7. Self-directed and life-long learning

Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes

Life-Long Learning (LLL) is a concept of learning that enables us to deal with continuous change in the life and practice of a professional. Lifelong learning skill is the ability to "continue one's self-education beyond the end of formal schooling." The technological and business changes in the last hundred years should convince us all to recognize that learning is a continuous and life-long pursuit. It is not possible to progress in one's career only with the knowledge and skillset acquired at graduation. If students are to be motivated and equipped to continue teaching themselves, their formal education must go beyond the presentation of predetermined content.

Activities that promote life-long learning can be

- Helping students to understand their learning processes
- Requiring students to take responsibility for their learning
- Creating an atmosphere that promotes confidence in students' ability to succeed
- Helping students see schooling and education as personally relevant to their interests and goals

- Incorporating activities that promote self-learning in some core courses. Rubrics need to be developed to measure the attainment of this outcome
- Making students do projects that promote self-learning, but appropriate rubrics are necessary for measurement

PO8. Design Mindset

Represent and develop tasks and work processes for desired outcomes.

With rapid changes takin place around us, the way we work is being redefined, moving away from routine tasks to nonroutine work. Nonroutine tasks require "problem-solving, intuition, persuasion, and creativity" and involve interpersonal skills. The teachers can prepare their students for nonroutine work using Design Thinking method. Designer is a person who uses the design process and strategies to think, plan, and act in improving a situation/experience or solving a particular problem. Design thinking (DT) represents the process of providing the structure and tools for every person to think and behave like a designer. The DT process consists of five phases: empathize, define, ideate, prototype, and test.

The concept of failure is central to design process. DT gives the students the permission to fail, learn from their failures, and improve upon their solutions. It is by thinking in terms of obviating failures hat successful designs are achieved. A designer must unlearn the fear of failure.

Activities that promote Design Thinking can be

- Presenting relevant case studies
- Making groups of students undertake DT projects
- Making students identify failures in each DT project.
- Making students to determine the applicability of a given solution to an altered context.

PO9. Computational Thinking

Understand data-based reasoning through the translation of data into abstract concepts using computing technology-based tools.

A large class of problems in all areas can be solved through programming. Data is extensively available on the internet on every facet of life. Many open source and proprietary computing tools are available to process the data. Every profession has decision making elements that require computational thinking.

Some activities that promote computational thinking are

- Courses like Statistics, Problem Solving through Programming, Simulation of Dynamic Systems of all kinds, Numerical Analysis, Database Management, Finite Element Methods, etc.
- Case studies that involve the use of databases.

PO10.Effective Citizenship

Acquire empathetic social concern and equity centered national development, and the ability to act with an informed awareness of issues and participate in civic life through volunteering.

We all wish that graduates of all programs be responsible citizens. Becoming responsible citizens requires an informed awareness of issues and participating in civic life. Effective citizenship means having an empathic social concern and a belief in equity centered development.

Some activities that can promote effective citizenship are

- Courses specifically designed to understand Indian society
- Service-learning courses
- Participating in service activities in a structured manner
- Case studies on issues that have a social impact

PO11. Global Perspective

Understand the economic, social, and ecological connections that link the world's nations and people.

Globalization is here to stay with all its positive negative impacts. Graduates of different programs are likely to work in multicultural groups. Graduates are likely to work in groups with members from different countries and interacting only online.

PO11 can be addressed through

- A course on the history of globalization
- Case studies on global issues that have both positive and negative impacts
- Writing reports on economic and social issues from a global perspective

PO12. Aesthetic Engagement

Integrates the intuitive dimensions of participation in the arts with broader social, cultural, and theoretical frameworks. You must demonstrate and master the ability to engage with the arts and draw meaning and value from artistic expression.

Chapter9

Program Specific Outcomes

Program Specific Outcomes (PSOs) are outcomes that are specific to a program. PSOs characterize the specificity of the core (core courses) of a program. PSOs of a general program can only be two to four in number. All programs should be designed and conducted to attain the POs identified by the University and PSOs identified by the concerned Boards of Studies. The PSO statement should start with one or more action verbs. The action verbs should be followed by clearly identified technical objects, and if required, by the conditions under which the actions are to be performed.

Some examples of action verbs

- Formulate, specify, conceive, design, plan, architect, build, implement, test, operate
- Select
- Analyze, determine, estimate, calculate

Some sample PSOs prepared by groups of faculty members from different branches are given below. It is not necessary to take them as standard. It is the Boards of Studies that need to rewrite the PSOs whenever the curriculum is reviewed and changed.

BSc Zoology

PSO1. Understand the nature and basic concepts of cell biology, Biochemistry, Taxonomy, and ecology.

PSO2. Analyze the relationships among animals, plants, and microbes

PSO3. Perform procedures as per laboratory standards in the areas of Biochemistry, Bioinformatics, Taxonomy, Economic Zoology, and Ecology

PSO4. Understand the applications of biological sciences in Apiculture, Aquaculture, Agriculture, and Medicine.

BSc in Chemistry

PSO1. Understand basic principles of Organic, Physical, and Inorganic Chemistry.

PSO2. Identify and estimate the components of organic and inorganic chemicals and determine the physical properties of compounds.

PSO3. Synthesize specified chemicals, characterize them, and interpret spectral data to elucidate the structure of the synthesized chemical compound.

PSO4. Solve problems in thermodynamics, electrochemistry, analytical chemistry, spectroscopy, and photochemistry.

BSc in Microbiology

PSO1. Understand concepts of microbial physiology, microbial genetics, microbial metabolism, virology, and mycology

PSO2. Understand basic concepts of biochemistry, biotechnology, instrumentation, biostatistics, bioinformatics, research methodology, nutrition, and immunology

PSO3. Perform procedures as per laboratory studies in microbiology, biochemistry, and biotechnology

PSO4. Understand the applicability of microbial studies in medical, agriculture, food and other industries, and environment

BSc in Biotechnology

PSO1. Understand the origin, history, and significance of biotechnology and its multidisciplinary nature combining microbiology, biochemistry, and cell and molecular biology.

PSO2. Illustrate the cellular and molecular biological processes that provide the platform for basic research in Biosciences.

PSO3. Understand the procedural strategies in Biotechnology, applications of biotechnology in medicinal, agricultural, environmental, and industrial fields, and the ethical issues related to Biotechnology.

PSO4. Perform procedures in Biochemistry, Cell Biology, Microbiology, and recombinant DNA technology as per laboratory standards.

BSc in Mathematics

PSO1. Understand the basic concepts and tools of Mathematical logic, set theory, number theory, geometry, calculus, analysis, abstract structures and algebra and methods of poofs

PSO2. Model real-world problems into Mathematics problems and find solutions and understand the application of Mathematics in other sciences and engineering

BSc in Statistics

PSO1. Understand the methods of collection, presentation, analysis, and interpretation of data

PSO2. Understand and apply the methods in the estimation of parameters and testing of hypotheses

PSO3. Understand and solve problems in probability, statistical distributions, correlation, and regression analysis

PSO4. Understand and apply the methods and techniques used in sampling techniques and the design of experiments.

BSc in Physics

PSO1. Understand and apply the basic principles of classical mechanics, quantum mechanics, statistical mechanics, nuclear physics, and thermodynamics

PSO2. Understand and interpret the principles of optics, laser, spectroscopy, relativity, and solid-state Physics.

PSO3. Understand the concepts of electricity and magnetism.

PSO4. Understand the principles of semiconductor and computational Physics.

Chapter10

Course Outcomes

Graduates of all UG and PG General Programs in India are required to attain the Program Outcomes (POs) identified by the University/College and Program Specific Outcomes (PSOs) identified by the University or the Department offering the Program. POs and PSOs are to be attained through courses, projects, and co-curricular and extra-curricular activities in which the performance of the students is evaluated.

Courses are broadly classified into core courses, electives, ability enhancement courses, and skill enhancement courses. POs and PSOs are to be attained through core courses, ability enhancement courses, and activities in which all students participate. Courses constitute the dominant part of any program. Under the present CBCS (Choice Based Credit System), the courses can be of 3:0:0, 3:0:1, 3:1:0. 4:0:0, 4:0:2, 5:1:0, 0:0:2, 0:0:1, 1:0:2 or1:0:1credits. It should be remembered that One Credit is defined as

Program Outcomes (POs) and Program Specific Outcomes (PSOs) are to be attained through core courses, projects, and co-curricular and extra-curricular activities in which the performance of the students is evaluated.

- One hour of classroom interaction per week over a semester
- One hour of tutorial per week over a semester
- Two hours of laboratory/fieldwork per week over a semester

The course content will have to be realistically adjusted to the number of credits allotted to the course.

Course Outcomes (COs) are what the student should be able to do at the end of a course. It is an effective ability, including attributes, skills, and knowledge, to conduct some activity that is identified successfully. The most important aspect of a CO is that it should be measurable.

Learning Outcomes (Instructional Objectives) as per R.E. Mager (1962), should include three elements

- **Performance**: An outcome statement should always say what the learner should be able to do.
- **Condition**: The outcomes always describe the important conditions, if any, under which the performance is to occur.
- **Criterion**: Whenever possible, an outcome describes the criterion of acceptable performance by describing how well the learner must perform to be considered acceptable.

Learning Outcomes (Instructional Objectives), as per Revised Bloom (2001), will have a common stem: **"**Student should be able to**."**

- The stem will be followed by a verb phrase and an object of the phrase.
- The verb phrase states the mental process belonging to any of the cognitive levels: Remember, Understand, Apply, Analyse, Evaluate, and Create.
- The object of the phrase states the type of knowledge.

We combine the elements proposed by Mager with the Phrase and Object of Anderson and Bloom. "Performance" of Mager will now consist of a Phrase and occasionally two Phrases and one or more Objects. We retain the optionality of "Condition" and "Criterion." The proposed structure of the Course Outcome statement in cognitive, affective, and psychomotor domains, in addition to the common stem, consists of "Action," "Knowledge," "Condition," and "Criterion."

The structure of CO statement now, in addition to the common stem, is

- **Action**: Represents a cognitive/ affective/ psychomotor activity the learner should perform. An action is indicated by an action verb, occasionally two, representing the concerned cognitive process (s).
- **Knowledge**: Represents the specific knowledge from any one or more of the four knowledge categories.
- **Condition**: Represents the process the learner is expected to follow or the condition under which to act (This is an optional element of CO).
- **Criterion**: Represents the parameters that characterize the acceptability levels of acting (This is an optional element of CO).

Sometimes it becomes equally important for a student to perform two cognitive processes on given knowledge elements. Only in such cases, two action verbs are used in a CO statement. It is not an artifact to combine two COs into one. Consider the example of a CO

- Prepare and explain financial statements using fund flow and cash flow.

Preparation and explanation are equally important, and both processes are related to the same knowledge element, "financial statement."

Some examples of CO statements are

Sample 1: Determine the slope from the given topographical map using the Wentworth method.

Action: Determine (Apply)
Knowledge: slope (Conceptual, Procedural)
Condition: given a topographical map, the Wentworth method
Criteria: None

Sample 2: Model a spring-mass system as a differential equation

Action: Model (Understand)

Knowledge: spring-mass system (Conceptual)

Condition: as a differential equation

Criteria: None

Sample 3: Understand the paradigm shifts in historical research.

Action: Understand (Understand)

Knowledge: paradigm shifts in historical research (Conceptual)

Condition: None

Criteria: None

Sample 4: Understand the concepts of Dhwani and Vakrokti

Action: Understand (Understand)

Knowledge: Dhwani, Vakrokti (Conceptual)

Condition: None

Criteria: None

Sample 5: Estimate the test reliability using Cronbach's Alpha method, accurate up to two decimal places, from the given test results.

Action: Estimate (Apply)

Knowledge: Test Reliability (Conceptual and Procedural)

Condition: Cronbach's Alpha method, Given test results

Criteria: accurate up to two decimal places

Writing COs to represent what the instructor wants his/her students to learn is the first and most important step in designing and conducting a course. The instruction and assessment need to be in alignment with the CO. There are several errors that are likely to be committed inadvertently while writing COs. These are best avoided using a simple checklist for writing Course Outcomes.

The CO

1. Does the CO begin with an action verb (e.g., state, define, explain, calculate, determine, identify, select, design)?
2. Is the CO stated in terms of student performance (rather than teacher performance or subject matter to be covered)?
3. Is the CO stated as a learning product (rather than in terms of the learning process)?
4. Is the CO stated at the proper level of generality and independent of other COs (i.e., is it clear, concise, and readily definable)?
5. Is the CO attainable (do they consider students' background, prerequisite competences, facilities, time available, and so on)?

How many COs should we write for a course? Too small a number does not capture the course adequately and may not serve instruction design that very well. Too many COs make all the

processes related to assessment design and computation of the attainment of COs messy and demanding. A 3:0:0, 3:1:0, and 3:0:1 course should have about seven course outcomes. The number of COs of courses carrying a different number of credits can be suitably adjusted.

Attainment of course outcomes is measured using summative assessment instruments. It should be possible to determine the attainment of a CO through the typically followed assessment mechanisms without needing additional instruments.

It is the practice of many Universities to present the syllabus, of course, as a set of Units to facilitate equal attention to all sections of the syllabus. There need not be one to one correspondence between Units of a course and the COs. A Unit can be addressed by more than one CO. A CO, if necessary, can address topics from more than one Unit. The unitization of the syllabus (list of topics) was brought in as an administrative convenience, and not recommended from Outcome Based Education. OBE demands that COs are written first, and the list of topics is identified next. Even if the scope of all COs is not the same, a simple method can resolve the issues of computation of CO attainment.

CO statements need to be tagged with several parameters to plan for proper instruction, assessment, and to compute the attainment of COs, POs, and PSOs. As stated earlier, a CO statement starts with an action verb from one of the cognitive levels, and occasionally by two action verbs from two cognitive levels. The action verb enables us to tag a CO with the Cognitive Level. One can use the acronyms R-Remember, U-Understand, Ap- Apply, An-Analyse, E-Evaluate, and C-Create. As there are no sharp demarcation lines between some cognitive levels, there is a possibility of one Action Verb representing two different cognitive levels. Use judgment in such cases. As mentioned earlier, a CO statement will include one or more categories of knowledge. The CO statement itself may not explicitly indicate all the concerned knowledge categories. Some knowledge categories may be implicitly addressed. The instructor needs to decide these categories based on the proposed design of instruction and assessment.

Each CO is also tagged with the number of classroom sessions likely to be taken to address that CO and the number of laboratory/field trip allocated hours.

If the PSOs are written well, there should not be any ambiguity regarding the PSO addressed by the course under consideration. All the COs of a course are likely to address the same PSO(s).

Many the courses as they are offered at present, particularly in non-autonomous institutions, do not directly address many POs. However, there may be some specific courses like Sustainability, Environment, and Communication that address specific POs. Projects and reports can potentially address many POs. But the POs addressed must get reflected in the rubrics used. Tagging a CO with a PO requires that the assessment includes items related to the identified PO. A CO of a course can potentially address more than one PO. However, it may not be possible to conduct instruction and assessment to address all the identified POs within

the available time and resources. Assessment items related to some POs cannot be efficiently designed, and even if designed, cannot be used in centrally conducted and evaluated examinations. A Department can arrange for some activities outside the curriculum to address some POs. However, the scope and distribution of these activities need to be carefully planned by the Department.

A Course Outcome (CO), therefore, is to be tagged with POs, PSOs, Cognitive Level, Knowledge Categories, number of Classroom Sessions, and/or number of Laboratory/Field Trip hours. It will facilitate the computation of CO attainment and PO/PSO attainment as well.

A Course Outcome (CO) is to be tagged with POs, PSOs, Cognitive Level, Knowledge Categories, number of Classroom Sessions, and/or number of Laboratory/Field Trip hours.

Samples of courses whose COs are tagged are given in the following. These samples were created by faculty participating in faculty development workshops. Some editing was done on some of the statements. These are the first iterations. Teachers concerned with these courses can improve the COs and add or delete COs.

Sample Course Outcomes

Course: Developmental Biology Credits 3:0:0

Program: BSc Biology

	Course Outcome	POs/ PSOs	CL	KC	Class Hrs
CO1	Understand the structural and functional features of the human reproductive system.	PO1, PSO3	U	C	5
CO2	Understand the type of eggs based on the amount, distribution, and position of yolk	PO1, PO5, PSO3	U	C	6
CO3	Compare the early developmental process of the egg up to gastrula stage	PO1, PO3, PSO3	U	C	6
CO4	Illustrate the development of 18 hr, 24 hr, 33 hr, and 48 hr chick embryo and development of extraembryonic membranes	PO3, PSO3	U	C	4
CO5	Understand aspects of human development including pregnancy, parturition, birth control, infertility, developmental defects, and miscarriage	PO3, PO5, PSO3	U	C	8
CO6	Describe the prenatal diagnostic techniques.	PO1, PO3, PSO3	U	F	3
CO7	Explain the scope of IVF, embryo transfer and stem cell research, and the ethical values involved in their practice.	PO3, PSO3	U	C	5
CO8	Enumerate the types of placentae and its functions in mammals.	PO1, PSO3	U	C	3
CO9	Understand the mechanism of embryonic cell differentiation and gene action leading to differential potency of cells	PO1, PO5, PSO3	U	C	5
	Total Hours of instruction				45

Course: Indian Economy (Credits: 4:0:0)

Program: BA Economics

CO	CO Statement	PO/ PSO	CL	KC	Class Hrs
CO1	Understand the characteristics of Indian Economy	PO1, PSO2	U	F, C	11
CO2	Analyze the changing pattern of Indian Agriculture	PO1, PSO2	An	C	13
CO3	Evaluate the performance of Industry and service sectors in India	PO1, PSO2	E	C	15
CO4	Describe the role of international trade in India's economic development	PO1, PSO1, PSO2	U	F	12
CO5	List the causes and consequences of population growth	PO2, PSO2	R	F, C	11
CO6	Explain the variables literacy, employment, and unemployment in Indian context	PO1, PSO2	U	C	18
	Total Number of Hours				80

Course: Electronic Communication (Credits: 3:0:0)

Program: BSc Electronics

CO	CO Statement	PO/ PSO	CL	KC	Class Hrs
CO1	Understand internal noise, external noise, signal to noise ratio and noise figure in Communication	PSO2	U	C	4
CO2	Understand AM and FM with mathematical proof	PSO2	U	C	6
CO3	Understand Balanced modulator circuit with mathematical proof and explain the three SSB generation techniques	PSO1, PSO2	U	C	8
CO4	Understand the working of AM radio receiver (TRF and SHR)	PSO1, PSO2	U	C	10
CO5	Understand FM Modulation and Demodulation techniques	PSO1, PSO2	U	C	10
CO6	Understand the concept of sampling and pulse modulation techniques	PSO2	U	C	10
	Total Number of Hours				48

Course: BHABHARATHNATYAM Practical- 1 (Credits: 0:0:3)

Program: BA Dance

CO	CO Statement	PO/ PSO	CL	KC	Lab Hrs
CO1	Perform Dhyaanasloka, Hastabhedas, Siro-drushti-greevabhedas, basic stances including aramandi, sama, muzhumandi, and the related exercises	PO2, PSO1	Ap	F, C	16
CO2	Perform thattadavus	PO2, PSO1	Ap	F, C	8
CO3	Perform naattadavus	PO2, PSO1	Ap	F, C	12
CO4	Perform tha-thai-thai-thaadavus	PO2, PSO1	Ap	F, C	20
CO5	Perform kudithumettadavus	PO2, PSO1	Ap	F, C	15
CO6	Perform tha-thai-thamadavus	PO2, PSO1	Ap	F, C	15
CO7	Recite adavus in tala	PO2, PSO1	Ap	F, C	5
CO8	Notate the adavus	PO2, PSO1	Ap	F, C	5
	Total number of hours				96

Course: Organic Chemistry 1 (Credits: 3:0:0)

Program: BSc Chemistry

CO	CO Statement	PO/ PSO	CL	KC	Class Hrs
CO1	Name organic compounds using IUPAC Nomenclature.	PO1, PSO1	Ap	F, C	6
CO2	Understand electron displacement effects in organic reaction mechanism.	PO1, PSO1	U	C	6
CO3	Identify the reaction intermediate and write the mechanism of nucleophilic substitution and elimination reactions.	PO1, PSO1	U	C	14
CO4	Explain the preparation and properties of alkane, alkene, alkyne, diene, polynuclear hydrocarbons, and cycloalkanes.	PO1, PSO1	U	F	15
CO5	Explain the preparation and properties of alkyl halides, dihalides, and trihalides.	PO1, PSO1	U	F	5
CO6	Explain the preparation and properties of alcohols and phenols.	PO1, PSO1	U	F	5
CO7	Distinguish between primary, secondary, and tertiary alcohols.	PO1, PSO1	U	C	1
CO8	Understand the mechanism of pinacol pinacolone, Fries and Claisen rearrangements	PO1, PSO1	U	C	2
	Total Number of Hours				54

Course: Fundamental Writing Skills (Credits: 4:0:0)

Program: BA English

CO	CO Statement	PO/ PSO	CL	KC	Class Hrs
CO1	Draft informal formal letters, CV, resume	PO1, PO2, PSO1, PSO2	Ap	P	8
CO2	Write texts for given concepts and specified needs	PO1, PO2, PSO1, PSO2	Ap	P	6
CO3	Create ads and brochures for given products and programs	PO1, PO2, PSO2	C	P	6
CO4	Prepare reports based on a given news	PO1, PO2, PSO2	C	P	6
CO5	Describe the characteristics of things, animals, people, and events and processes	PO1, PO2, PSO2	C	P	10
CO6	Evaluate, summarize and paraphrase	PO1, PO2, PSO2	U	P	6
CO7	Prepare notice, agenda, minutes	PO1, PO2, PSO2	C	P	8
CO8	Edit and proofread texts	PO1, PO2, PSO2	Ap	P	8
	Total Number of Hours				58

Course: Bhakthi Movement in Hindi literature(Credits: 4:0:0)

Program: BA Hindi

CO	CO Statement	PO/ PSO	CL	KC	Class Hrs
CO1	Understand the historical survey of medieval Hindi language and literature	PO1, PSO2	U	F, C	12
CO2	Analyze trends and structure of medieval Hindi literature	PO1, PSO2	An	F, C	10
CO3	Understand the novel and interesting features of medieval Hindi literature	PO2, PSO2	U	C	8
CO4	Develop a critical attitude about literary studies	PO1, PSO2	An	F, C	12
CO5	Identify the human values and sense of social service in Bhakthi Hindi literature	PO3, PSO2	An	C	10
CO6	Explore the features of Bhakthi movement in Hindi literature.	PO5, PSO2	An	F, C	12
	Total Number of Hours				64

Course: History of Modern India (Credits: 4:0:0)

Program: BA History

CO	CO Statement	PO/ PSO	CL	KC	Class Hrs
CO1	Describe the role of leaders, nature of events and stages of freedom struggle	PO1, PSO1	R	F	5
CO2	Understand the impact of colonialism on the Indian economy and society	PO1, PSO1	U	C	8
CO3	Explain the concept of nationalism and its phases of growth	PO1, PSO1	U	C	7
CO4	Understand the legacy of the national movement in the making of modern India	PO1, PSO1	U	F, C	6
CO5	Explain the political and social issues in postcolonial India in the context of colonial experiences	PO1, PSO1	U	C	7
CO6	Identify the centers of freedom struggle, the borders during the partition of Bengal and partition of India in the relevant maps and locate states and union territories in India	PO1, PSO1	R	F, P	4
CO7	Construct arguments in defense of or against a historical proposition based on the analysis and evaluation of historical writings	PO1, PSO1	An	C, P	8
	Total Number of Hours				45

Course: Marketing Management (Credits: 5:0:0)

Program: BBA

CO	CO Statement	PO/ PSO	CL	KC	Class Hrs
CO1	Understandtraditional and modern marketing concept, selling and marketing, service marketing, marketing environment, marketing mix	PO1, PO2, PSO1	U	C	5
CO2	Understand consumer behavior concept and market segmentation concept	PO1, PSO1	U	C	8
CO3	Determine the length and breadth of the marketing mix of a given situation	PO6, PSO1	A	P	10
CO4	Understandthe concept branding, publicity, public relations, personal selling, and Product life cycle	PO1, PO2, PSO1	U	C	15
CO5	Formulationof pricing strategy of a product	PO6, PSO1	A	P	10
CO6	Understandthe distribution and physical distribution, advertising, and sales promotion	PO1, PSO1	U	C	12
CO7	Prepare advertisement copy of a given product, design a marketing mix for consumer goods and market segmentation of a given product	PO6, PSO1	A	P	10
CO8	UnderstandNature and functions of sales promotion, relative merits of advertising medias	PO1, PO2, PSO1	U	C	10
	Total Number of Hours				80

Course: Graph Theory(Credits: 4:0:0)

Program: BA Mathematics

CO	CO Statement	PO/ PSO	CL	KC	Class Hrs
CO1	Understand a Graph, Euler's theorem on Graph, Sub Graph, types of Graphs including simple, bipartite, Complete, regular, and their properties	PO1, PSO1	U	C, P	10
CO2	Understand a Walk, Trail, Path, Circuit, Connected Graph, di-Connected, n-connected	PO1, PSO1	U	C, P	10
CO3	Understand Tree, Spanning tree, Cayley's Formula	PO1, PSO1	U	C, P	10
CO4	Understand Eulerian graphs, Hamiltonian Graphs and around the World Problem	PO1, PSO1	U	C, P	10
CO5	Formulate flow network problems using graphs	PO9, PSO1	Ap	C, P	4
CO6	Solve flow network problems using graphs	PO9, PSO1	Ap	C, P	4
CO7	Model Real World Problems using the concepts of Graphs	PO9, PSO1	Ap	C, P	8
CO8	Solve Real-World Problems using the concepts of Graphs	PO9, PSO1	Ap	C, P	8
	Total Number of Hours				64

Course: Weaker Sections of Indian society (Credits: 4:0:1)

Program: BA Social Work

CO	CO Statement	PO/ PSO	CL	KC	Class Hrs	Lab Hrs
CO1	Identify the weaker sections of Indian society	PO1, PO4, PSO1	U	C	6	3
CO2	Examine historical processes that contributed to the low status of weaker sections	PO1, PO4, PSO1	U/A	F/C	6	2
CO3	Identify constitutional provisions for weaker sections	PO2, PSO1	U	F	6	2
CO4	List the Govt. welfare programs for the weaker sections	PO2, PSO1	R	F	6	2
CO5	Check the appropriateness of 10% financial reservation to the poor among the higher castes	PO2, PSO1	E	C, M	8	4
CO6	Identify the developmental status of Scheduled castes and Scheduled tribes	PO2, PO7, PSO1	An	F, C	6	3
CO7	Understand the caste system and its impacts	PO1, PO7, PSO1	U	F, C	5	2
CO8	Describe progressive social movements in the upliftment of weaker sections	PO1, PO7, PSO1	U	F	5	2
	Total Number of Hours				48	20

Course: Symbolic Logic and Informatics (Credits: 4:0:0)

Program: BA Philosophy

CO	CO Statement	PO/ PSO	CL	KC	Class Hrs
CO1	Understand the fundamental symbols used in symbolic logic	PO2, PSO4	U	C	10
CO2	Understand the truth tables for conjunction, disjunction, negation, implication, and equivalence	PO2, PSO4	U	C	11
CO3	Classify statements and argument forms using truth tables	PO2, PSO4	U	C	9
CO4	Understand the nine rules of inference	PO2, PSO4	U	C	12
CO5	Construct formal proof of validity for simple arguments using the nine rules	PO2, PSO4	Ap	P	12
CO6	Understand the fundamentals of informatics and the philosophical approach to informatics	PO2, PSO4	U	F	10
	Total Number of Hours				64

Course: Tour Operations Management(Credits: 4:0:0)

Program: Bachelor of Tourism & Travel Management

CO	CO Statement	PO/ PSO	CL	KC	Class Hrs
CO1	Understand the definition, history, types, and regulations of tour operators	PO1, PSO1	U	F, C	9
CO2	Understand the types and components of tour packages	PO1, PSO1, PSO2	U	C	9
CO3	Understand the preparation of tour itineraries	PO1, PSO1, PSO2	U	C	8
CO4	Prepare domestic and international tour itineraries	PO1, PSO2	C	F, C, P	10
CO5	Understand the tour operation process, managing crisis situations	PO1, PSO2	U	C, P	10
CO6	Describe the major tour operating companies in India and tour operation trends	PO1, PSO2, PSO3	U	F, C	8
CO7	Understand the concepts and practices of tour guiding and tour escorting	PO1, PSO2	U	F, C	10
	Total Number of Hours				64

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Annexure 1

Action Verbs associated with Revised Bloom's Cognitive Levels

Remember

- Recognize/Identify
- Recall/Retrieve: List, mention, state, draw, label, define, name, describe, prove a theorem tell, show, label, collect, examine, tabulate, quote, who, when, where, etc.

Understand

- Summarize: Generalize and abstract
- Explain: Illustrate, construct a model, confirm, state, write down, associate, and discuss
- Compare: Contrast, match, map, distinguish and differentiate
- Interpret: Translate, paraphrase, represent, describe, express, extend and clarify
- Exemplify: Illustrate and instantiate
- Classify: Categorize and subsume
- Infer: Extrapolate, interpolate, predict, conclude

Apply

- Execute: Determine, calculate, compute, estimate, solve, use, draw, and conduct (a procedure in the known situation)
- Implementing: Determine, calculate, compute, estimate, solve, draw, and carry out (aprocedure in an unfamiliar situation)

Analyze

- Differentiate: discriminate, select, focus and distinguish (between accurate and inaccurate, cause and effect, consistent and inconsistent, dominant and subordinate, essential and inessential, facts and conclusions, facts and hypotheses, facts and inferences, facts and opinions, facts and value statements, plausible and implausible, possible and impossible, relevant and irrelevant, summaries and conclusions, supportive and contradictory, valid and invalid, verifiable and unverifiable, warranted and unwarranted)
- Organize: Identify (adequacy, assumptions, attributes, biases, causes, central issues, completeness, concepts, consequences, contradictions, criteria, defects, distortions, effects, elements, errors, exceptions, fallacies, inconsistencies, inferences, limitations, main ideas, nature of evidence, organization, plausibility, problems, procedures, reasoning, relationships, relevance, stereotypes, trends, validity, variables), structure, integrate, find coherence, outline, and parse.
- Attribute: Deconstruct and ascertain (Assumptions, attitudes, biases, conditions, characteristics, motives, organization, points of view, purposes, qualities, relationships)

Evaluate

- Check/test (Accuracy, adequacy, appropriateness, clarity, cohesiveness, completeness, consistency, correctness, credibility, organization, reasonableness, reasoning, relationships, reliability, significance, usefulness, validity, values, worth), detect, monitor, and coordinate.
- Critique/judge (Criteria, standards, and procedures)

Create

- Generate alternatives and hypotheses
- Plan/design
- Produce/construct

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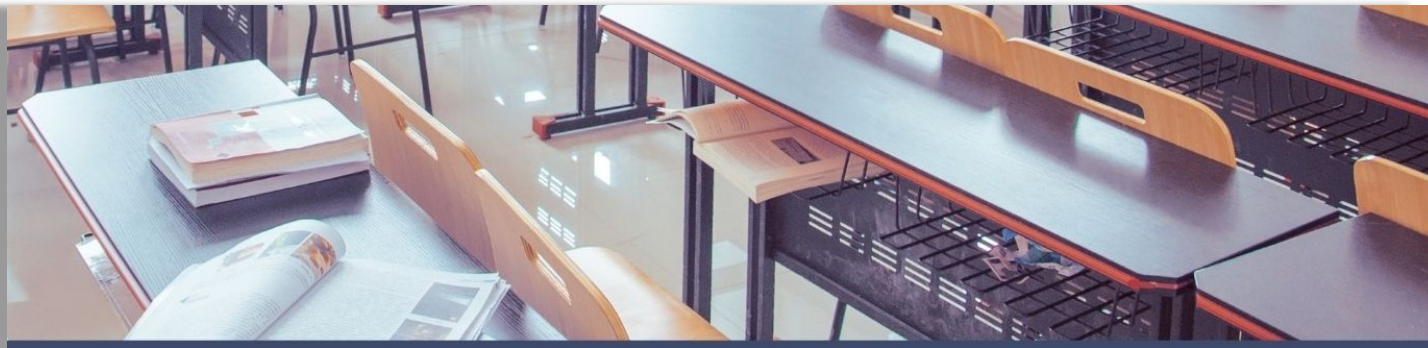

HANDBOOK

OUTCOME BASED EDUCATION

GENERAL

Prof. N.J. Rao

KERALA STATE HIGHER EDUCATION COUNCIL

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