Teaching and Learning in Engineering (TALE)
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Lecture - 15
Taxonomy Table

Greetings and welcome to Unit 15 which is about Taxonomy Table.

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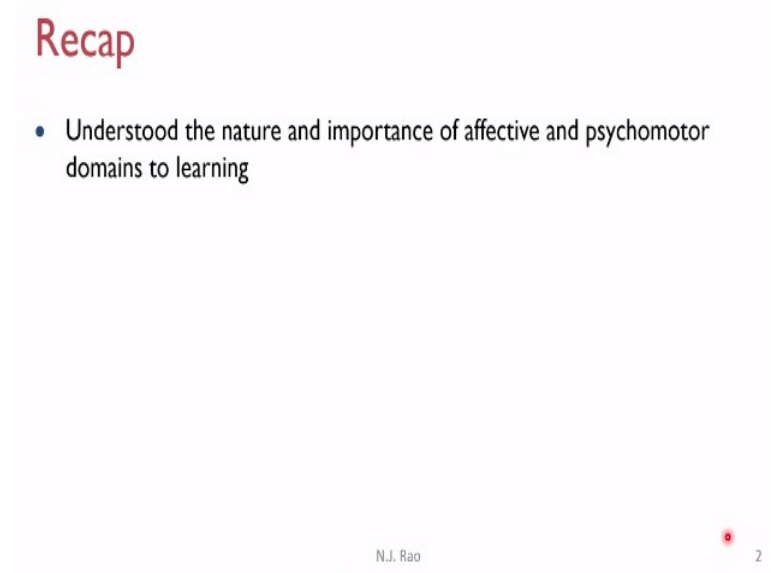

Now in the last unit we understood the nature and importance of affective and psychomotor domains to learning but we also said we as yet we do not have adequate methods and processes to integrate affective domain learning along with the cognitive domain learning.

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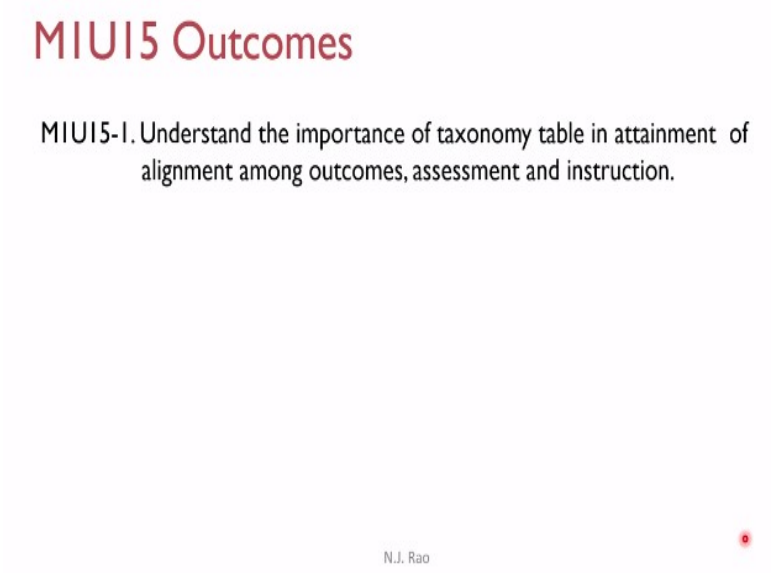

Main outcome of this module is - understand the importance of taxonomy table in attainment of alignment among outcomes, assessment and instruction. Note that there are three elements of any course. One is outcomes. What should the student be able to do? That is outcomes. Then we should be able to measure that attainment. Whether student has attained that or not - outcomes is done through assessment and the third one is I must facilitate the students in my class to be able to perform well in my assessments. Through that we are attaining the outcomes.

That is broadly, so any course has these three elements or you should be able to view a course in terms of these three elements; outcomes, assessment, and instruction. And in doing so, the taxonomy table is a useful tool. It does not substitute for what you want to do, but you can use it for variety of purposes in your instruction.

Either locating the outcomes at the right level or making the assessment in alignment with outcomes or planning instruction making sure that your instruction is in line with what you wanted your student to be able to do. So this is broadly the outcome of this unit.

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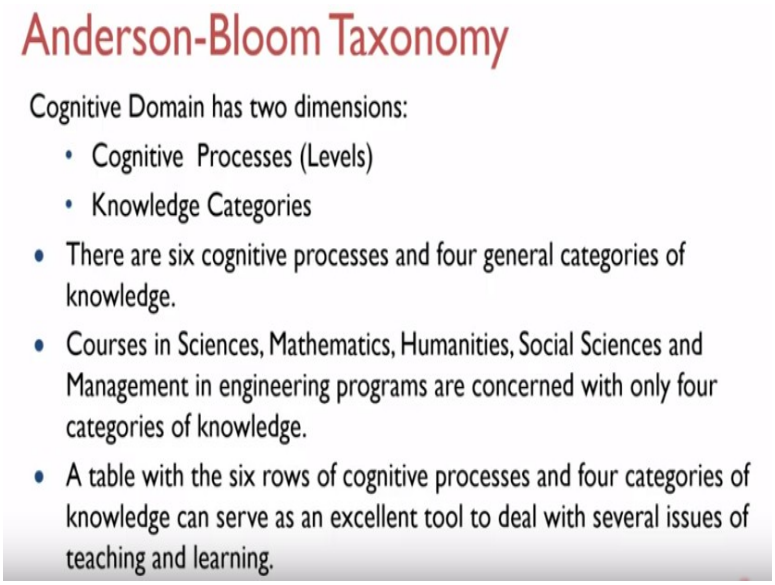

Okay to recap, cognitive domain has two dimensions namely cognitive processes; we also call them levels. In literature cognitive processes and cognitive levels are used interchangeably. Then you have knowledge categories. Now what we have is there are six cognitive processes and four general categories of knowledge, six and four.

And courses in sciences, mathematics, humanities, social sciences and management, because we have courses in all these areas in an engineering program and they do constitute something like about maybe 20% or even more in an engineering program and they are concerned with only four categories of knowledge. So if you are looking at courses in sciences, mathematics, humanities, social sciences and management you need to worry about six cognitive processes and four general categories of knowledge.

So why not we put them together in a table with six rows of cognitive processes and four categories of knowledge that can serve as a tool with as we said earlier with several issues of teaching and learning. So it is a simple table, create. Okay, that is what it is.

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Anderson-Bloom Taxonomy Table

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

The cognitive processes are Remember through Create and knowledge categories of Factual, Conceptual, Procedural. For example each one of the cognitive process is associated with a set of action verbs. Any statement that you make about outcome will start with some action verb belonging to one of these cognitive processes and these cognitive process deals with some elements of knowledge and elements of knowledge may come from one or more of these four categories.

That is broadly the purpose of taxonomy table. Let us move on to some features of this.

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Features of AB Taxonomy Table

- A cell of the Taxonomy Table can be numbered by its cognitive process (1 to 6) and its knowledge category (1to 4).
- The cell (4,3) represents Analyse-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.

If you look at a cell of the taxonomy table can be numbered by its cognitive process 1 to 6 and its knowledge category 1 to 4. So you can have a cell let us say you are here. So what happens, the cell is 2, 2. When it is 2, 2; that is you are in understanding the concepts of some concepts that you are stating because that is what it is. So I can label this as 2, 2. Similarly, this will be 3, 2 or this will be 3, 3 and so on okay? So we are labeling the, we are able to identify a cell.

And in addition there is hierarchy among cognitive processes. What does it mean? Anything that you Create is higher level than Evaluate. Evaluate is higher level than Analyze and so on. So what happens, if I identify an activity here, let us say apply and procedural then the cognitive activities in Understand and Remember are implied. That is I do not have to separately identify these as cells of our concern.

If I write something here or if I write an activity, identify an activity here; then it can be expected all the activities related to these four lower level categories are implied. I do not have to separately identify them. For example an activity, let us say in the Analyze is of high, an activity of higher complexity compared to an activity let us say in Understand. So as you keep moving up this cognitive level hierarchy the activity can become more and more complex as we call it.

The complexity should be differentiated from the difficulty. I can have very difficult activity even here; which is intellectually is a lower level activity. For example if I want to call give me the capitals of all the South Asian countries. I may or I would consider it is difficult but not complex. Whereas an activity here may be simple not that very difficult but it has a higher level complexity. So the two words that one has to be familiar with, complexity and difficulty.

Because unfortunately many teachers consider complexity is synonymous with difficulty and they say they somehow prevent or eliminate complex activities from actually instruction and assessment and that would be doing a great disservice to the students because you can give simpler problems belonging to higher cognitive levels and they will not become difficult but students should experience these complex activities.

So one of the things to learn is that complexity and difficulty we will elaborate more when we look at the issue of assessment in a later module.

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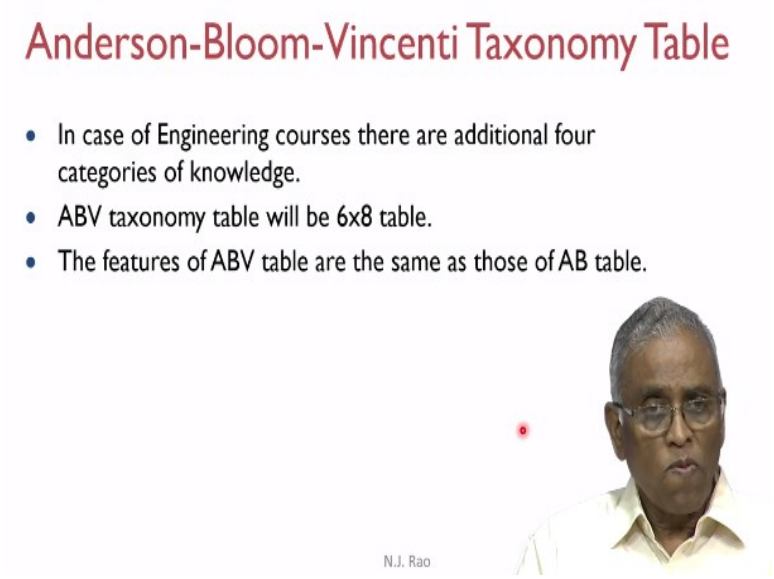

Now in case of engineering courses, we found that we have four additional categories of knowledge. So now you have we call it ABV taxonomy table, Anderson-Bloom-Vincenti taxonomy table. It will be 6 by 8 table; 6 cognitive process and 8 categories of knowledge. And the features of ABV table are the same as those of AB table that is in terms of hierarchy, complexity as well as difficulty. All those features are the same in ABV table as well.

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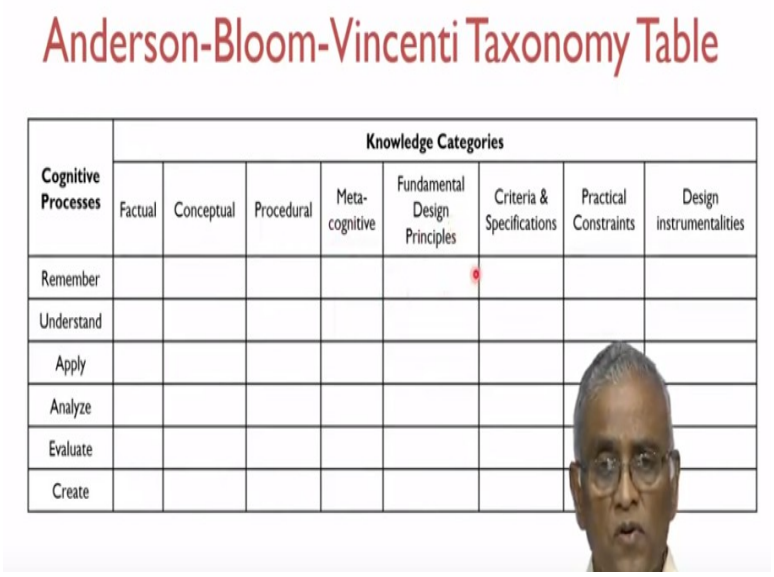

And how does the table look? The table looks like you have the same, 6 cognitive levels, 4 general categories here and then 4 category specific to engineering.

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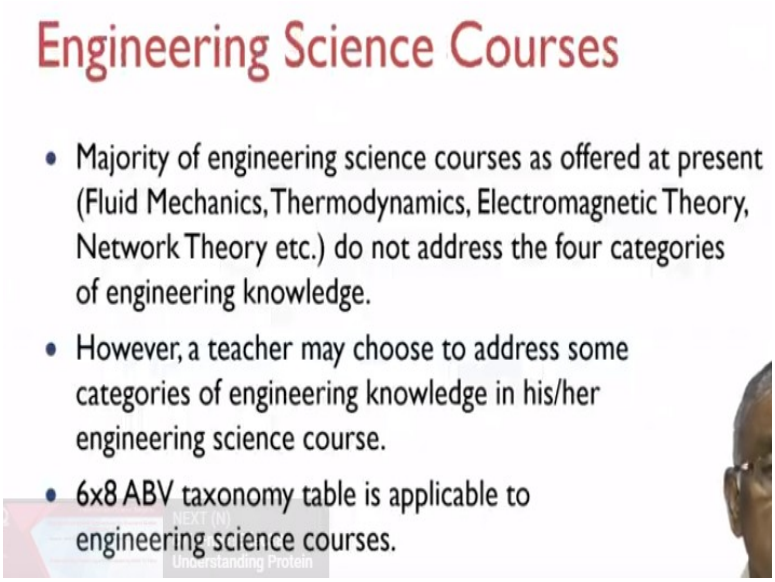

Now where do the engineering science courses come to? Because engineering courses are different from engineering science courses. What are the engineering science courses? Engineering science courses examples Are Fluid Mechanics, Thermodynamics, Electromagnetic Theory, Network Theory, Aerodynamics; you call it there are several such courses. Each branch has at least 4-5 engineering science courses.

They directly as they are offered right now, they do not address the four categories of engineering knowledge. Then the issue come, should I classify them under the earlier AB taxonomy table or ABV taxonomy table? Which one should I deal with? But a teacher of this engineering science courses may choose because of his interest and passion for engineering may choose to address some categories of engineering knowledge even in engineering science courses.

So what happens as of now we will consider 6 by 8 ABV taxonomy table is applicable to engineering science courses as well. If I choose to deal with the course purely as a science course, then I am ignoring, I am not looking at this 6 by 4 that is half the cells I am not putting any activity in that. That is what it means. But because some people may want to use, so we will

say 6 by 8 ABV taxonomy table is applicable to engineering science courses as well. This is the position we are taking.

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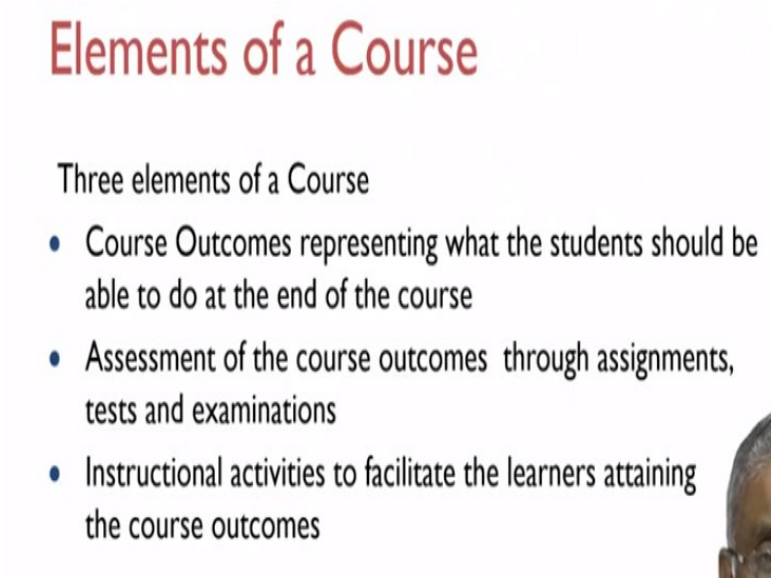

Now once again to reinstate the three elements of a course are Course Outcomes, representing what the student should be able to do at the end of a course. Assessment of the course outcomes through assignments, tests, and examinations. Assignments can be many. Tests can be many varieties. And instructional activities to facilitate the learners attaining the course outcome. Okay, these are the three elements of this. And these three elements should be in alignment with each other. That is what we are coming to.

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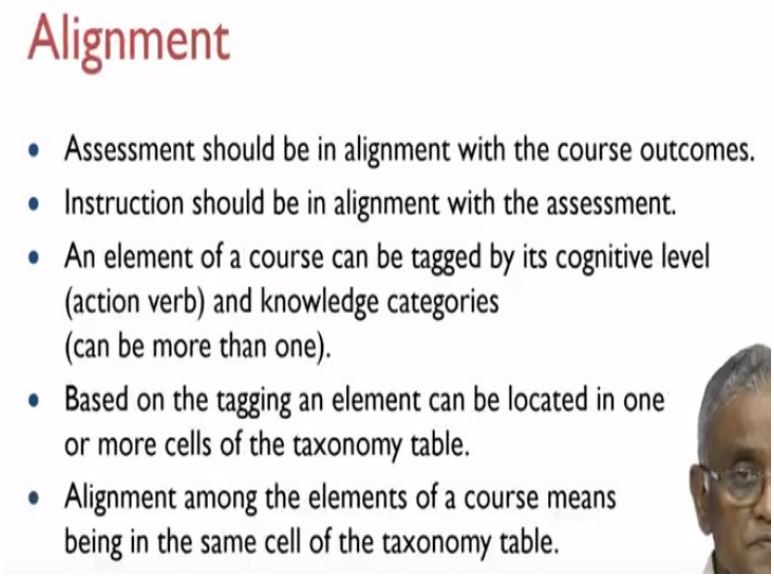

Alignment means assessment should be in alignment with the course outcomes. For example if I want my student should be able to design let us say a complex circuit, I cannot merely ask him, assess him only in terms of does he understand the physics of the devices that are used or given a circuit what does it function? I cannot limit my assessment only to those. I must, assessment should include making him design some complex circuit. That is what we mean by alignment.

Similarly, instruction should be in alignment with the assessment. If I want my student to be able to design a complex circuit, I must tell him how to design and actually design some complex circuits in the class taking realistic specifications of the same. And to ensure that the proper alignment takes place an element of a course can be tagged by its cognitive level. By looking at its action verb we can say what cognitive level does it belong to.

And similarly we can also identify the knowledge categories. Remember that in any element of the course one may be dealing with more than one knowledge category. That we will elaborate more on the following units when we start writing the course outcomes. Based on the tagging an element can be located in one or more cells of the taxonomy table. Depending on how you tagged an element, for example I say it is Apply and Conceptual.

So I can immediately put it in the particular cell of the taxonomy table which will be Apply will be 3, Conceptual is 2. So it will be 3, 2 cell of the 6 by 8 table. Alignment among the elements of a course means that I am putting all the three elements in the same cell of the taxonomy table. That is what we mean by alignment.

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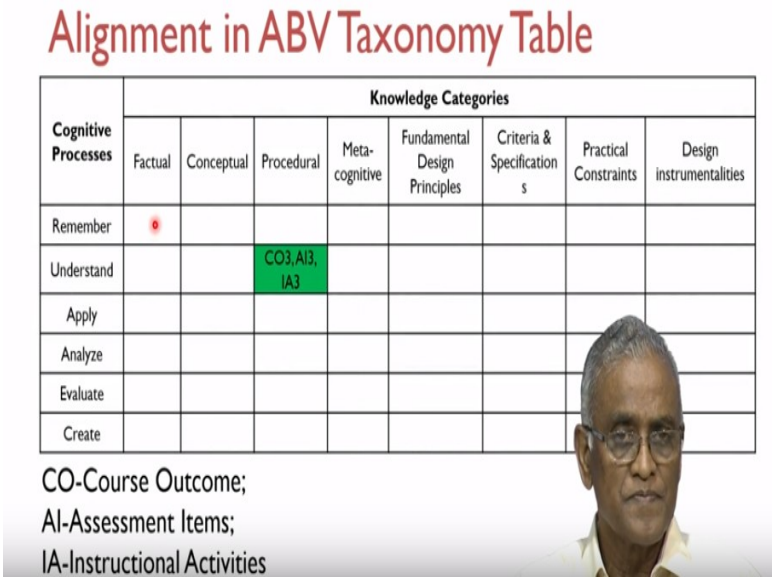

Let us look at this. Alignment in ABV taxonomy table, we have put as 6 by 8 and here CO means course outcome, AI is assessment items, IA means instructional activities. What we do in the classroom or laboratory or through any other type of interaction. Whatever mechanism that you have, direct teaching or flipped classroom or online; anything that you talk about. Instructional activities means in some kind of interaction or knowledge transfer from the teacher to the student.

Now that means if CO3 is located in Understand and Procedural your assessment items that is assessment items include assignments, tests, and examination all of them are located in the same cell, okay? And then my instructional activities also are in the same cell. When all the three are together in the same cell, we consider we have a perfect alignment. That is what we mean by alignment.

For example if CO3 and IA3 are in the same cell but AI3 somehow belongs to let us say Remember and Factual. I ask some definitions and I ask him to reproduce a theorem then it becomes AI3 has moved here. AI3 is here. If it is so, my CO3 is here, my assessment items are here then obviously there is no alignment between my outcome and the assessment items. That is what we mean by alignment.

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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								

Now, let us look at other things that happened as of now. The issue is this. I have my CO4 and instructional activities are also in this here. But what happens is I have AI4 here and some AI4 also here. So what does it mean? My assignments or test items are not in the Apply category. But they are in Understand and Remember category. While these are related to CO4 that means the items that I am asking are relevant to CO4 but they are not in alignment with this.

So that is why the alignment of these two is lot less than if they are here. For example if I am still my outcome is related to solving certain type of problems or applying certain procedures but I should know what the procedure is and what the theory of that is and I must remember some facts. So there is some scope of having items here, having test items here. But there is no excuse for not putting AI4, some of the AI4 in this cell; in this, this is not acceptable.

While still that is partly acceptable but not having any AI4 here is totally unacceptable. And unfortunately that is what is happening in majority of the question papers that people design that they seem to be relevant. I ask some questions about the same topic but not at the level, cognitive level that a student is required to learn. Now you have another case, you have CO5 is in analyze conceptual category but I have my assessment items as well as instructional activities or all at the lower level activities.

And this is total because instruction itself is not doing anything to make a student analyze. Then CO5 itself is that is in terms of implementation itself it is a failure, okay? So both these things, both the types of things are being done and a teacher should avoid this and that can be easily identified because sometimes we do it inadvertently.

When I design a question paper, depending on the situation, I may forget to include some items at the, which are in alignment with the, my selected CO. To avoid all that we can tag each assessment item and based on that we can verify whether we have adequate number of items which are in alignment with the stated CO.

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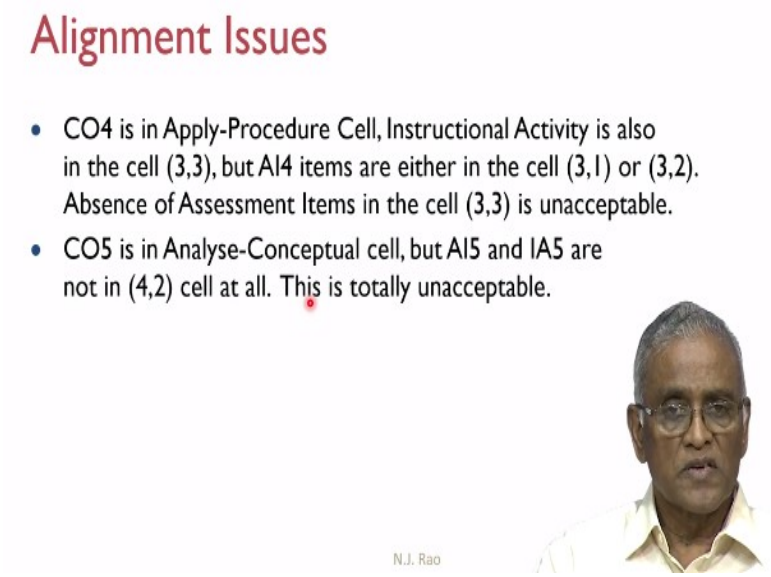

So that is what we have explained that not having instructional activities and assessment items at the same level as CO is not acceptable.

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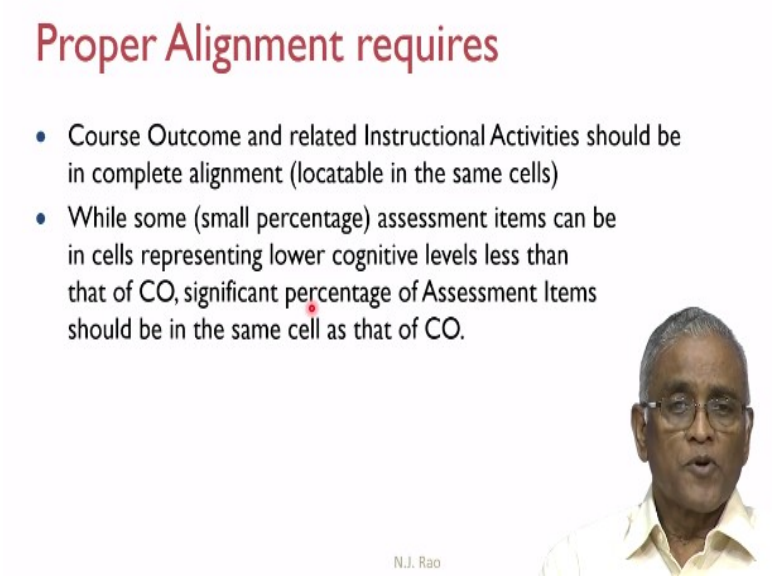

So proper alignment requires course outcomes and related instructional activity should be in complete alignment. They should be located in the same cell. But remember that both instructional activity as well as course outcome statement when I put it at a particular cognitive level, both the knowledge elements of the course outcome and cognitive processes at the lower level are considered to be taken care.

So when I am trying to, a higher cognitive level activity my instructional activity will introduce the terms and explain what the term means and what the underlying concept is and finally make him do at a higher cognitive level. So to that extent my instructional activity which is in complete alignment automatically involves the lower cognitive level activities.

Coming to assessment while some small percentage of assessment items can be in cells representing lower cognitive levels less than that of a given CO significant percentage of assessment item should be in the same cell as that of CO. This is a very major consideration that one has to look at. We will look at that more when we are trying to write about CO, writing COs and CO attainments. And also it will come in our next module on Course Design.

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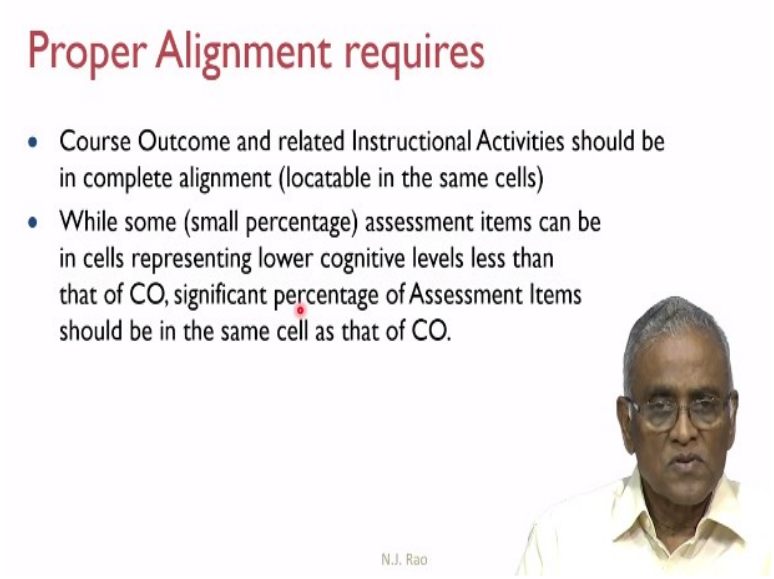

So what does a taxonomy table do? It can facilitate achieving a specified alignment among the three elements of a course and eliminate chance occurrences. As I mentioned by properly tagging and locating them in the proper cells of the taxonomy table and subjected to peer review as well. So by discussing with peers we can make sure that we are not overdoing something or underdoing something. That is the advantage of using a taxonomy table.

It is easy way to communication between, communication between the peers. It can help in the design of well-structured test item banks and consequently the validity and reliability, two important properties of assessment can be achieved. While we state here that means you can design a good test item bank and also ensure validity and reliability, this we will be elaborating only in the next module on Course Design.

It can also serve as an effective tool for organizing direct or automatic intelligent tutoring. Tutoring is one to one instruction. You make the student to do some activity and then you interact at one to one level and if you find the student is unable to do that, the taxonomy table can help you and say okay what is the next activity that I want to give him so that he can perform this activity properly. So we go cognitively one level lower.

And you must be able to plan some activity at the next lower level for him to kind of solve and for us to understand where exactly there is a deficiency in his understanding or ability. So this we

have used it extensively in planning intelligent tutoring. So taxonomy table can serve all the three purposes.

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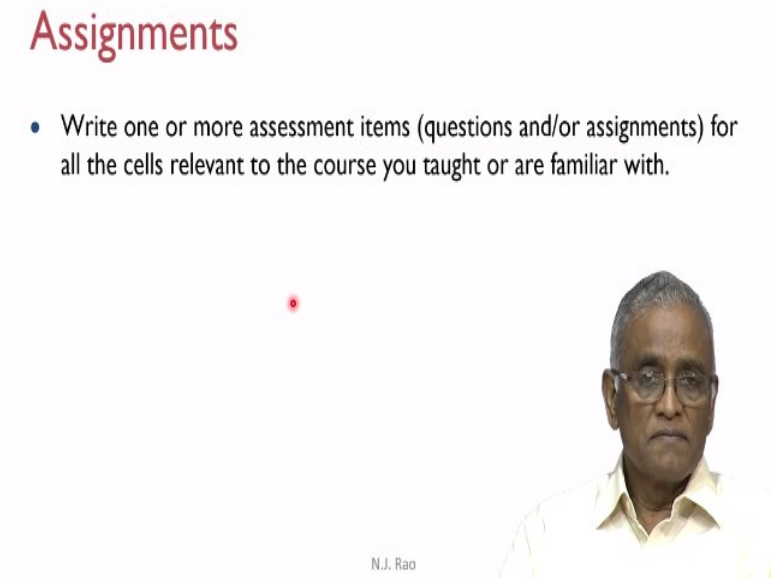

You have before you 6 by 8, 48 cells. Any course that you are dealing with I am sure that you are unlikely to use all the 48 cells. So whatever cells that you consider are relevant to the course that you have taught or familiar with write one or more assessment items that can be tagged and put in that particular cell that you have chosen.

So it could be let us say in 6 by 8, 48 you may be dealing with 12, 16, or 20 depending on how you look at the course; you can identify all the cells that are relevant and for each identified cell you write one or more assessment items, okay questions something like that.

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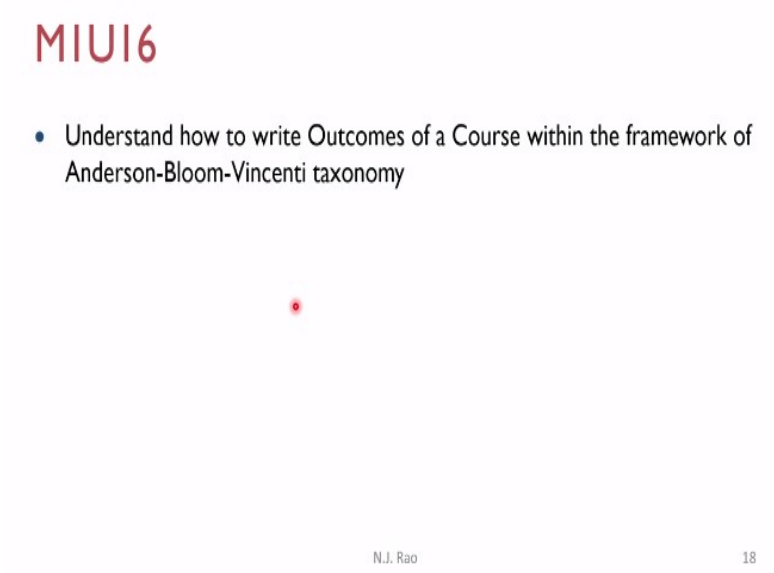

And in the next unit we understand how to write outcomes of a course within the framework of Anderson-Bloom-Vincenti taxonomy. That is our, the practically the goal of this particular module itself. How to write course outcomes for a course in the framework of ABV taxonomy. Thank you very much.