Teaching and Learning in Engineering (TALE)
Prof. N.J. Rao
Department of Electronics Systems Engineering
Indian Institute of Science, Bangalore

Lecture - 10
Cognitive Levels

Greetings. Welcome to the Unit 10 of Module 1 of TALE. We are going to look at the taxonomy of learning which we started last time in the last unit. We are going to look at the remaining cognitive levels.

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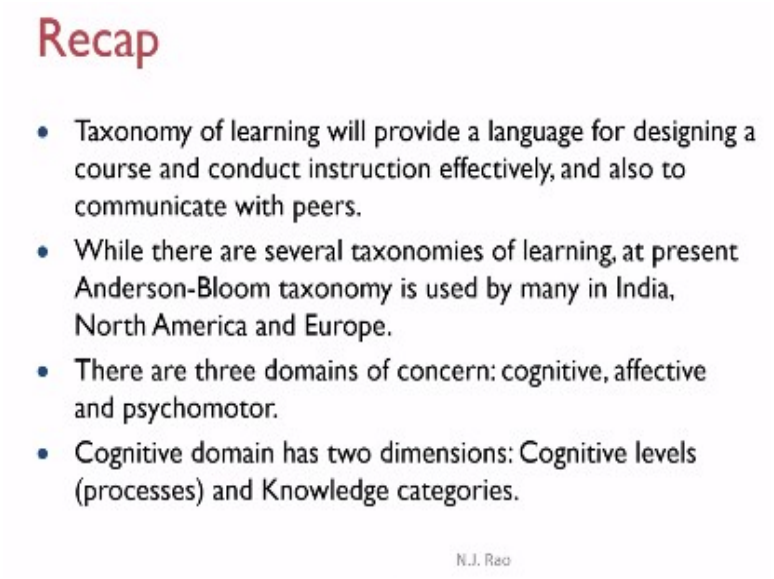

We, in the earlier unit we introduced the need for taxonomy and we noted that taxonomy of learning will provide a language for designing a course and conducting of instruction effectively and also to communicate and interact with peers so that two people, two faculty members when they are discussing they are talking about the same thing. There are several taxonomies and they are followed by various universities, various organizations.

But at present Anderson-Bloom Taxonomy is used by many in India, North America, and Europe. As per this taxonomy, there are three domains of concern. Cognitive, Affective, and Psychomotor and we dominantly will be looking at cognitive domain. Cognitive domain is concerned with what do you call processing information, converting into knowledge, solving problems. So the cognitive domain has two dimensions.

Cognitive levels or processes and knowledge categories. So we looked at the two cognitive levels, elementary cognitive levels namely Remember and Understand in the earlier unit.

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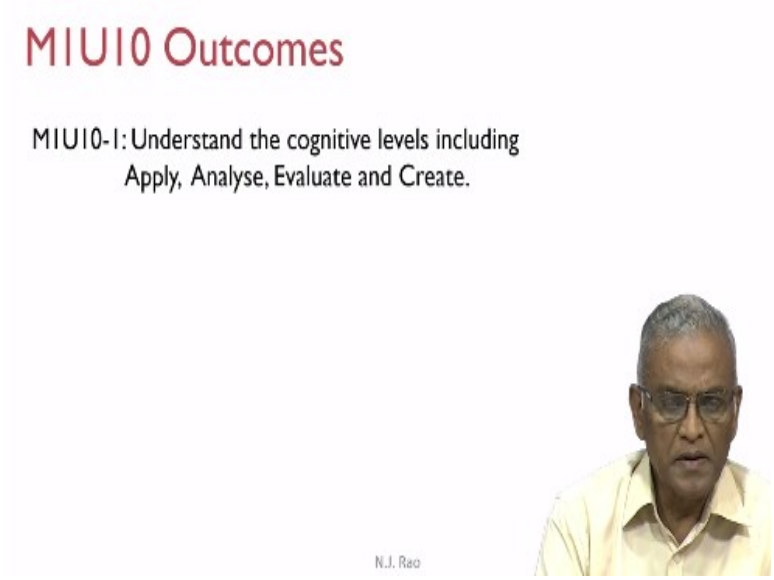

Now this Unit 10, the main outcome is understand the cognitive levels including Apply, Analyze, Evaluate and Create. These are the four different cognitive levels we are concerned with.

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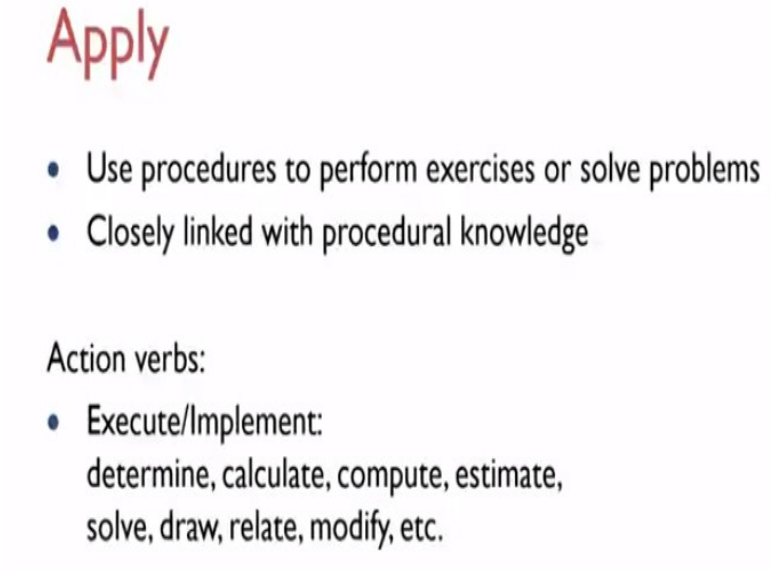

Now, let us start with Apply. What does it do? Use procedures to perform exercises or solve problems. That means you are applying certain processes. That procedure is explained to you, possibly understand why each step is necessary but then you have to apply the procedure that is

given to you and generally it is to solve a problem. And it is also closely linked with what we call subsequently as procedural knowledge.

And now there are broadly two categories of two sub-processes you can say execute and implement. Now what happens the same action verbs that we will be associating with both of them like action verbs of concern are determine, calculate, compute, estimate, solve, draw, relate, modify, etc. You can also coin some more words. Now the difference is, let us look at some examples before we come back to execute and implement.

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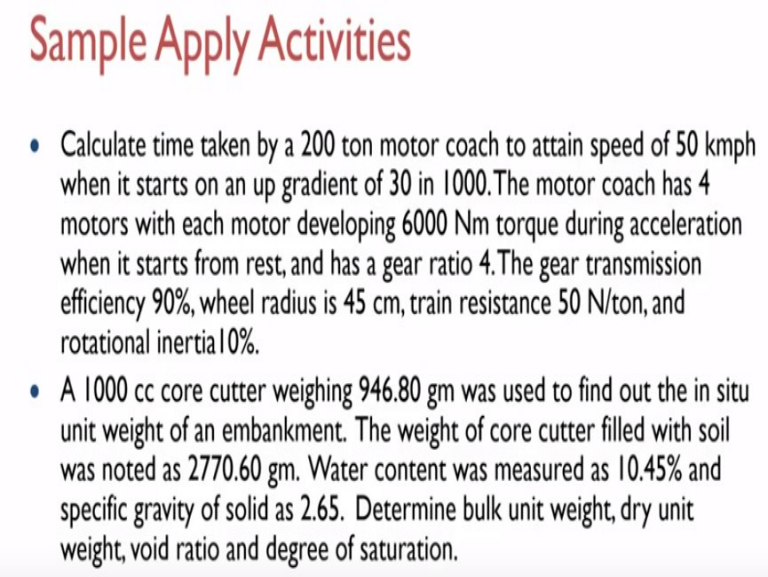

These are the types of problems that taken from the examination papers or test papers from various branches of engineering. Now if you look at, let us not worry about the detail, but here calculate time taken by 200 ton motor coach to attain the speed of 50 km. And then it starts at some conditions and there are certain parameters of concern are given to you, various numbers are given to you. And then you have to calculate, what do you calculate?

Calculate time taken by that. That means there are several variables and there are several input variables or parameters and there is one unknown variable that is the time taken needs to be computed based on the given variables and parameters. So that is what generally apply activity will involve. That means in any situation you have some known variables and some unknown variables. Unknown variables may be one, two, three also.

And there may be large number of known variables. So the major task is to determine the unknown variables in terms of known variables. That is broadly the apply activity in engineering that we see. Another problem: A 1000 cc core cutter, again with all descriptions or parameters that are given and finally you have to determine bulk unit weight, dry unit weight, void ratio and degree of saturation.

As you can see there are four unknown variables and some known variables are all given. All the four unknowns namely unit weight, dry unit weight, void ratio and degree of saturation will have to be determined or calculated.

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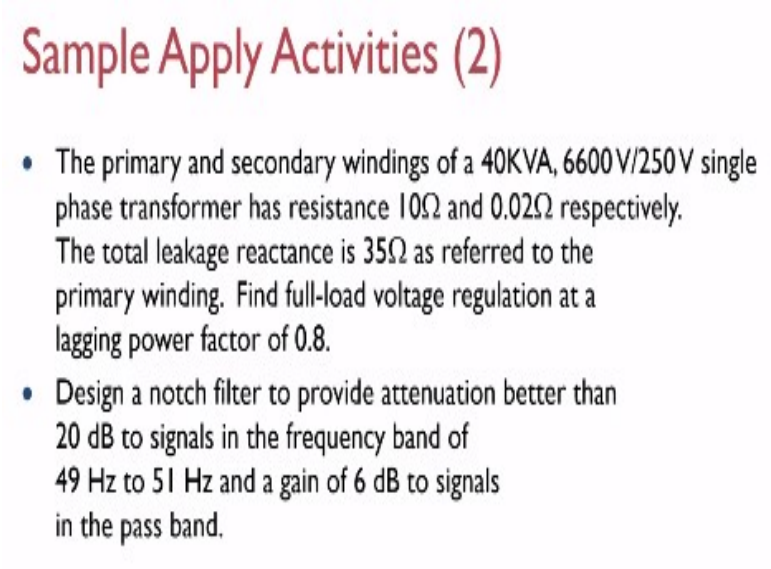

Let us look at some more examples. In electrical engineering you have a transformer and some parameters of the transformer are given or some variables associated with are given. Finally you have to find full load voltage regulation at lagging power factor of 0.8. Here there is only one unknown variable namely voltage regulation. Yet another problem in the area in electronics: Design a notch filter to provide attenuation better than 20 dB to signals in the frequency band of 49 Hz to 51 Hz.

And a gain of 6 dB to signals in the pass band, okay? So again that means you are now designing a notch filter. That means notch filter will have a some kind of a circuit and the parameters of the

circuit will have, first you have to identify what that filter is? What kind of circuit it would be and then you have to determine all the parameters of the components associated with the notch filter. Now if you see there is a small difference between the earlier problems then the one here.

First of all there are two steps here. First of all one should know what is the notch filter structure. That means you should be able to draw a circuit diagram. And then based on the values given you have to determine the parameters of that. So if you do not know the structure of the notch filter, obviously you cannot solve this problem. So this looks like a two-step process compared to the other one. Okay, these are samples of apply activities.

Let us go back a little bit and look at these two activities, execute and implement. Implement would mean it is very clear what exactly you need to calculate. That means the procedure is asked or you have to remember certain sets of formulae and then put that and implement. But what kind of formula to be used? That is either implicit or known. But in the execute part, what happens the problem description is that you should also find out which procedure to apply and then apply the procedure.

Implement is use the procedure whereas in execute you have to identify what procedure to be applied and then apply the procedure. As you can see this is slightly higher level. Execute is slightly higher level than implement in terms of cognitive activity. There are two-step process.

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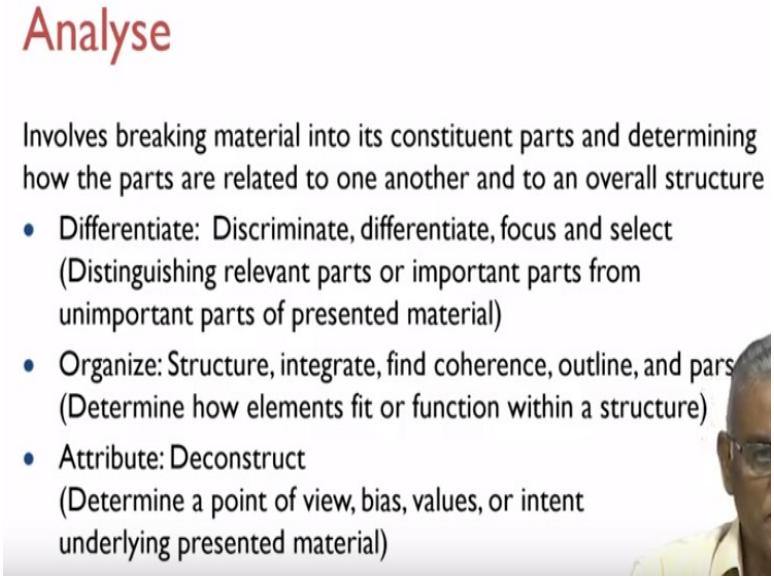

Now as far as apply is concerned, that is fairly commonly there is no complication in that and for example all the end of the chapter problems mostly will come under the category of apply. Now the next one, next level cognitive process is analyze. Now first let us describe how the Bloom's taxonomy, Anderson-Bloom's taxonomy uses the word - analyze. Analyze involves breaking the material into its constituent parts and determining how the parts are related to one another and to an overall structure.

That is what strictly analyze is. And now these will include differentiate. That means something is presented to you. Let us say you are given an article written in the newspaper and now you have to distinguish relevant parts or important parts from unimportant parts of the presented material. One can always do that kind of analysis.

What is important, what is not important and so that you can focus on the, you can see many newspaper items will have lot of unimportant or repetitive materials rather than by the time you come to the what you consider important part of the presented material. Or you can also say organize. Structure, integrate, find coherence, outline and so on. Determine how the elements fit or function within a structure.

That is another type of activity and then what you call a tribute or deconstruct. That means from a given let us say take again a typical newspaper article, what is the point of view that is being

presented by the newspaper or by the author of that article. What is the point of view? What is the bias? What are the values he is promoting or what is the intent underlying the presented material.

And actually political speeches they are great things to really examples for analyzing but we are more interested in the engineering type of activity.

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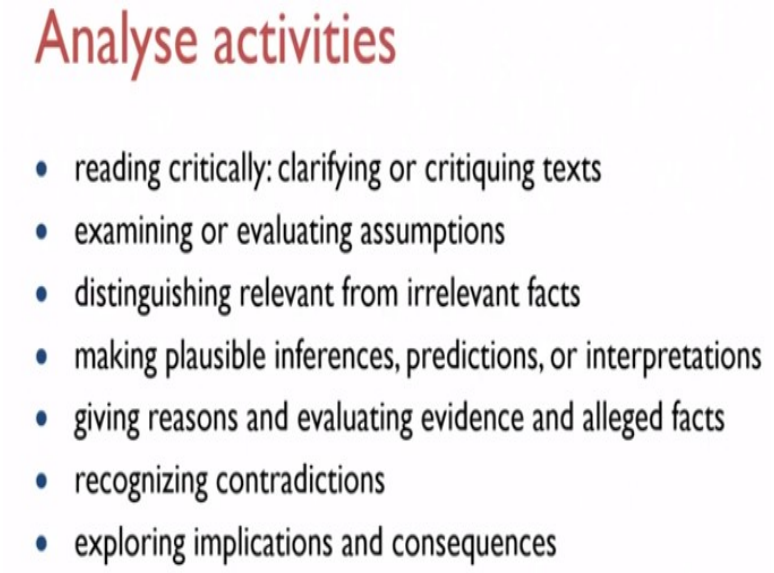

Now some of the analyze activities are reading critically. Clarifying or critiquing texts. Examining or evaluating assumptions. Distinguishing relevant from irrelevant facts. Making plausible inferences, prediction or interpretations. Giving reasons and evaluating evidence and alleged facts. Recognizing contradictions. Exploring implications and consequences. For example if you say if I change a certain parameter what happens to the system.

You may be exploring the implications or consequences. It can be very simple. For example in a given electronic circuit you can say if I change the resistor value to another value what happens. Now what happens is, is that analysis or apply?. In a simple case like that question is determine the output when the parameter changes from a value x1 to value x2 which is a very simple one. So you can practically consider as belonging to the - apply.

But if you have a little more complex system that is when the implications are not very obvious you have to explore using whatever relevant tools.

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Further, refining generalizations and avoiding over simplifications; developing one's perspective, creating or exploring beliefs arguments or theories; clarifying issues, conclusions or beliefs; developing criteria for evaluation. That also is a analysis activity. What kind of criteria do you use for evaluating something? That depends on what criteria you are using depends on your values and standards. But are you clear about it?

So the activity is involved in clarifying your own values and standards will be required for developing the criteria. Evaluating the credibility of sources of information; questioning deeply raising and pursuing root or significant questions; clarifying arguments, interpretations, beliefs or theories. So analyze activities are very many but that is where we get into problem when we come to engineering.

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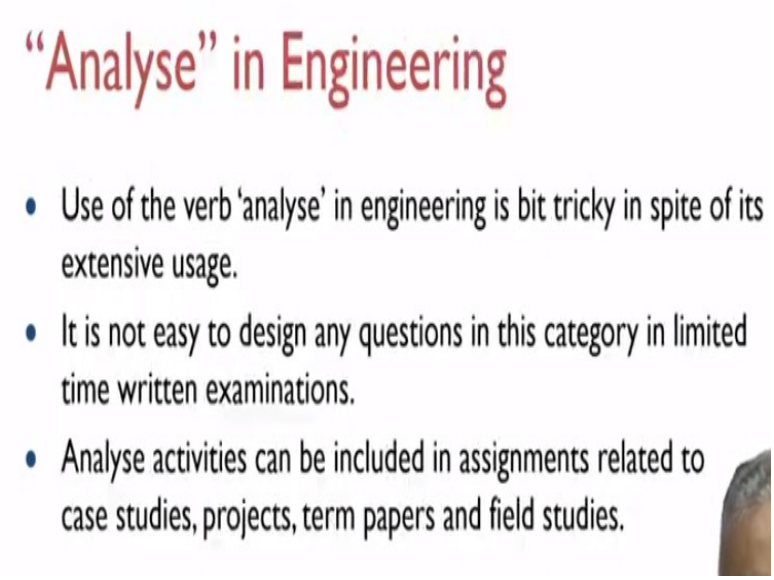

First thing is the word analyze is extensively used (by) during our activities; as teachers as students we keep using it. But analyze in the context of Bloom's taxonomy has a very specific meaning. So if you are operating within Bloom's taxonomy you have to use the word analyze only in the way it is defined. For example you can say analyze a circuit which is or analyze a structure.

So in that case (what) when we are talking about analyzing the circuit what you really are asking for determine some unknown variable in terms of known variables. That is also used as analysis in a loose way, in a commonsensical way you can say. But, so when you are trying to use the Bloom's taxonomy all the people will have to discipline themselves to use analyze in a very in this very specific manner.

Now even if you sort that out let us say we all agree to use the word analyze only in the sense that is described by Bloom's taxonomy. But can we design questions of this category in limited time written examination? Most of our evaluation or assessment is in the form of limited time examinations. If it is class test, it is one and a half hours. If it is end semester exam, it is generally about 3 hours and you may have some lab exam separately.

But majority of the assessment is in the form of written examinations. Now in such a case, and any particular question that you ask cannot take in a 3-hour exam more than half an hour because

an exam paper will have several questions and a 10-mark questions should take normally not more than half an hour. And if you are trying ask a question/an item or a question that belongs to the category of analyze, first thing is you have to write elaborate description.

And then ask questions from analysis saying that are the assumptions complete? Is the data complete? And whole bunch of questions you have to ask and generally that takes lot more time than half an hour to sort out. So it is not easy to put analyze questions right into limited time written examination. If you are interested analyze activities can be included in assignments related to case studies, projects, term papers and field studies.

The other issue is many of the activities that we talked about under analyze are not very common to engineering. They are quite common to subjects in social sciences and humanities. But why is it not so? The engineering science subjects or science subjects; the way at the level at which we are handling in a 4-year program they are fairly structured subjects in the sense we are not exploring on the frontiers and we are also talking about in very very narrow context.

So when the whole subject is very well organized the scope for analyze questions will be lot less. Whereas you can ask analyze questions in any social science and humanities subjects very easily. So that is what should be noted. It does not mean that we are devaluing but we should understand with respect to our engineering subject where exactly we are operating.

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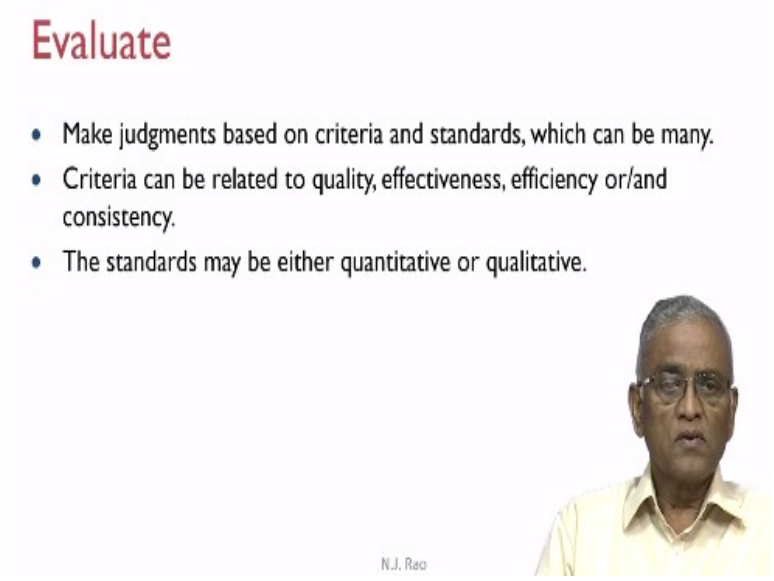

Now come the word Evaluate. It is the next one. What happens is if you have three or four alternatives for you and if you have to select one, how do you select? That is called evaluation process. That is make judgment based on criteria and standards which can be many, okay? Criteria can be related to quality, effectiveness, efficiency, or and consistency. The standards may be either qualitative or quantitative. So what happens?

If I have A, B, C three solutions with me, can I select one out of these? On what basis do I select? First thing is - I have to list a set of criteria. And what criteria do I select? So selection of criteria itself is a part of evaluation process. You may consider like the color of a product let us say. You may consider color of the product does not make much difference. So you will keep that particular criterion separate.

But that choice has to be made by you for the very clearly stated reasons. And first thing is you have to identify a criteria. Some of them are qualitative or some are quantitative. Then what happens? You have to apply these criteria to the each one of the solutions that you have in front. For example one may be - its quality. A has the highest quality but B is more effective. C is more efficient and so on.

So what happens is they do not exactly translate into one single number to determine again to select among three solutions or four solutions one particular solution. When there are multiple,

each one is good with respect to some criteria, you have to again come with another next level criterion from which you have to select this. So an evaluate process can be quite complex when you look at a fairly bigger problems.

When you talk about very big problems or complex problems then selection of criteria, that is where you all the time get into problems with regard to large projects like constructing a bridge or a flyover or any number of controversies will come because each one is talking from a different set of criteria.

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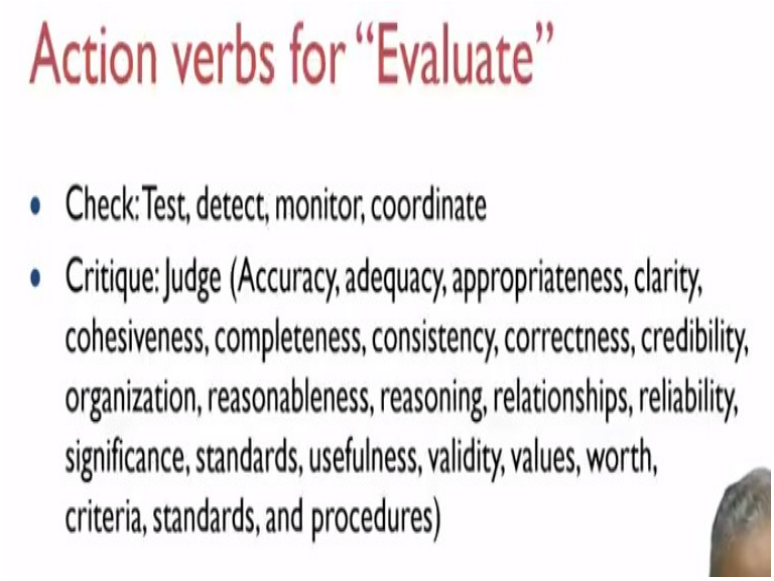

So the action verbs associated with are either you are checking. Checking means testing, detecting, monitoring, coordinating or critiquing. Judging the accuracy, adequacy, appropriateness or clarity, cohesiveness, completeness, consistency, correctness etc. you have a whole bunch of these things you want to judge. So put in simple words, evaluate is concerned with selecting certain criteria and applying these criteria to the solutions and coming to or judging or making a decision with regard to the preference of a particular solution.

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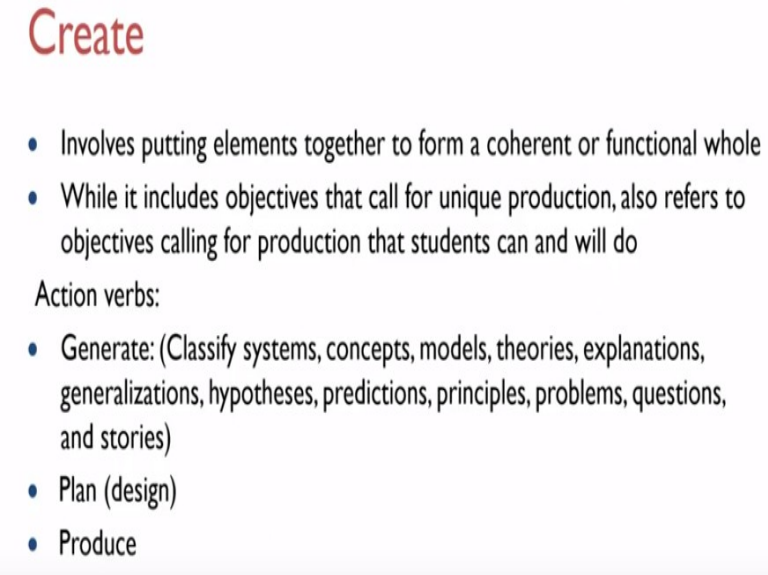

Now the final sixth cognitive process is create. Creation is strictly involves putting elements together to form a coherent or a functional whole. That is elements are available to you but you are putting them together to form a another coherent and functional whole. And this is done at three, there are three different levels. One is generate. What do you generate?

Generation is it can be classifying systems, concepts, models, theories, explanations, generalization, hypothesis, predictions, principles, problems, questions, and stories. For example take a simple thing like a test could be - write a story. The story can be again the word create is used in loose sense in many ways. But creating, writing a story the question is to - write a story which should be different from what is already available.

It may not differ very much from something that you already read. But at least it is different. That means you have created a story, created something. Similarly, create a plan. Plan or designing something. Design strictly the word means creating a plan to make something. I can ask you to design a chair. When you are asked to design a chair, I may exactly copy an existing chair and give you that. In that case it does not become create.

Even if I make small changes, the angles or the joints or the way I design the chair it becomes that means you are creating a plan to fabricate something and that is what do you call is a create process. The third one is actually “Produce”. For example you are asked to create a model. Or

you create the chair or in aerospace engineering you are asked to create a let us say a model of a plane, whatever part of a plane, whatever it is.

And then you have to sit in the workshop and you have to produce your own. When you are producing somehow it becomes a unique piece. That means you are creating. So that is what is create process. First thing is creation, let us look at what exactly it means for an engineering program or how do I train my engineer for create activity. Creation involves producing multiple solutions for a given problem. Multiple correct solutions to a given problem.

The fact that one is better than the other comes next but you should be able to produce multiple solutions for a given problem. Whereas apply is strictly you already the path is known and you generally come to a single point solution, not multiple solution. So create, actually in our engineering programs we do not train people for creating multiple solutions to a problem because most of the problems that are addressed in the standard courses are end of the chapter problems where the answers are unique.

Okay, till now we have looked at the six cognitive levels namely Remember, Understand, Analyze, Evaluate and Create. And practically all cognitive actives can be it is claimed can be can come under one of these categories and they are hierarchically arranged so a particular activity or a particular problem that you are addressing may involve activities at more than one level. But if you say create, design a particular engineering system if you are giving it as a problem it is likely to involve activities from all the previous five cognitive levels.

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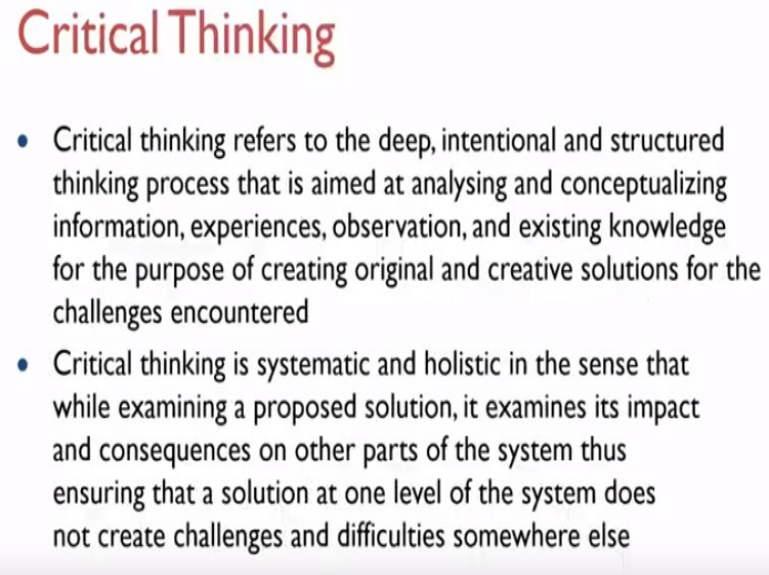

Now there are two other words that are of concern. One is Critical Thinking. The other one is Problem Solving. So our issue is, is critical thinking is another activity or is it can be considered subsumed under six cognitive processes of Bloom. Many people want to deal with this critical thinking independently. But if you look at by their own definitions, let us strictly go through this.

Critical thinking refers to the deep intentional and structured thinking process that is aimed at analyzing and conceptualizing information, experiences, observation, and existing knowledge for the purpose of creating original and creative solution for the challenges encountered. That means here look at the various parts which is strictly like analysis process. Leave the first phrase. The critical thinking aims at analyzing and conceptualizing information and experiences.

Observations and existing knowledge, again for the purpose of creating original and creative solutions. So leave the purpose. But if you look at the activity, it is analyzing, conceptualizing information, experiences and so on. So you can see analyze and conceptualize. Conceptualize, you may be creating a new concept. In that case it will come under create or you are putting under the existing known concepts. Then it will come under understand or analysis.

So what happens is as the statement goes you are looking at analyzing or maybe understanding, and the purpose is to create. But not actually creating the original solutions. See it refers to the deep intentional and structured thinking, okay. Now coming to the next aspect of this is critical

thinking is systematic and holistic in the sense that while examining a proposed solution it examines its impact and consequences or other parts of the system.

Thus, ensuring that a solution at one level of the system does not create problems and difficulties somewhere else. Again, you are examining a proposed solution for again there is a purpose. So if you look at examining a proposed solution comes under the category of evaluation. So critical thinking will involve analysis and evaluation. But the goal is to create an original solution for a problem.

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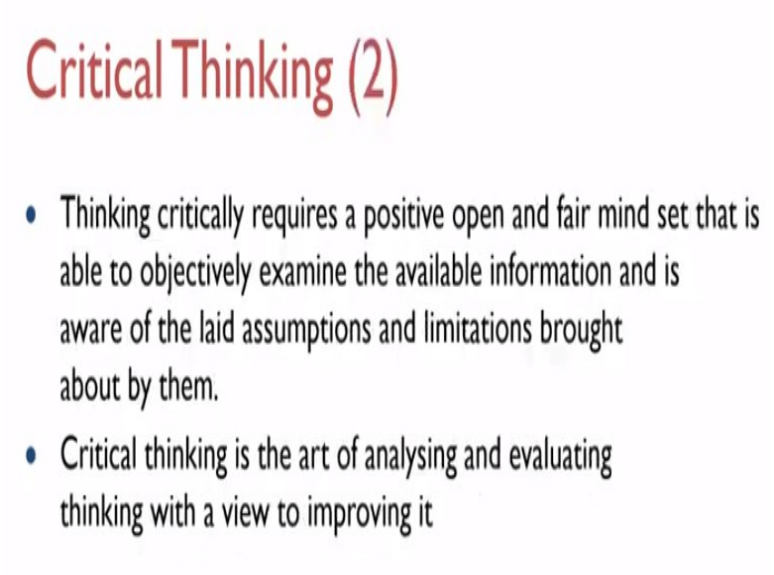

And here another aspect, thinking critically requires a positive open and fair mindset that is able to objectively examine the available information and is aware of the laid assumptions and limitations brought about by them. Thinking requires open mind, a fair and open mind. That is requirements of critical thinking. But actually critical thinking is the art of analyzing and evaluating thinking with a view to improving it. The purpose is to improve.

So as you can see critical thinking will/is subsumed by analysis and evaluate activities of Bloom's taxonomy.

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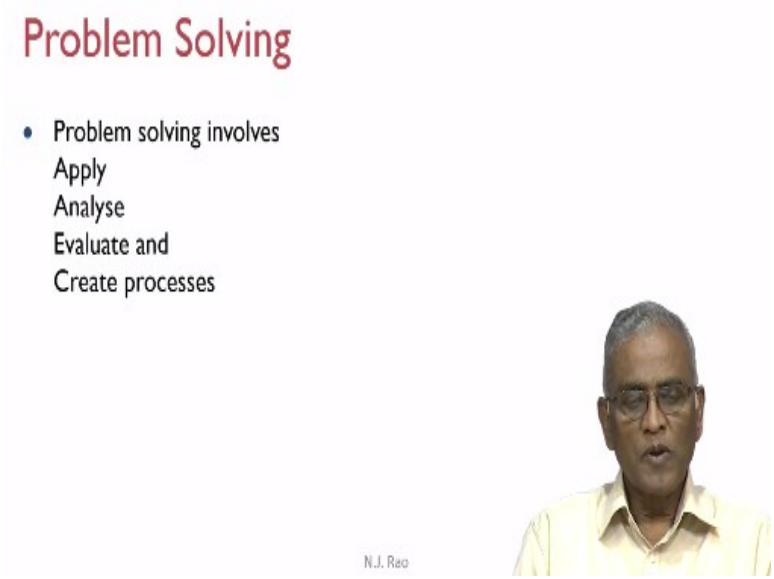

Now problem solving is another interesting one. People have written extensively about that. There are lots of books. But if you put all of them together, anywhere from some people mere application of some procedure is considered problem solving. That is what you are doing, solving problems. Or it may require analysis, it may require evaluate and it may and create processes. All the four processes may be involved or only some processes are involved.

So in that case we are also effectively looking at that is problem solving is also subsumed under Bloom's taxonomy.

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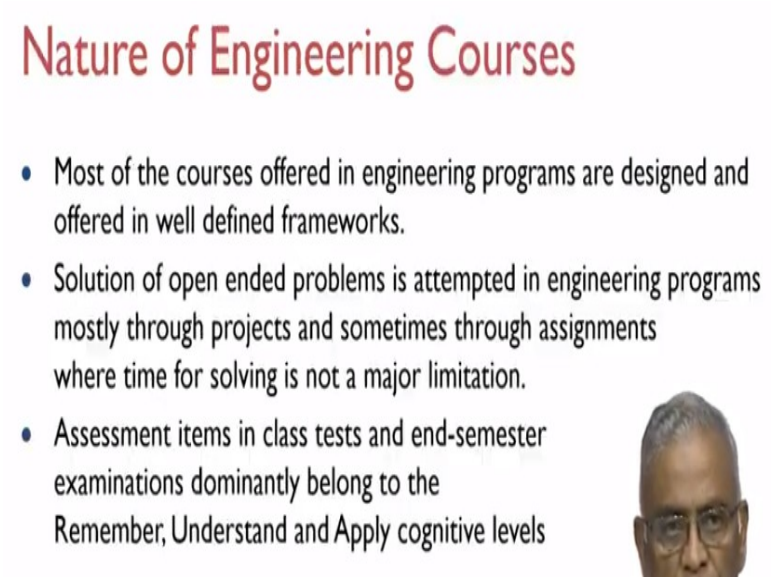

And now we need to understand the nature of engineering courses. Most of the courses offered in engineering programs are designed and offered in a well-defined frameworks, okay? First thing is that. There is not much of ambiguity about whether something is valid or not and so on. It is directly the way at the level at which we are handling, it is a well-defined framework. And solution of open-ended problems is attempted engineering programs mostly through projects.

And sometimes through assignments where time for solving is not a major limitation. Even this in practice if you see not much of this kind of exercises are given to the engineering students. Assessment items in class tests and end-semester examinations dominantly belong to the Remember, Understand and Apply cognitive levels. so even at this level, if you analyze the examination papers, many not all, many examination papers are confined to Remember and Understand.

And only very small percentage of weightage is given to Apply level. And sometimes you will find even 70 to 80% of the questions belong merely to the Remember level.

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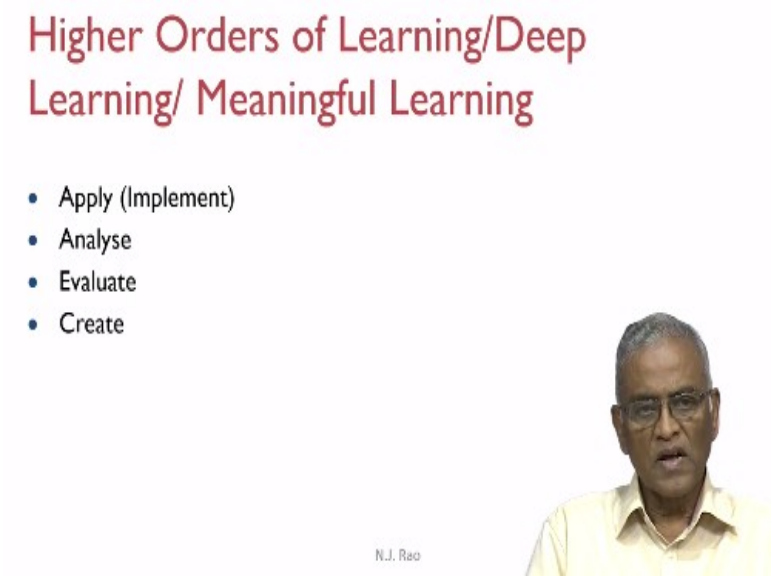

And this is another word that you have to be familiar with where there are words used, higher orders of learning, deep learning, meaningful learning; all this would mean higher level of Apply and then Analyze, Evaluate and Create.

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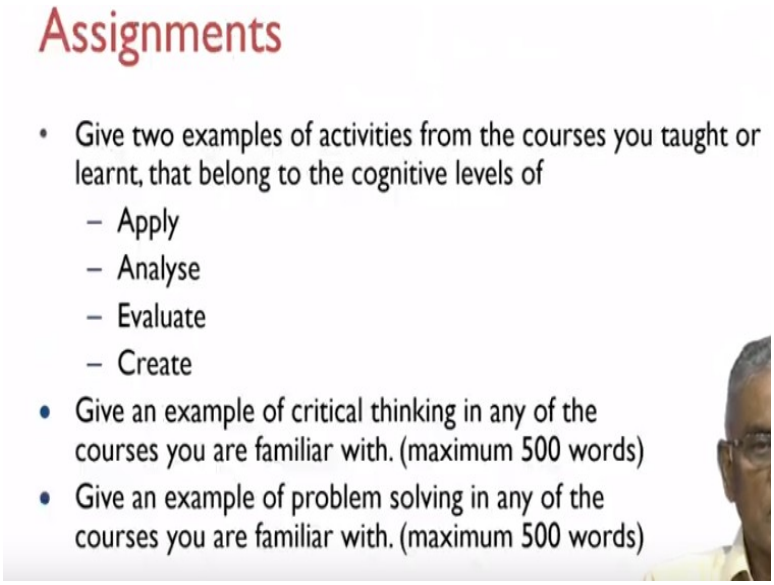

Now, assignments. Give two examples of activities from the courses you taught or learnt that belong to the cognitive levels; Apply, Analyze, Evaluate, and Create. And give an example of critical thinking in any of the courses you are familiar with, maximum 500 words statement. Give an example of problem solving in any of the courses that you are familiar with in the way you understand what is problem solving and similarly what is critical thinking as it is explained.

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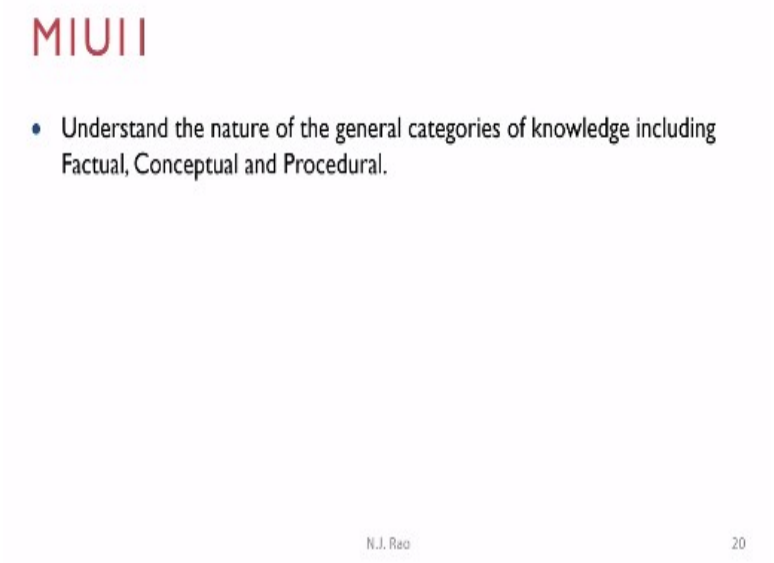

Now in the next unit, we will be moving on to the categories of knowledge as we considered knowledge and cognitive process are the two dimensions of cognitive domain. We will be looking at out of the four knowledge categories Factual, Conceptual and Procedural knowledge we will be looking at in the unit level. Thank you very much.