NBA Accredition and Teaching-Learning in Engineering
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Lecture 11
Taxonomy of Learning

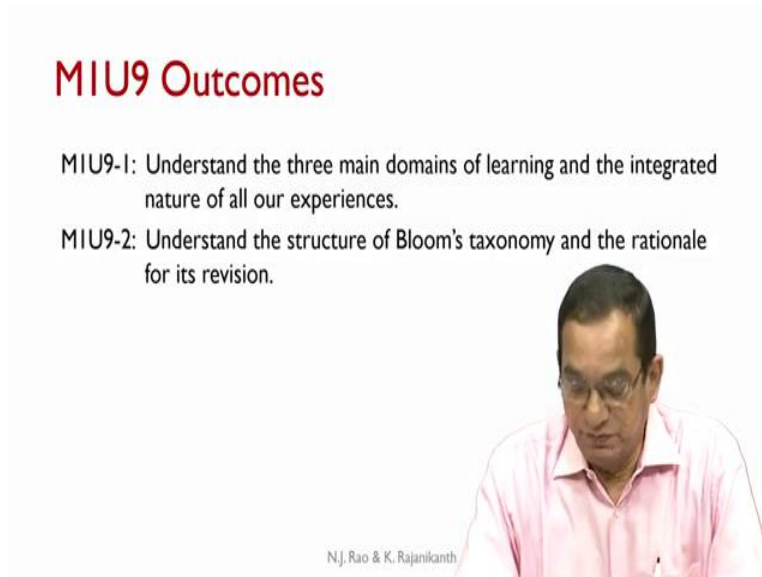Greetings welcome to module 1 unit 9 on Taxonomy of Learning.

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In the previous unit, we understood how to write the PSOs of good quality. In this unit, we look at taxonomy of learning the outcomes for this unit to understand the 3 main domains of learning and the, the integrated nature of all our experiences. Understand the structure of Bloom's Taxonomy and the rationale for its revision.

Learning outcomes, as we have seen earlier, are what the learners are expected to do at the end of the unit of learning. The unit of learning can be an instructional unit, a course or the entire program. At the end of the unit of learning, what is it that the learners are expected to do or perform that is what we are calling us learning outcomes. Outcomes, of course, and instructional units can be more conveniently written, if there is a well-accepted taxonomy of learning.

It is desirable to have a taxonomy that is applicable to learning outcomes, assessment, and teaching with any course, these are the 3 main concerns. What are the learning outcomes? How do we assess the learning of the students? And how do we teach to facilitate the learners acquire the intended outcomes. Thus, it is desirable if we have a taxonomy that is applicable to learning outcomes, assessment and teaching. Outcome statement should have a well-defined structure. This will help make the outcome statements of better quality.

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Taxonomy of Learning

- At course level, it would help addressing all 3 concerns – Course Outcomes, Instruction, and Assessment - and also in addressing the issue of alignment among these three concerns.
- Several taxonomies exist: Bloom, SOLO, Fink, Gagne, Marazano, Kendall etc.
- All taxonomies are attempts to give a structure to the cognitive processes involved in learning. Such attempts are based on observations of learning behaviors and the limited understanding of how the brain functions.

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At course level, a taxonomy of learning would help addressing all 3 concerns; course outcomes, instruction and assessment. And also in addressing the issue of alignment among these 3 concerns. We will look at the issue of alignment among these 3 concerns in a later unit. There are several taxonomies reported in the literature, we have the Bloom's taxonomy, SOLO taxonomy, taxonomy is due to Fink, Gagne, Marazano and Kendall, etc.

All taxonomies attempts to give a structure to the cognitive processes involved in learning. Such atoms are based on observations of learning behaviors, and the quite limited understanding of how the brain functions. In this sense, no taxonomy may be completely perfect. There are attempt to give a structure to the underlying cognitive processes. To the extent that we have a limited understanding of how brain functions, the taxonomies also are likely to have certain limitations.

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Bloom's Taxonomy

- Benjamin Bloom was working along with a group of measurement specialists in early 1950s on the development of a taxonomy of learning.
- In 1956, the group produced "Taxonomy of Educational Objectives: The Classification of Educational Goals. Handbook I: Cognitive Domain." (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956). This became quite popular and was generally called "The Handbook."
- After a similar process of discussions involving several experts, a major revision was proposed in 2001. Anderson, Krathwohl et. al. (Eds): "A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives "
- Our focus is this Revised Bloom's Taxonomy.

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The Bloom's taxonomy, and its revision will be the focus for this unit. Benjamin Bloom was working along with the group of measurement experts in the early 1950s. On the development of a taxonomy of learning, the primary interest of that group was to develop a taxonomy framework that would facilitate sharing of assessment items across schools. In 1956, the group produced taxonomy of educational objectives, the classification of educational goals and book 1 cognitive domain. This became quite popular and was generally called the handbook. Though the original intention was to facilitate sharing of assessment items.

Bloom recognized the importance of the taxonomy for instruction, as well as for writing clear learning objectives. After about 45 years of experience with Bloom's taxonomy, a similar process of discussions took place in around 2000. After such a similar process of discussions involved in several experts, a major revision was proposed in 2001. It was edited by Anderson, Krathwhol et. al. and the book, which has now become very popular, is titled as A Taxonomy of Learning, Teaching and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives.

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Bloom's Taxonomy: Learning Domains

- Any given task tends to be generally dominant in one of the three psychological domains: cognitive, affective, or psychomotor.
- The cognitive domain deals with a person's ability to process and utilize information in a meaningful way.
- The affective domain relates to the attitudes and feelings that result from or influence the learning process.
- The psychomotor domain involves manipulative or physical skills.
- This classification is for focus and convenience; all the three dimensions are involved to varying degrees in all intended learning experiences and activities.

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Our focus is this revised Bloom's taxonomy. According to the Bloom's taxonomy, any given task tends to be generally dominant in 1 of the 3 psychological domains cognitive, affective, or psychomotor. The cognitive domain deals with the person's ability to process and utilize information in a meaningful way. Primarily, it is a cognitive activity. The affective domain relates to attitudes and feelings that result from our influence the learning process. The psychomotor domain involves manipulative our physical skills. Bloom conjectured that any given task tends to be dominant in 1 of these 3 domains.

This does not mean that it is exclusively belonging to 1 domain, but it is dominant in 1 domain. This classification is for focus and convenience. All the 3 dimensions are involved to varying degrees in all intended learning experiences and activities, the realities 1 integrated whole. For the purpose of understanding and focus, we look at that as consisting of 3 domains, namely, cognitive domain affective domain psychomotor domain.

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This is an example of dominantly cognitive domain.

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This would be dominantly affective domain obviously.

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Dominantly Psychomotor

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This is dominantly psychomotor domain.

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Integrated Experiences

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And this is an example of integrated experiences.

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Dominantly Psychomotor

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But it is to be noted that even in dominantly psychomotor domain, the cognitive domain is at work, the affective domain is also at work.

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Dominantly Affective

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Similarly, in the dominantly affective domain also cognitive process is happening. Thus, realty is an integrated whole, all learning experiences are integrated experiences.

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Changing Domains

In 90 minutes Exam

First 85 minutes | Last 5 minutes

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Of course, domains can change. The first 85 minutes you are in 1 domain and the last 5 minutes in a different domain.

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Revision of Bloom's Taxonomy

The original taxonomy had six categories in the cognitive domain:

- Knowledge
- Comprehension
- Application
- Analysis
- Synthesis
- Evaluation

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The original taxonomy had 6 categories in the cognitive domain knowledge, comprehension, application, analysis, synthesis, evaluation. It was a 1 dimensional taxonomy in the sense that the categories were across 1 dimension only and there were 6 categories along the dimension.

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Revision of Bloom's Taxonomy (2)

- The categories were ordered from simple to complex and from concrete to abstract. Further, it was assumed that this order represented a cumulative hierarchy!
- All these categories, except Application, had several sub-categories.
- Example: Knowledge of - terminology, specific facts, conventions, trends and sequences, classifications and categories, criteria, methodology, universals and abstractions in a field, principles and generalizations, theories and structures.

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The categories were ordered from simple to complex, and from concrete to abstract. Knowledge was concerned as simplest of all, more complex was comprehension, still more complex was application and so on. The highest complexity was at the level of evaluation. Further, it was assumed that this order represented a cumulative hierarchy.

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Revision of Bloom's Taxonomy

The original taxonomy had six categories in the cognitive domain:
- Knowledge
- Comprehension
- Application
- Analysis
- Synthesis
- Evaluation

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Someone had to have a knowledge before comprehension was possible and the learner had to comprehend properly in order to be able to apply and application was necessary, if the learner

had to analyze and analyze was necessary in order to synthesize and synthesize was necessary in order to evaluate.

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Revision of Bloom's Taxonomy (2)

- The categories were ordered from simple to complex and from concrete to abstract. Further, it was assumed that this order represented a cumulative hierarchy!
- All these categories, except Application, had several sub-categories.
- Example: Knowledge of - terminology, specific facts, conventions, trends and sequences, classifications and categories, criteria, methodology, universals and abstractions in a field, principles and generalizations, theories and structures.

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So, it was assumed that the order represented a cumulative hierarchy. All these categories except application had several sub categories. The knowledge category had the maximum number of sub categories knowledge of terminology, specific facts, conventions, trends and sequences, classifications and categories, criteria, methodology, universals and obstructions in a field principles and generalizations, theories and structures. Indeed, a very large number of subcategories were proposed under the category of knowledge.

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Knowledge Category of Bloom's Taxonomy

An anomaly in Knowledge Category:
- *Knowledge's* extensive subcategories actually represented aspects of subject matter (Noun or noun-phrase).
- Definition given to *Knowledge* stated that the student was expected to be able to recall or recognize knowledge (verb or verb phrase)
- This dual nature of *Knowledge* category made it different from the other Taxonomic categories.
- This anomaly was eliminated in the revised Taxonomy by allowing these two aspects, the noun and verb, to form separate dimensions!
- The noun was the basis for the Knowledge dimension.
- The verb was the basis for the Cognitive Process dimension.

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But, we can see an anomaly in the knowledge category. Knowledge is extensive subcategories actually represented aspects of subject matter. Knowledge of terminology. So, if you look at terminology specific facts, conventions, these are all actually aspects of subject matter specific domain so, this represents a kind of a noun or noun-phrase. But, what does the learner do with this knowledge?

Definition given to knowledge stated that the student was expected to be able to recall or recognize knowledge. This is a verb aspect or verb-phrase aspect. Thus, the analogy category actually had 2 aspects, the noun or noun phrase, which indicated aspects of the subject matter and the verb, verb phrase, which indicated what was to be done with the subject matter. This dual nature of knowledge to get knowledge category made it different from other taxonomic categories.

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Revision of Bloom's Taxonomy

The original taxonomy had six categories in the cognitive domain:
- Knowledge
- Comprehension
- Application
- Analysis
- Synthesis
- Evaluation

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If we see the other categories, comprehension, application, analysis, synthesis, evaluation, they do not tell this dual nature. Only the knowledge category had this dual nature of having both a verbal aspect and a noun aspect.

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Knowledge Category of Bloom's Taxonomy

An anomaly in Knowledge Category:
- *Knowledge's* extensive subcategories actually represented aspects of subject matter (Noun or noun-phrase).
- Definition given to *Knowledge* stated that the student was expected to be able to recall or recognize knowledge (verb or verb phrase)
- This dual nature of *Knowledge* category made it different from the other Taxonomic categories.
- This anomaly was eliminated in the revised Taxonomy by allowing these two aspects, the noun and verb, to form separate dimensions!
- The noun was the basis for the Knowledge dimension.
- The verb was the basis for the Cognitive Process dimension.

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So, this anomaly was resolved in the revised Bloom's taxonomy. The noun was the basis for the knowledge dimension, the verb was the basis for the cognitive process dimension. Thus, the

anomaly was eliminated in the revised taxonomy by allowing these 2 aspects, the noun and the verb to form separate dimensions. The revised Bloom's Taxonomy is 2 dimensional in nature.

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Two-Dimensions of Revised Bloom's Taxonomy

- The two-dimensional nature of the Revised Taxonomy allows a more natural expression of an outcome statement.
- 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)
- Example: 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)

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This allows a more natural expression of an outcome statement. A typical outside 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 ever or that phrase. An example, state Maxwell's field equations, this is an outcome statement. In this outcome statement, the noun phrase Maxwell's field equations represents the subject matter content, knowledge category. State, what is to be done with or to that content represents the verb or verb phrase and that is the cognitive process.

State actually represents the cognitive process of recall. The student is expected to recall from her long term memory Maxwell's field equations. Thus, the outcome statement has 2 natural dimensions, a cognitive process dimension and a knowledge dimension. The revised Bloom's Taxonomy tried to capture this natural dual aspect of an outcome statement by making the taxonomy a 2 dimensional 1.

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Knowledge Dimension of Revised Taxonomy

- The original sub-categories were represented in 3 knowledge categories in the Revised Taxonomy:
  - Factual Knowledge
  - Conceptual Knowledge
  - Procedural Knowledge
- A fourth category – Metacognitive Knowledge was added!
- The importance of this fourth category was not realized well at the time of the Handbook! It is assuming increasing significance these days as more evidence from Learning Theories confirm its importance.

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The original subcategories of knowledge were represented in 3 knowledge categories in the revised taxonomy, factual knowledge, conceptual knowledge, and procedural knowledge. The revised taxonomy added another category, a fourth category called metacognitive knowledge. The importance of this fourth category was not realized well, at the time of the handbook. It is now assuming increasing significance, as more evidence from the learning theories confirm its importance. In a later unit, we look at the metacognitive knowledge, its nature and importance in greater detail.

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The cognitive process dimension of revised Bloom's Taxonomy also has 6 categories. But certain changes were made from the original taxonomy. The verb aspect of what original knowledge category was named 'remember'. Comprehend, was there in the original taxonomy, and that was changed to understand the original taxonomy had synthesis that term was changed to 'create'. Application, analysis and evaluation were retained from the original taxonomy. But, what changed you to the verb form?

Apply, analyze and evaluate. The original taxonomy stated them as application analysis and evaluation. The revised taxonomy states them in the word form, apply, analyze and evaluate. And there was a change made with respect to the highest 2 categories. Create was made higher in the hierarchy then evaluate. In the original taxonomy, evaluate was at the highest level synthesis was at 1 lower level, but in revised taxonomy 'create' was made higher in the hierarchy then evaluate.

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Thus, the cognitive processes of revised taxonomy look as follows. At the lowest level we help remember, then understand, apply, analyze, evaluate, and finally, create.

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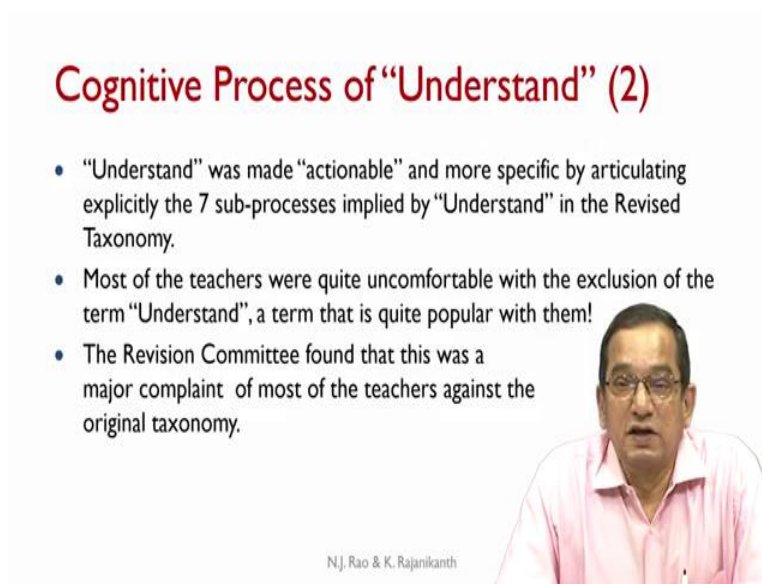

Now, the cognitive process of understand is somewhat tricky. The original group avoided understanding and used comprehending. They give the reason that the term understanding was being used to represent a wide range of competencies from comprehending, applying, analyzing,

synthesizing, and even evaluating. Faculty, were using the term understand to mean several different cognitive processes. There was no consensus on what actually understand would entail the original team wanted to avoid this fuzziness.

So, they tried to bring in a new word comprehension, which they hope would be more focused understanding was eliminated and comprehending was brought in, in the original taxonomy. Today, some scholars object to understand on the grounds that it does not represent an actionable process. It does not represent an activity that can be demonstrated. This is the ground on which some teachers object to the user the word understand even today. However, the revision committee decided, after considerable deliberations to use the word understand itself. Comprehend what replaced again by understand.

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The cognitive process understand, was made actionable and more specific, but articulating the sub-processes implied by understand the revised Bloom's Taxonomy states, seven cognitive sub-processes, which are implied by understand. This categorization of the sub-processes was made to make understand very specific. Most of the teachers were quite uncomfortable with the exclusion of the term understand; a term that is quite popular with them.

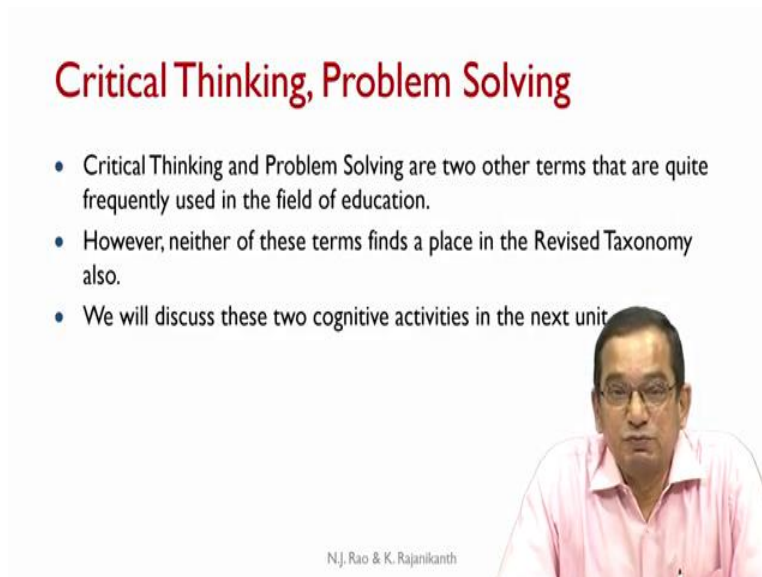The revision committee found that this was a major complaint of most of the teachers against the original taxonomy. Most of the teachers complained that while they use the word understand

quite liberally, during the interaction with the students. They are not being allowed to use that word in the taxonomy. That was a major complaint and the revision committee felt that bringing back the word understand would be more convenient from the perspective of the teachers.

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Critical thinking and problem solving are 2 other terms that are quite frequently used in the field of education. However, neither of these terms finds a place in the revised Bloom's Taxonomy also. These 2 terms are absent in the original taxonomy. They are absent in the revised Bloom's Taxonomy also. We will discuss these 2 important cognitive activities in the next unit.

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Hierarchy of Cognitive Processes

- The cognitive processes in the revised taxonomy are hierarchical in general.
- Thus Remember is of lower complexity than Understand and so on.
- However, because of the wider scope of Understand, occasionally, in specific cases, the hierarchy may not hold. For example, in a specific case, the Explaining may be more complex cognitively than Executing!
- Teacher must use her discretion in arriving at proper conclusions.

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When we look at the hierarchy of the cognitive processes, the original Bloom's Taxonomy assumed that all the 6 categories were strictly hierarchical. The cognitive processes in the revised taxonomy are also hierarchical in general does remember is of lower complexity than understand, which in turn is of lower complexity than applied and so on. Create is the cognitive process of highest complexity thus, the 6 cognitive processes are hierarchical in general.

However, because of the wider scope of understand, occasionally, in specific cases, the hierarchy may not hold. For example, in a specific case the explaining maybe more complex cognitively, then executing, executing might involve a very routine application of the cognitive process and that might be actually less complex than explaining. But in general, the hierarchy holds. In a very general sense, the hierarchy of the rebel Bloom's Taxonomy holds.

Remember, is at a lower level of complexity, understand, is at the next higher level of complexity, apply, at the next highest level, then analyze, then evaluate, then create is at the highest complexity level. So, very broadly, the hierarchy implied by the revised Bloom's Taxonomy does hold. Teacher must use her discretion arriving at proper conclusions regarding the complexity levels of the activities involved.

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Cognitive Processes and Action Verbs

- Action verbs used in the outcome statement depend on the specific cognitive process of the outcome.
- However, the cognitive process can not be determined blindly from the action verb!
- Example: Compare is an action verb that corresponds to "Understand" as well as "Analyze" – two different cognitive processes.
- In-depth study of the taxonomy is essential for its proper use.

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For every cognitive process, certain action verbs are indicated. Action verbs used in the outcome statement depend on the specific cognitive process of the outcome. However, the cognitive process cannot be determined blindly from the action verb. For example, compare is an action verb that corresponds to the cognitive process of understand, as well as the cognitive process of analyze 2 different cognitive processes.

In the next unit, we look at the action verbs that correspond to different cognitive processes we will see that compare occurs at the level of under as well as at the level of analyze, but the compare used at the level of understand is different from the compare used at the level of analyze this, we should not look at an action verb and mechanically determine what is the cognitive process implied by that action verb. In-depth study of the taxonomy is essential for its proper use.

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The revised Bloom's Taxonomy has several advantages over the original taxonomy has already noted. It allows the outcome statement to appear more natural. There are 2 dimensions in the revised Bloom's Taxonomy which capture the essence of an outcome statement in a very natural fashion. 1 dimension represents the cognitive process, and another dimension represents the knowledge category.

However, some teachers still prefer the original taxonomy to its revised version. We use the revised taxonomy and strongly recommended or the earlier taxonomy. But it is possible that some teachers prefer the original taxonomy. And it is also possible that some experts from the visiting peer committee may prefer the original taxonomy. However, the revised Bloom's Taxonomy has several distinct advantages over the original taxonomy and we recommend the use of the revised taxonomy.

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In the next unit will understand the cognitive processes remember, understand and apply of the revised Bloom's taxonomy. Thank you and we will meet in the next unit. Thank you.