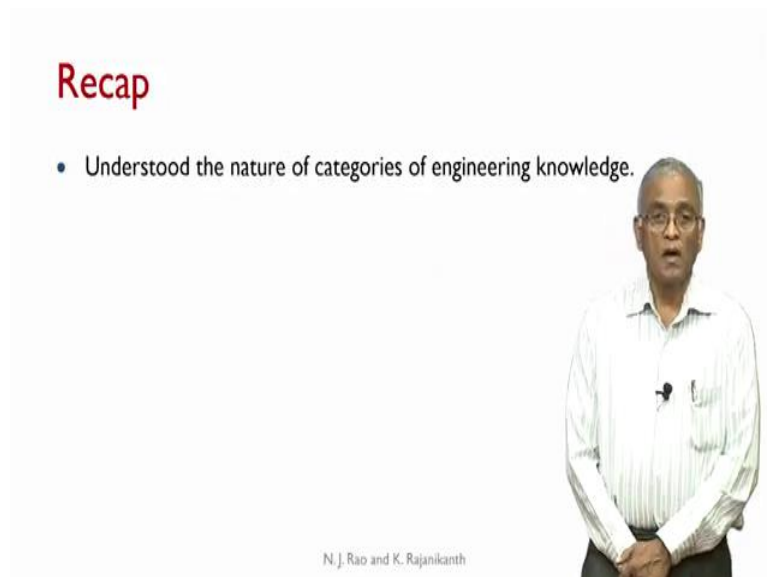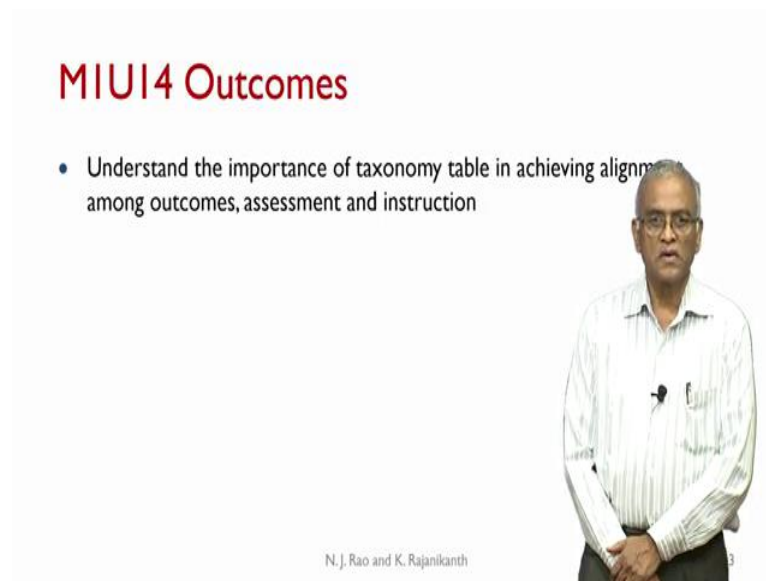**NBA Accreditation and**
Teaching – Learning in Engineering
(NATE)
Professor N. J. Rao
Department of Electronics Systems and Engineering
Indian Institute of Technology, Bengaluru
Lecture 15
Taxonomy Table

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Greetings and welcome to NATE module 1, unit 14 of NBA, Accreditation and Teaching and Learning in Engineering. In the previous unit, we understood the nature of categories of engineering knowledge and prior to that we also looked at categories of knowledge which fall under the general category. We identified between the two, 8 categories of knowledge.
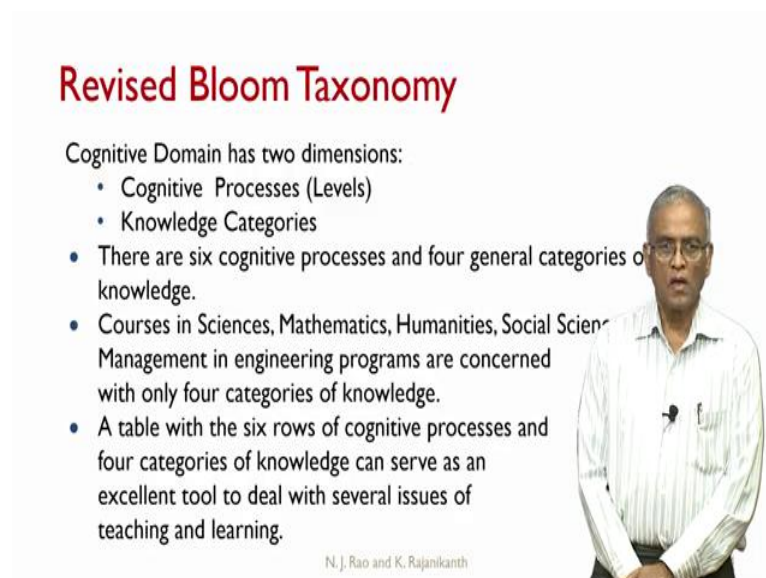
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And in this unit, we try to understand the importance of taxonomy table in achieving alignment among outcomes, assessment and instruction. As we mentioned already, alignment between these 3 elements in a course, is very important and taxonomy table provides a simple tool to kind of address this issue of alignment.

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Now to take a re-look at our revised bloom taxonomy, cognitive domain has 2 dimensions, cognitive processes and knowledge categories. There are 6 cognitive processes and 4 general categories of knowledge. And courses in sciences, mathematics, humanities, social sciences, management in engineering programs if you take because engineering programs have all these categories.

They are only concerned with the 4 categories of knowledge. So one can create under revised bloom taxonomy, a table with 6 rows of cognitive processes and 4 categories of knowledge can serve as an excellent tool to deal with several issues of teaching and learning.

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Revised Bloom (RB) Taxonomy Table

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

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This is how the table would look. The rows are cognitive process, and columns are knowledge categories. So you have a 6 by 4 kind of metrics. So you have 24 cells there and each cell represents certain combination of cognitive process and knowledge category. One thing we need to point out in the Crotch Walls book or Anderson and Crotch Walls book, they have presented the taxonomy table with rows and columns reversed.

That means the rows or knowledge categories and the columns are non-cognitive process. We felt that natural order is this in the sense, whenever you write an outcome, you start with an action verb, which represents a cognitive process. So, cognitive process comes first, cognitive activity comes first and the knowledge categories come later. That is the reason why, whenever you look at it, we felt that the row should be represented by cognitive process, but it is a very simple change.

It does not alter anything otherwise. If somebody feels comfortable with the, these two reversed, it is fine. There is no issue involved in that.

Features of RB Taxonomy Table

- 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 Analyze-Procedure outcome, instructional activity and/or assessment.
- As there is hierarchy among cognitive processes the cell (4,*) represents more complex (higher level) cognitive activity than the cell (3,*), but not necessarily more difficult activity.
- The cell (4,*) implies all activities in (3,*), (2,*) and (1,*) cells.

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Revised Bloom (RB) Taxonomy Table

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

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Now, let us look at the features of the, this RB or revised bloom taxonomy table. A cell of the taxonomy table can be numbered by its cognitive process 1 to 6 and its knowledge category 1 to 4. So, the cell 4-3 represents analyze procedure outcome or analyzed procedure instructional activity are actually and or analyzed procedure assessment.

So, a cell, you can, for example, if you want to look at, apply procedure outcome then we can write it as 3 comma 3. There is a hierarchy among the cognitive process that we have mentioned earlier that analyzes at a higher hierarchical level then apply level. So, to their extent, the hierarchy among cognitive process, the cell 4 comma star represents more complex.

Complexity is defined in terms of higher level cognitive activity then the cell 3 comma star means any knowledge category. So, here we define complexity as something belonging to higher cognitive level. But it is not necessarily more difficult activity, difficulty is another dimension altogether. So, complexity and difficulty should not be mixed.

Unfortunately, they have been mixed without knowing by large segment of the faculty. They consider a higher level complex activity is more difficult, it does not have to be, okay. So, difficulty and complexity are 2 different concepts and 2 different things, difficulty represents another, you can say third dimension of this taxonomy table.

And because of the hierarchy, the cell 4 comma star, implies all activities in 3 comma star, 2 comma star and 1 comma star. For example, going back to this, if, if I take 4 comma 3 is what 4 comma 3. If this is a activity, if this is a cell that I am looking at, if I am looking at a outcome here, all the activities related to these 3 cells, which are hierarchically lower, they are automatically implied. That means I do not have to mark those cells that is the implication of hierarchy.

Revised Bloom-Vincenti Taxonomy Table

- In case of Engineering courses there are additional four categories of knowledge.
- RBV (Revised Bloom-Vincenti) taxonomy table will be 6x8 table.
- The features of RBV table are the same as those of RB table.

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Revised Bloom-Vincenti Taxonomy Table

Cognitive Processes	Knowledge Categories							
	Factual	Conceptual	Procedural	Meta-cognitive	Fundamental Design Principles	Criteria & Specifications	Practical Constraints	Design instrumentalities
Remember								
Understand								
Apply								
Analyze								
Evaluate								
Create								

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Now we move on to engineering courses. A revised Bloom-Vincenti taxonomy table is different from revised bloom taxonomy table because we are adding another 4 categories of knowledge that were mentioned by Vincenti. So now, we may call it as a RBV taxonomy table, revised Bloom-Vincenti taxonomy table will have 6 rows and 8 columns.

Otherwise the features of RBV table are the same as those of RB table okay. Now if you look at, you have the taxonomy table for engineering courses is like this. We add these extra these factual conceptual procedural metacognitive, to them we add these 4 categories of engineering knowledge. So, it becomes a 6 by 8 matrix.

Engineering Science Courses

- Majority of engineering science courses as offered at present (Fluid Mechanics, Thermodynamics, Electromagnetic Theory, Network Theory etc.) do not address the four categories of engineering knowledge.
- However, a teacher may choose to address some categories of engineering knowledge in his/her engineering science course.
- 6x8 RBV taxonomy table can be made applicable to engineering science courses.
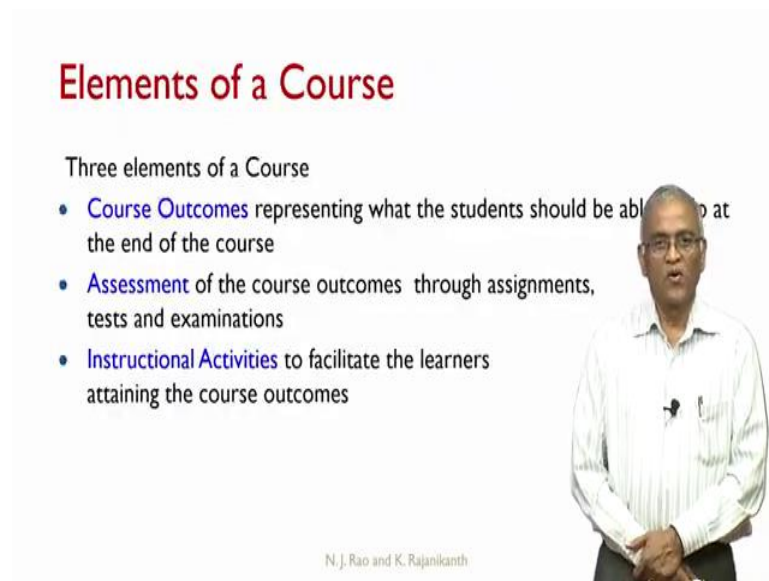
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Now, majority of engineering science courses offered at present like fluid mechanics, thermodynamics, electromagnetic theory, network theory, a do not normally address the 4 categories of engineering knowledge. However, a teacher may want to choose to address some of the categories of engineering knowledge in his or her engineering science courses.

But by and large people do not address the engineering knowledge categories in engineering science courses. So, if you want 6 by 8, RBV taxonomy table can be made applicable to engineering science courses. So, if you look at your curriculum, you will find if you eliminate all the basic science courses, engineering science courses, management courses, English and all that, the number of true engineering courses are very constitute only small percentage.

So, as you can see, in an engineering program, the importance given to engineering courses is very small. Sometimes it is insignificant percentage that is a reason why a graduate of engineering programs is likely to be engineering scientists rather than an engineer.
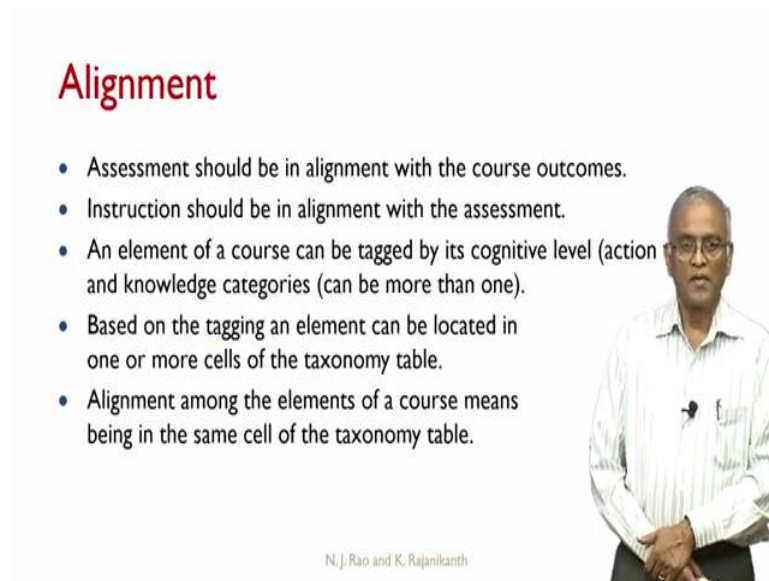
What are the elements of a course, we have mentioned earlier, we are going to mention this repeatedly because of its importance. The 3 elements of the course are, course outcomes, representing what the student should be able to do at the end of the course, which you will look at it in great detail in the following the units.

Assessment of the course outcomes through assignments, tests and examination and instructional activities to facilitate the learners attaining this course outcomes. So, the 3 activities when you actually implement in the classroom, you will have course outcomes rate communicated to the students then you conduct instructional activities, then you do the assessment.

When you design the course, you change the order. You write the course outcomes first, then design the assessment and adjust your instructional activities to facilitate the learners to perform against the proposed assessment instruments okay.

Alignment

- 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 and knowledge categories (can be more than one).
- Based on the tagging an element can be located in one or more cells of the taxonomy table.
- Alignment among the elements of a course means being in the same cell of the taxonomy table.

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Now, what is alignment? We said assessment should be in alignment with the course outcomes, instruction should be in alignment with the assessment. So, when all the 3 are in alignment with each other, then only you have the right kind of learning. And we also said any element of the course that is assessment, instruction course outcomes they can be tagged by its cognitive level through which is indicated by the action verb and knowledge categories which can be more than one.

So, based on the tagging that you have, which we mentioned like 4 comma, 3 comma 3 like that, based on the tagging an element, it can be located in one or more cells of the taxonomy table, okay we will presently see. So, alignment among the elements of a course means being in the same cell of the taxonomy table. If all the 3 activities are in the same cell, then all the 3 are aligned, that is how we look at alignment.

Alignment in RBV Taxonomy Table

Cognitive Processes	Knowledge Categories							
	Factual	Conceptual	Procedural	Meta-cognitive	Fundamental Design Principles	Criteria & Specifications	Practical Constraints	Design instrumentalities
Remember								
Understand			CO3, AI3, IA3					
Apply								
Analyze								
Evaluate								
Create								

CO-Course Outcome;   AI-Assessment Items;   IA-Instructional Activities

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Less Alignment Still Relevant

Cognitive Processes	Knowledge Categories							
	Factual	Conceptual	Procedural	Meta-cognitive	Fundamental Design Principles	Criteria & Specifications	Practical Constraints	Design instrumentalities
Remember		AI5, IA5	AI4					
Understand		AI5, IA5	AI4					
Apply		AI5, IA5	CO4, IA4					
Analyze		CO5						
Evaluate								
Create								

CO-Course Outcome;   AI-Assessment Items;   IA-Instructional Activities

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Now, we took at RBV taxonomy table, the same thing will be applicable to the RB taxonomy table as well. And here, we looked at we are looking at the cell 2 comma 3. That is understand procedural. Now CO 3 is located there. And AI 3 and IA 3, AI is assessment items, AI is assessment items or instruments. IA 3 is instructional activity. When all the 3 are located in the same cell, we call it complete alignment.

But in actuality that is not the only thing that is acceptable. What we may have? We can call it less alignment but still relevant. Let us take the second column where with CO 5 is in analyze conceptual category. But what happens is we have AI 5 or IA 5, let us take IA 5, instructional activity is dominantly in the apply category, but not in the analyzed category.

That means CO 5 and IA 5 are not in complete alignment, but still that activity is relevant, but less aligned. Similarly, you can have IA 5 in understand conceptual category and also IA 5 is in remember conceptual category, said all these are required to address CO 5 you may say. But if there is no IA 5 at all, in that 2 comma sorry, 4 comma 2, then obviously you are not, you cannot say that you have attained CO 5.
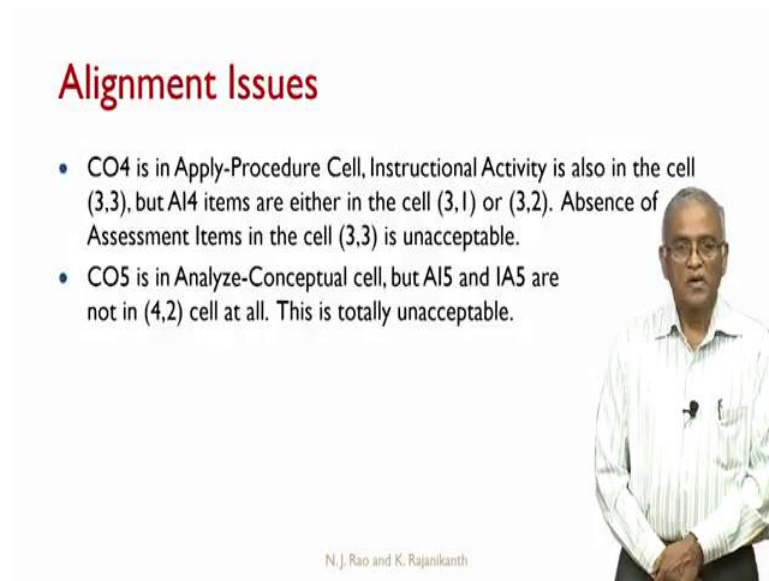
Same thing applies to assessment instruments also, my questions, the questions that I asked in any of the assessment part is not located in the 5, 2 category. It is always less. So that level of non-alignment is not acceptable. That means you are not doing what you are expected to do. You wrote a very high level, higher cognitive level outcome, but neither you are testing them in that nor doing your instructional activity that leads to attainment of CO 5.

You take another one, CO 4 that is apply procedural category, which is very common. And IA 4 means my instructional activities are actually done there, which is quite good. That means instructional activity and course outcome are aligned, but I do not ask any questions in my examinations or tests that come under the come into this particular cell.

They are all above that is AI 4 in understand procedural issue and the otherwise remember, procedural. This is generally what happens in presently in most of the colleges in terms of assessment. That means, I cannot claim if my assessment is confined to 2 comma 3 or 1 comma 3, then I am not I cannot claim that I am I have I am attaining CO 4 at all.

So, we request you to kind of spend time on this and take a look at how you are doing and what is it that you can do, so that AI 4 can also be brought into the cell 3 comma 2, sorry 3 comma 3, why need to bring them here, okay I hope I have been able to explain the importance of alignment through the taxonomy table.
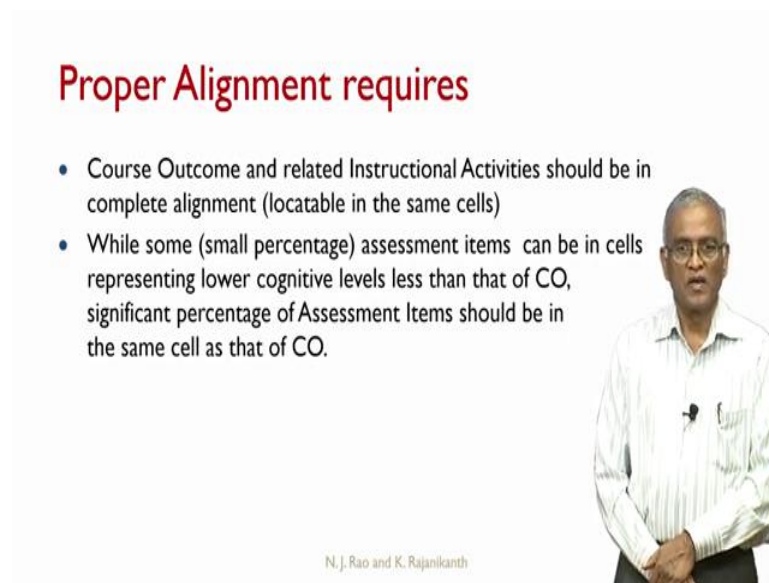
This is what we have just no explained like CO 5 is an analyzed conceptual sell, but AI 5 and IA 5 are not in 4 comma 2 cell and this is totally unacceptable.
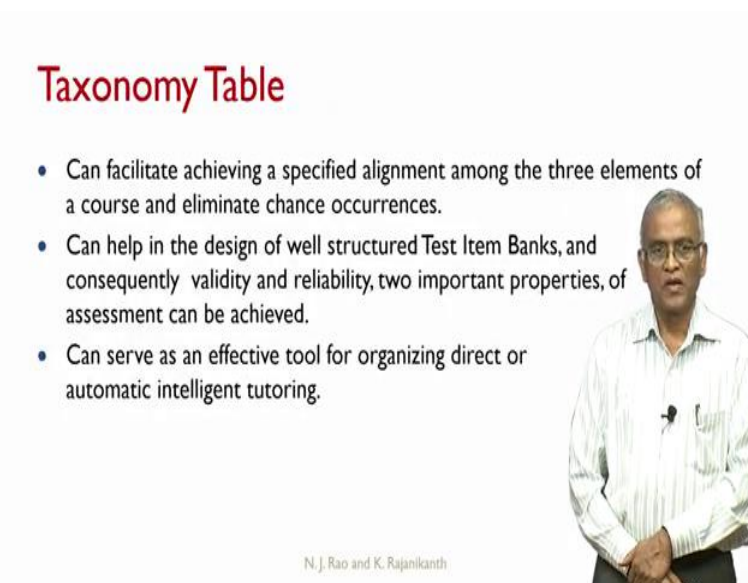
A proper alignment requires course outcome and related instructional activity should be in complete alignment at least that much should be done. That means they are locatable in the same cells. While some small percentage of assessment items can be in cells represent in lower cognitive levels. Less than that of CO but significant percentage of assessment items should be in the same cell as that of CO, what is this significant percentage? What percentage is acceptable?

If my CO is in one particular cell, at least we consider more than 50 percent of the questions that you ask in any of the assessment instruments should be in that category. This is of course, is a little bit of what you called personalized statement. And we claim subsequently we show that it should be more than 50 percent means we put that figure at 60 to start with. If you want to make it 100 percent, you are most welcome.

But 100 percent may lead to other issues. So, we are suggesting which we will elaborate later that 60 percent of the assessment items should be in the same cell as that of CO. Ofcourse, this language may be different from what you are familiar with, but this is related to the alignment issue.
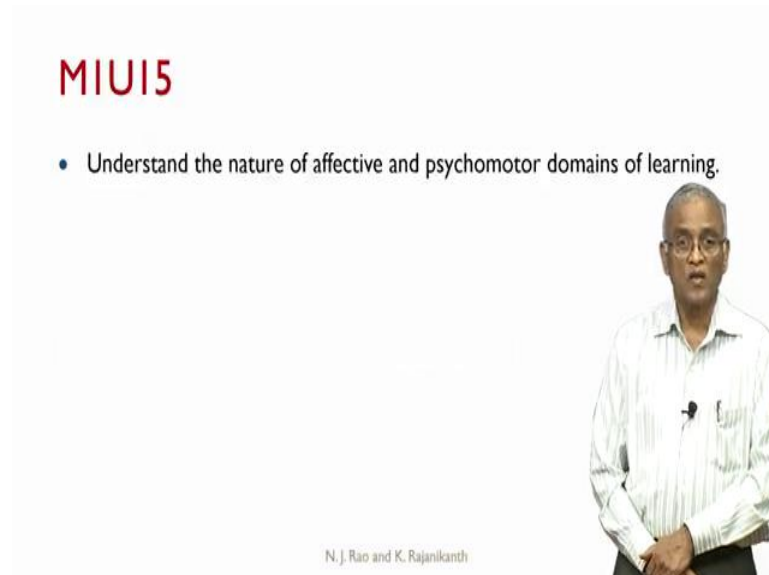
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So, what can the taxonomy table do? It can facilitate, achieving a specified alignment among the 3 elements ofcourse and eliminate chance occurrences. For some reason you have decided, I want to give more weightage to the lawyer cognitive level than the CO. So, take the taxonomy table and put your percentages to start within corresponding cells. So what happens when you are designing you are either question bank or your assessment instrument.

So you have the numbers, reference numbers in front of you. That is one purpose, the taxonomy table can serve. And also, we will show in the later module, it can help design of a well structure test item banks, and consequently validity and reliability, these 2 are two important properties of assessment can be achieved.

Validity and reliability, of your assessment can be achieved. We will elaborate on the concept of validity and reliability in the second module. So, these two are two key properties of any

assessment and it can also serve as a tool for organizing direct or automatic intelligent tutoring. This we have done extensively which is outside the scope of this and it can be from this taxonomy table can serve as a, an excellent tool in organizing, tutoring whether it is automatic or direct tutoring can be organized using the taxonomy table, okay.

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In the next unit, we try to understand the nature of affective and psychomotor domains of learning, which we have mentioned briefly that after cognitive domain you have psychomotor and affective domain as well. While we are not going to spend too much time on this in the following, follow up lectures.

But a kind of awareness of affective and psychomotor dominance is necessary for a teacher. And in fact, we encourage the teachers to spend time on their own to explore the affective and psychomotor domains relevant to their, the subjects of concern. Thank you very much for your attention.