NBA Accreditation and
Teaching – Learning in Engineering
(NATE)
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Lecture 13
Categories of Knowledge-1

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Greetings and welcome to module 1, unit of 12 of NATE that is NBA Accreditation Teaching and Learning in Engineering. This unit is related to knowledge categories.

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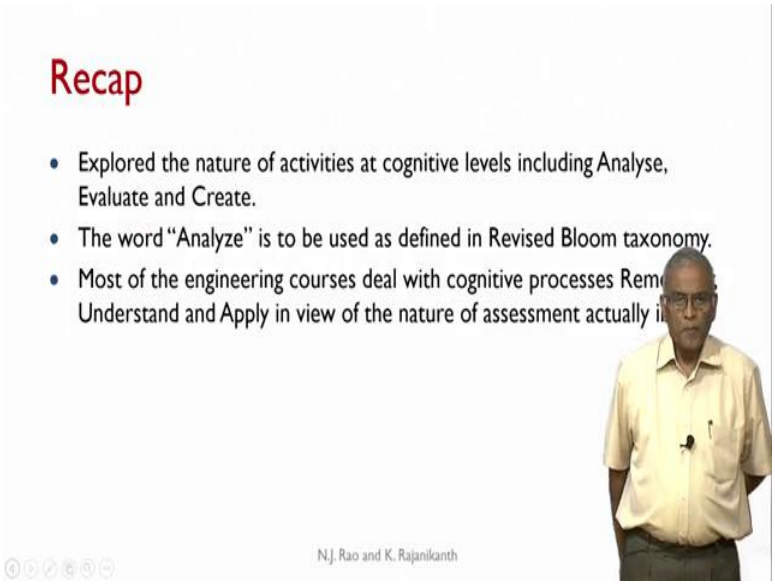

Previous unit, we explored the nature and activities of cognitive levels, including analyze, evaluate and create. The word analyze, you should remember it requires special attention is to be used as defined in revised bloom taxonomy. Most of the engineering courses deal with the cognitive processes remember, understand and apply. Most of the engineering courses deal with cognitive process remember, understand and apply. This conclusion is made in view of the nature of assessment actually used okay.

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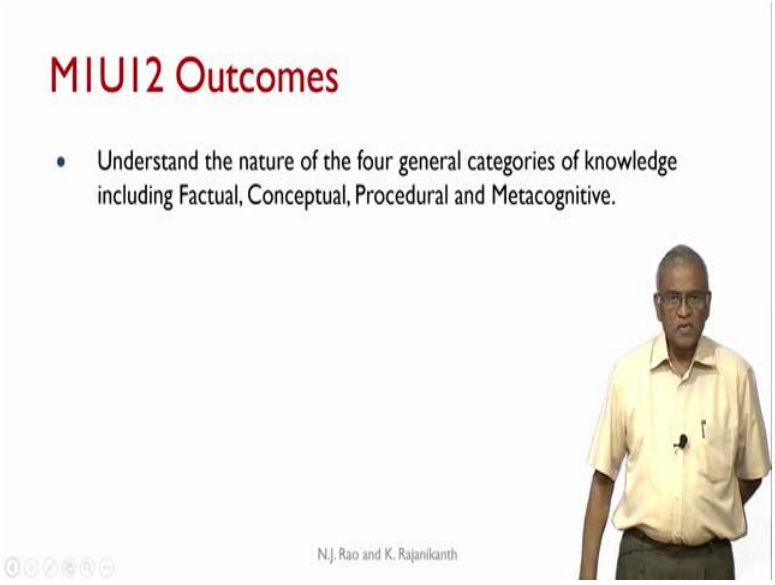

Now in this unit, we will look at the other dimension of revised bloom taxonomy, namely the knowledge categories. So, here we understand the nature of 4 general categories of knowledge including factual, conceptual, procedural and metacognitive.

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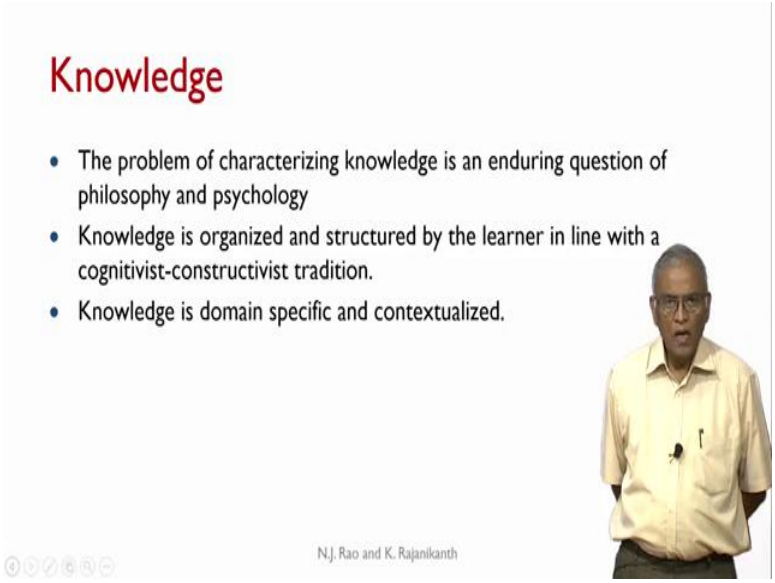

Now, the word knowledge is an interesting one. All of us are quite comfortable in using this knowledge, the word knowledge. And we do not have any ambiguity about it, until someone asks us to formally define what knowledge means. And the moment you start defining the knowledge, you practically get into the realm of philosophy.

For example, the problem of characterizing knowledge is what you call is an engineering question of philosophy and psychology. At least a philosophy for the past few 1000 years and the conclusion is not anywhere near future. So we have to be satisfied with what we call operational definition of the word knowledge.

Now, one of the assumptions that we make knowledge for our purpose teaching and learning purpose is organized and structured by the learner in line with a cognitivist-constructivist tradition. We looked at what are the cognitive processes and we say what do you mean by constructivist approach? That is we are constructing the knowledge or we are creating our own mental model of the external world.

And also another assumption we make knowledge is domain specific and contextualized. We ofcourse, the moment you say if these are violated what happens that becomes philosophical question, which we are not going to address right now. So, under these assumptions, we now look at the categories of knowledge.

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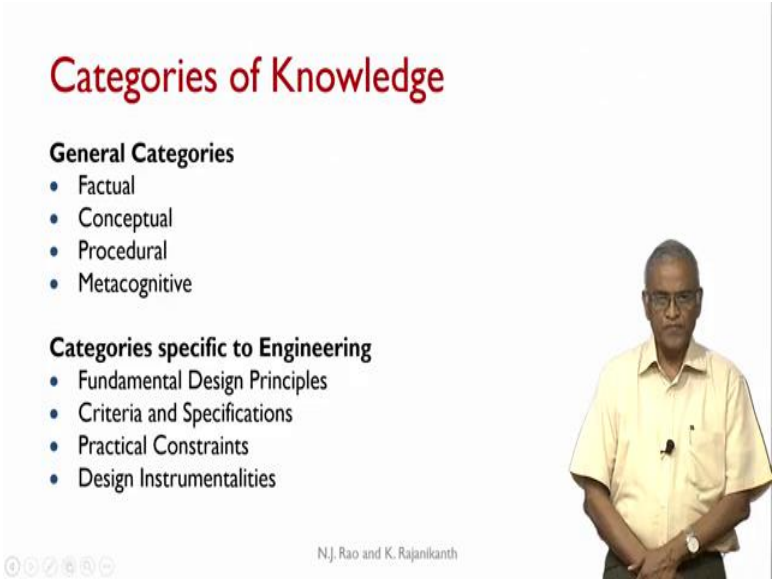

There are 4 general categories, general categories means they will be applicable to any discipline, any subject, whether you have engineering or sciences, humanities, social sciences and so on. The general categories include factual, conceptual, procedural, and metacognitive, we will explain them in detail presently. And we also take a position especially when you are talking about engineering programs, that there are categories of knowledge specific to engineering.

And these now, we consider as fundamental design principles, criteria and specifications, practical constraints and design instrumentalities. We will explore these 4 categories in the next unit. So, let us first concentrate on categories of general categories of knowledge.

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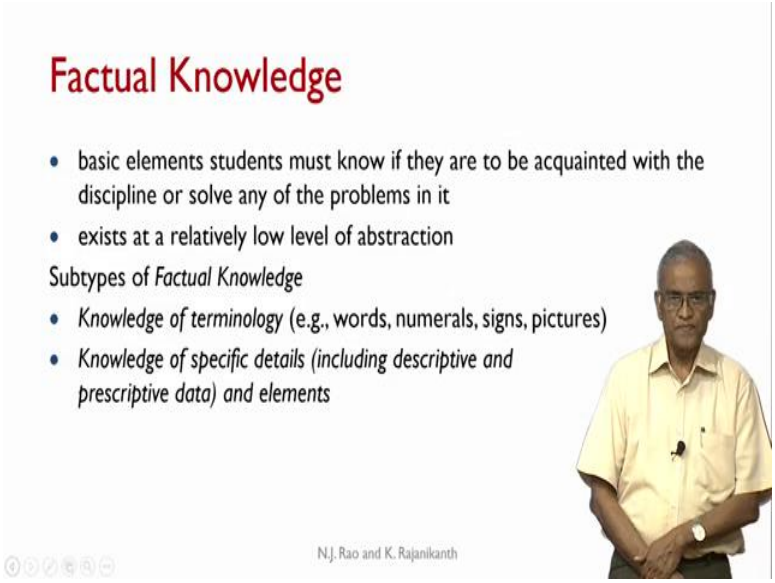

Now, factual knowledge is fairly easy to understand. There is basic elements students must know if they are to be acquainted with the discipline or solve any of the problems in it. And this knowledge exists at relatively low level of abstraction. For example, you can use a word let say force. So, I should know force represents something that is all I need to be familiar with the word force. And I should be able to say force that word belongs to the discipline of let us say mechanics or some mechanical engineering and so on.

Now, what are the subtypes of factual knowledge, factual knowledge of terminology? There is examples like words, numerals, science and pictures and knowledge of specific details, including descriptive and prescriptive data. There are some numbers associated, we should be familiar with them okay.

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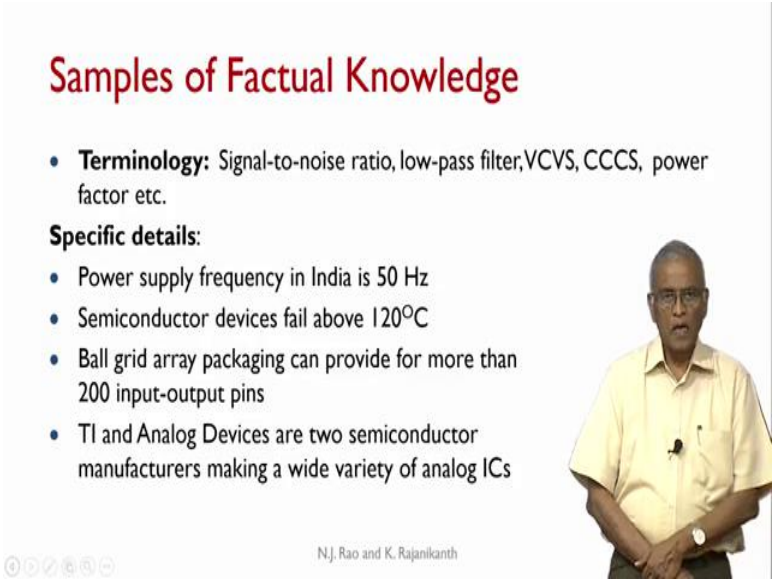

Now, let us look at some samples. Terminology, I am giving mainly from electrical engineering, but I am sure you can find out such terminology from every discipline. Signal-to-noise ratio, low pass filter, VCVS, CCCS power factor etc these are some terms that are used in the electrical engineering discipline. And what are the specific details? Power supply frequency in India is 50 hertz.

Semiconductor devices fail about 120 degrees. Ball grid array packaging can provide for more than 200 input-output pins. And TI and analog devices are two semiconductor manufacturers making a wide variety of analog ICs. These are just facts and figures.

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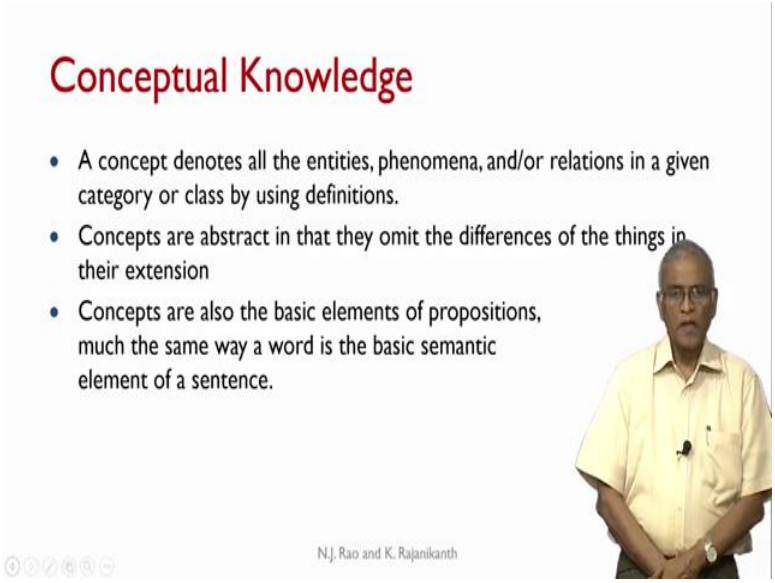

Now, come to the conceptual knowledge, all of us consider concepts are very important. And we generally find that when we ask anybody to define what a concept is, they do have some issues and they have they require some clarity, I think every teacher should be very clear about what a concept is. The formal definition of a concept is a concept denotes all the entities, phenomena and our relations in a given category or class by using definitions, it looks complex. And concepts are abstract in that they omit the differences of things in their extension.

Now, let us look at these two sentences and try to understand what the concept is. Let us take the word tree, tree is a concept because there is nothing like an object, you have example of a tree, but there is nothing like a tree physical object exists. So, what happens when I call, when I use the word concept tree, I am willing to ignore the differences between a mango tree and a coconut tree. Both are trees. And even if I take mango tree as a concept, there are any number of any varieties of mango trees in the world.

So, when I am referring to the word mango tree, as long I use that word, that concept mango tree, I am willing to ignore the differences between different mango trees, different types of mango trees. So, that is a concept. Now if you come to engineering concepts, you can talk force is a concept okay, velocity is a concept and so on.

That means, when somebody presents an example to you, you should be able to say whether it belongs to this category or not. If you if you are able to precisely understand the given

statement or given word belongs to that category or not then you have understood the concept better.

Now, concepts are also basic elements of propositions. Much the same way, a word is the basic semantic element of a sentence okay. Now, what does it mean?

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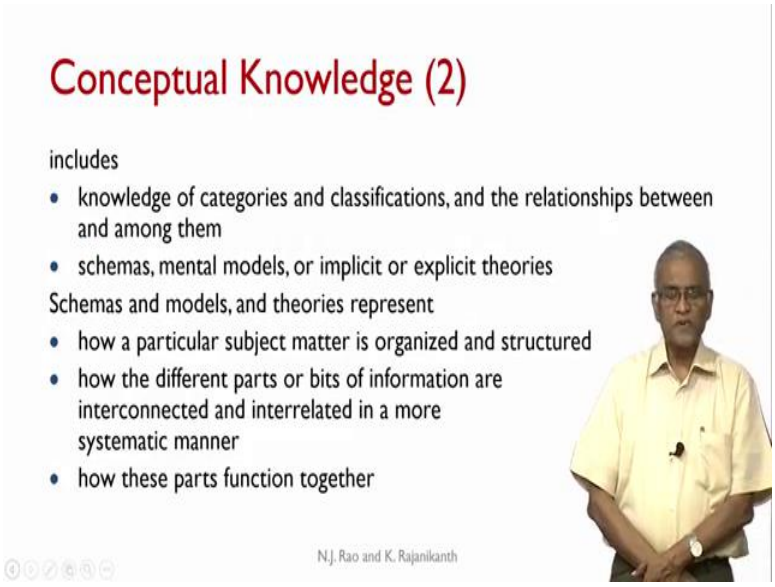

Now, conceptual knowledge does not stop with what do you call simply list of concepts. It also includes conceptual knowledge includes, a knowledge of categories and classifications as we have already stated and the relationship between and among them And even above like schemas, mental models or implicit or explicit theories are all they all belong to the category of conceptual knowledge.

What do schemas, models and theories represent? For example, how a particular subject matter is organized and structure, the way for example, civil engineering subjects are organized or within that, what do you call subject matter of fluid systems is organized, maybe very different the way geotechnical systems are organized.

So, the kind of models, the kind of constraints under which a subject matter is structured or organized is also conceptual knowledge and how the different parts or bits of information are interconnected and interrelated in a more systematic manner. Because every subject has some different bits of information, but how do you connect them, that is also that belongs to the, this category of schemas, models and theories. And how these parts function together, these all include are included in the conceptual knowledge.

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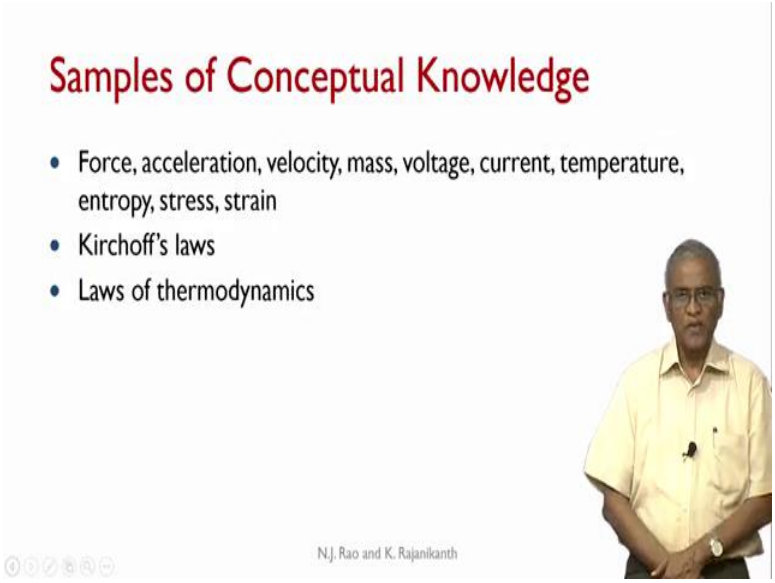

Now, take something like this, samples of conceptual knowledge force, acceleration, velocity, mass, voltage, current, temperature, entropy, stress and strain, then I can go a little further and say, what do you call signal to noise ratio which you have given as example, under factual knowledge is also a concept okay. So, you have whole bunch of these words I think every one of you can make a list of these words representing concepts in your specific discipline.

Now, when you come to keep Kirchhoff's laws, it is now trying to relationship under some constraints between voltages and currents. So, now you are relating 2 concepts or 2 or more concepts into a single statement. If you talk about Newton's law, one law of motion, F equal to m a, F is force and m is mass, then a is acceleration, three different concepts. And a law now, Newton's law says force equal to acceleration into mass. So that becomes you can say, either a law or principle. Similarly, laws of thermodynamics, these are all samples of conceptual knowledge.

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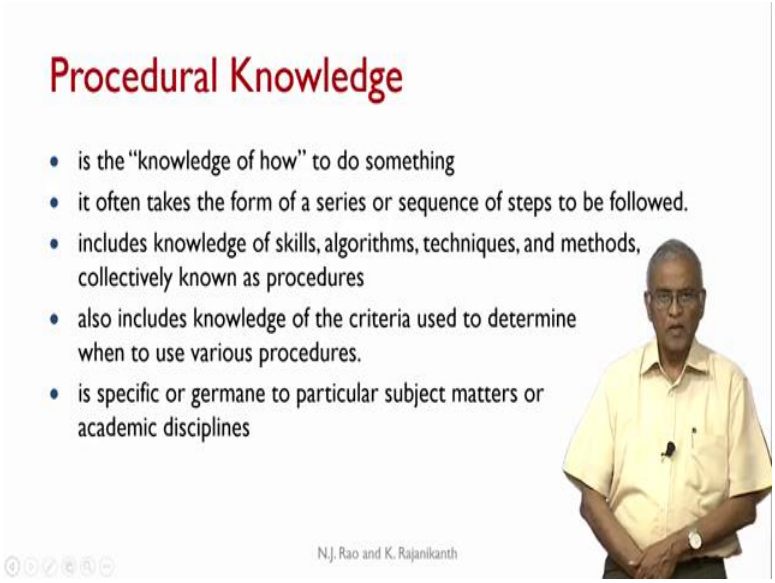

Now, coming to procedural knowledge, is the knowledge of how to do something. It often takes the form of a series of or sequence of steps to be followed. It includes knowledge of skills, algorithms, techniques and methods collectively known as procedures. For example, you want a student in a workshop to turn a particular metal object into or turn it into a certain dimension. For example, it requires certain series of steps and also certain skills as well.

So, that is a procedural knowledge. Let me go back a little bit. There is a sequence of steps represents a procedure. So I can ask the student to go through the series of steps. So, it is very clear, the sequence of steps are very clear. And the student goes through those steps. Every step demands a certain either calculations or doing something in that step. It is like an algorithm. But you also require the knowledge, what procedure do I apply in a given context. That is also procedural knowledge.

And this procedural knowledge again is specific or germane to particular subject matter or academic disciplines. See, you follow a certain procedure to arrive at or to determine something, but then that procedure may not be applicable in some other discipline. So, they are all most of these procedural knowledge is also subject specific.

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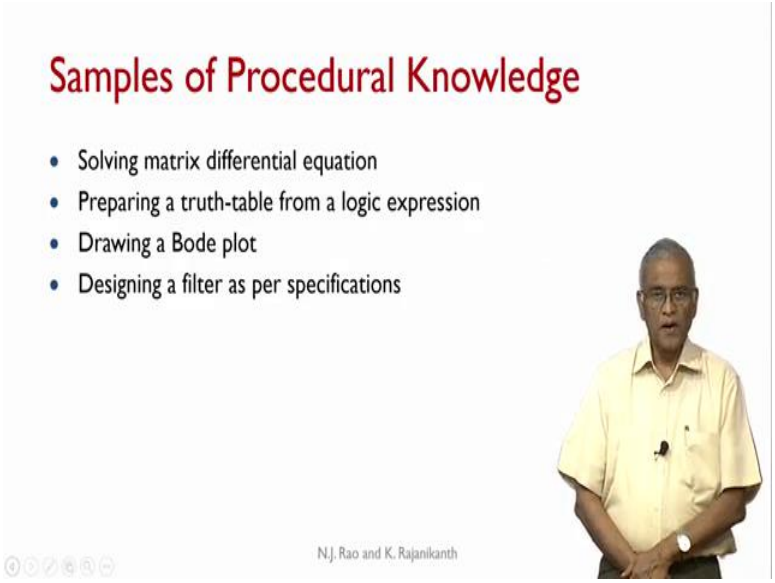

Now, samples of procedural knowledge if you look at, solving a first order differential equation, solving a matrix differential equation, preparing a truth table from a logic expression, drawing a Bode plot or designing a filter as per specifications. All of them involve certain procedures. And also the knowledge, what procedure to be applied in what context that is also procedural knowledge.

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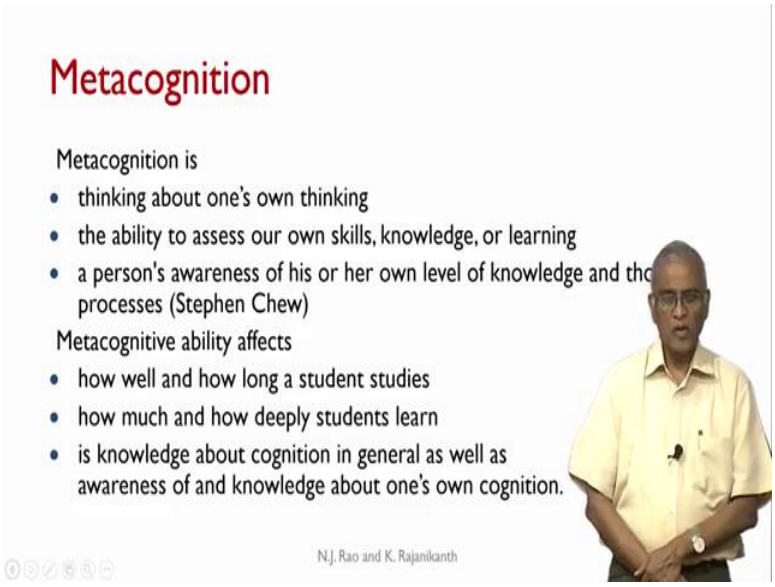

Now, comes the, a little more difficult one, there in the, if you maybe a decade ago, not much attention was paid to the, this category of knowledge namely metacognition. The word meta

itself, of cognition, itself says it is somewhat different from cognition. So, metacognition is cognition about your own cognition, are thinking about ones own thinking. That is what metacognition is. And this ability is also very important to individuals. The ability to assess our own skills, knowledge or learning, the formal definition has given by Stephen Chew, a persons awareness of his-her own level of knowledge and the thought processes.

Now, why is it important, because metacognitive ability affects how well and how long a student studies. That is, if for if some student says, yes, I am not that capable. I need more time to understand something, solve problems, then if student understands is metacognitive ability like that, he will spend more time to study. But if you are not aware of it, then you will spend less amount of time on that.

And especially these factors become very important have started becoming important in the last 2 decades because earlier engineering degree was pursued by much smaller number of people. That means, you had selection and you effectively selected people with good abilities. But now, you want more engineers, there are more colleges, so you have people with lot less metacognitive ability entering into them, entering into the engineering stream.

So, and that is a reason why the metacognition starts becoming important depending on where you are studying, at what level you are studying. And the teachers should now pay attention to the role of this metacognitive ability. So, metacognitive ability affects how well and how long a student studies? How much and how deeply students learn and knowledge about cognition in general as well as awareness of a knowledge about one's own cognition.

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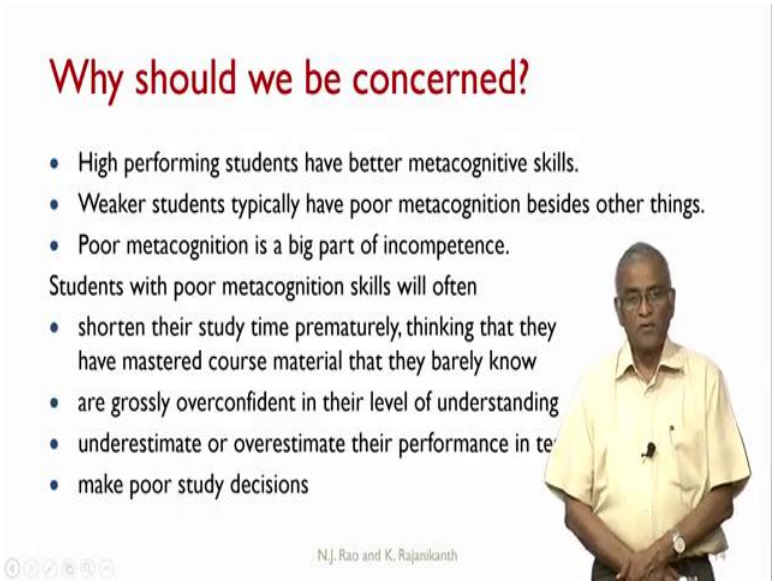

Now, as we said already, why should we be concerned about metacognition? It is known that high performing students generally have better metacognitive skills. That means we do not have to really worry. They already have the metacognitive skills. They may not use the word level metacognitive. But they have the necessary skills. They do not have to worry. But weaker students typically have poor metacognition besides other things. And you can say a poor metacognition is a big part of incompetence.

It does not mean they cannot study engineering. First of all, if you have a large percentage of your students with poor metacognitive abilities, then what is it that you should do? You should give them first they should be made aware of their own metacognition and you must go through the exercises or series of processes through which their metacognitive knowledge first improves.

Once that is done, then they also require more time to master anything that kind of time should be provided. So, one should not have same curriculum or same process that are followed in what do you call, in colleges where the students already through various selection processes, you are selecting people with good metacognitive skills.

The processes applicable to them are not, will not be adequate for the students with poor metacognition. And students with poor metacognition skills will often shorten their study time prematurely thinking that they have mastered course material that they barely know. Are grossly overconfident in their level of understanding or underestimate or overestimate their performance in tests. Make poor study decisions.

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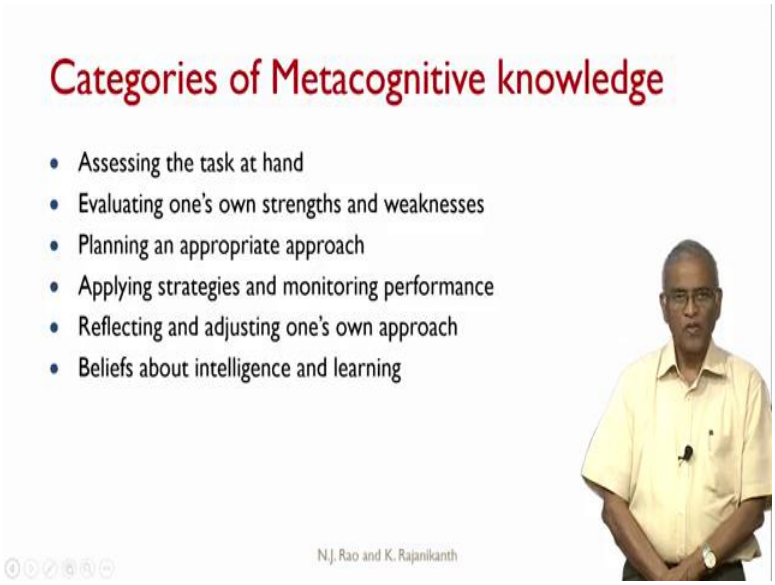

Now, some of the categories of metacognitive knowledge these are absolute categories. We just say indicative we can say. They can be re-categorized into less number of categories. Assessing the rank, assessing the task at hand when some task is presented, you must be able to assess what kind of effort is required, what kind of time is required. So, you need to assess the task that is one metacognitive ability.

Evaluating ones own strengths and weaknesses that means, students should be able to say, when something is presented to you, I need, let us say 2 hours of work to understand this. Or maybe I require 5 hours of study to understand this task. So, one should be able to evaluate ones own strengths and weakness.

Very smart students, what is smartness actually? People with very high IQ, they are able to come to conclusion when something is presented to them very fast. So, a student with high IQ will know his own strength. He may not know much of his weaknesses though. Any way, we will not be getting into that level of detail. Another category is planning an appropriate approach or applying strategies and monitoring ones own performance. Ability to monitor your own performance is also a metacognitive knowledge. Reflecting and adjusting once own approach that is having monitored.

This is where you are, but you are far from your goal. So, you should be able to reflect on that and keep adjusting your own approaches. Beliefs about intelligence and learning, these are all categories of metacognitive knowledge.

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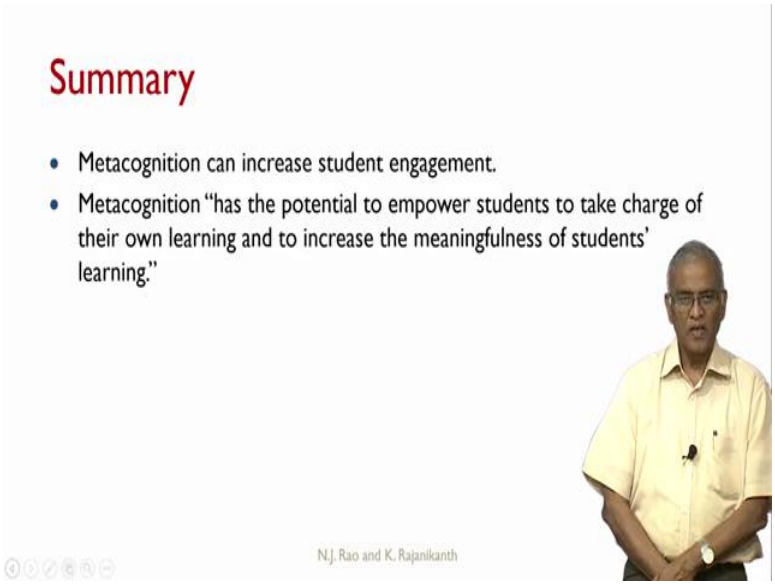

In summary about metacognition, metacognition can increase student engagement. This we found out even from our own experiences by conducting systematic studies the, if students are willing to subject themselves to this. And once you improve their metacognition, their performance in the subjects significantly improves.

But they have to go through the process of finding out about their own metacognitive abilities. So, metacognition has the potential to empower students to take charge of their own learning and to increase the meaningfulness of students learning. So, especially colleges, who take students with whether you call lower or higher ranks or poor ranks of CET that those programs should pay in my opinion attention to the training students in metacognition.

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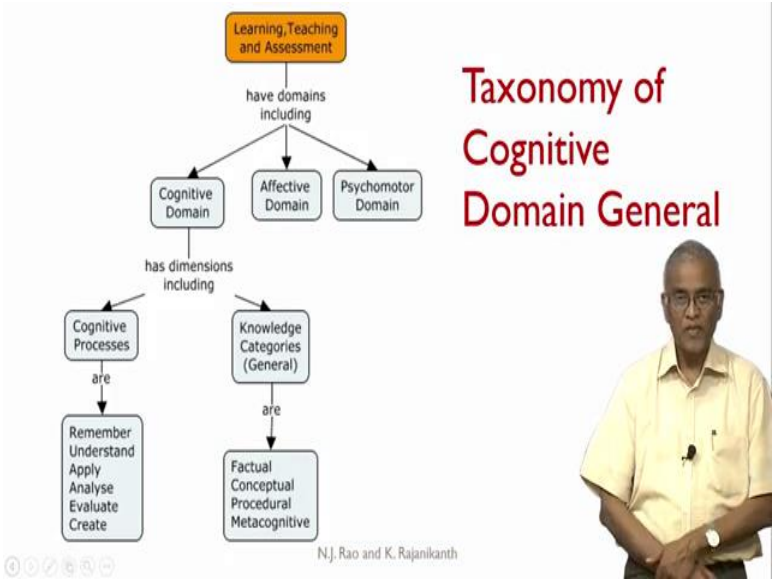

Now, broadly this is the one that captures here, we are talking about learning, teaching and assessment, have domains including we have already mentioned cognitive domain, affective domain, psychomotor domain will come to them presently in another unit. And as per Revised Blooms Taxonomy has 2 dimensions, one is cognitive process, the other is knowledge categories. Right now, we are looking at general categories.

And these cognitive processes are remember, understand, apply, analyze, evaluate and create and the 4 categories of knowledge or factual, conceptual, procedural metacognitive.

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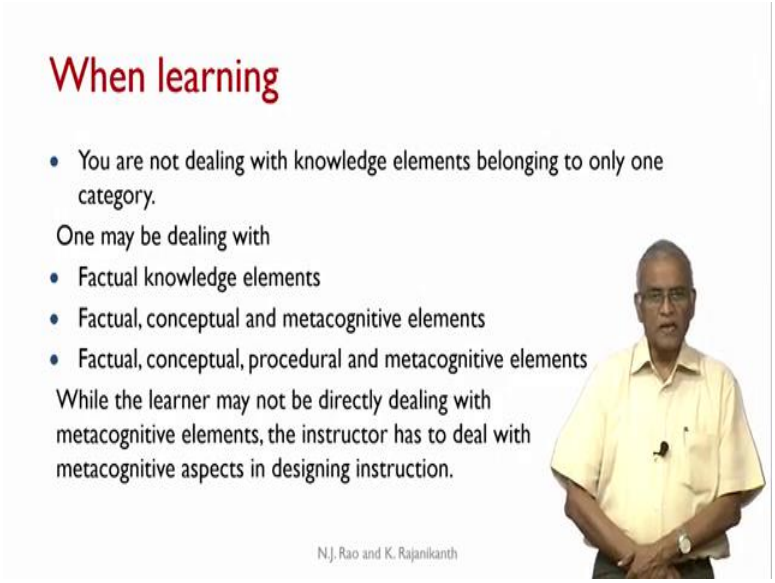

When learning, you are not dealing with knowledge elements belonging to only one category. That should be very clear. One may be dealing with factual knowledge elements only or one maybe dealing with factual, conceptual and metacognitive elements or you will be dealing with all the 4 elements.

The only aspect is while the learner may not be directly dealing with metacognitive elements, the instructor has to deal with metacognitive aspects and designing instruction. If teacher wants to be really effective in facilitating his students to learn, he has to pay attention to metacognition aspects of learning.

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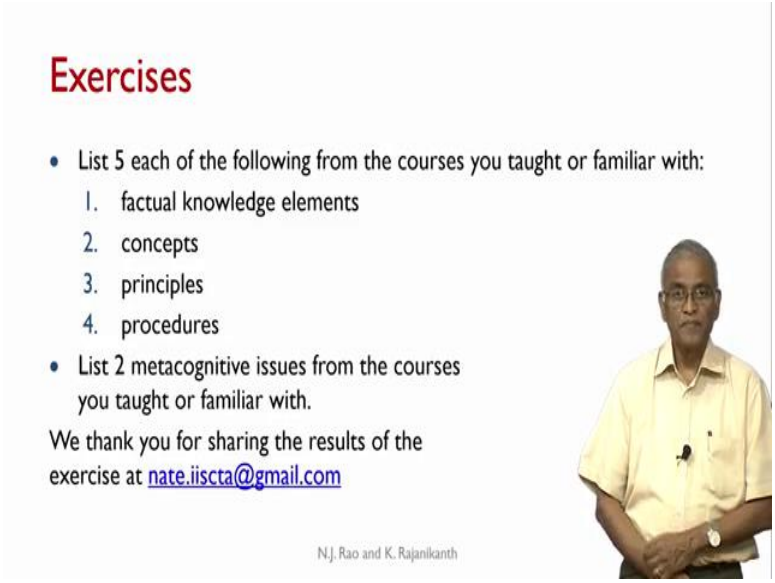

So, we request you to try a list 5 each of the following from the courses you taught or familiar with. That is try to list 5 factual knowledge elements, it should be very easy. And similarly, list 5 concepts or 5 principles or 5 procedures. And separately, we request you to list 2 metacognitive issues from the courses you taught or familiar with. And we will thank you, if you can share those results of the exercises with us.

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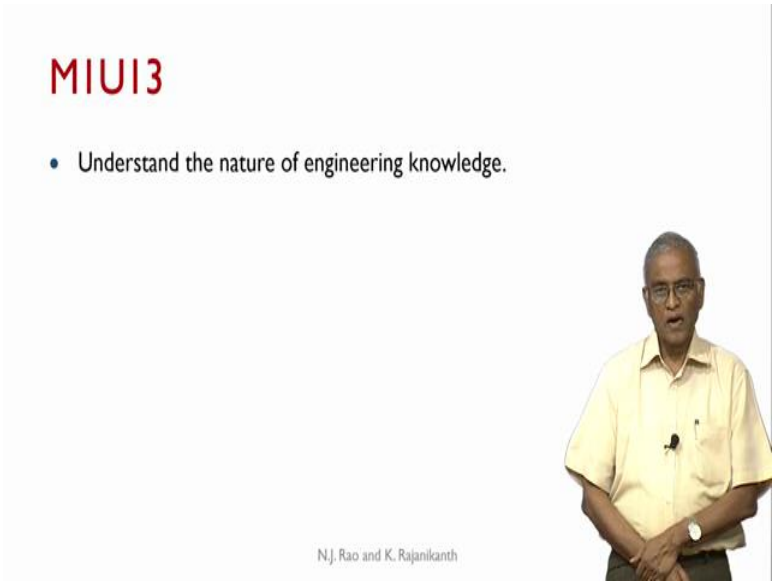

And in the next unit, we will try to understand the nature of engineering knowledge and thank you for your attention.