TALE - 2 Course Design and Instruction of Engineering Courses

Prof. N. J. Rao
Department of Electronic Systems Engineering
Indian Institute of Science, Bengaluru

Lecture – 23
How Brain Learn 3

Greetings and welcome to Module 3, Unit-5 of TALE, that is Teaching and Learning in Engineering. This unit is a continuation of our effort to understand How Brains Learn.

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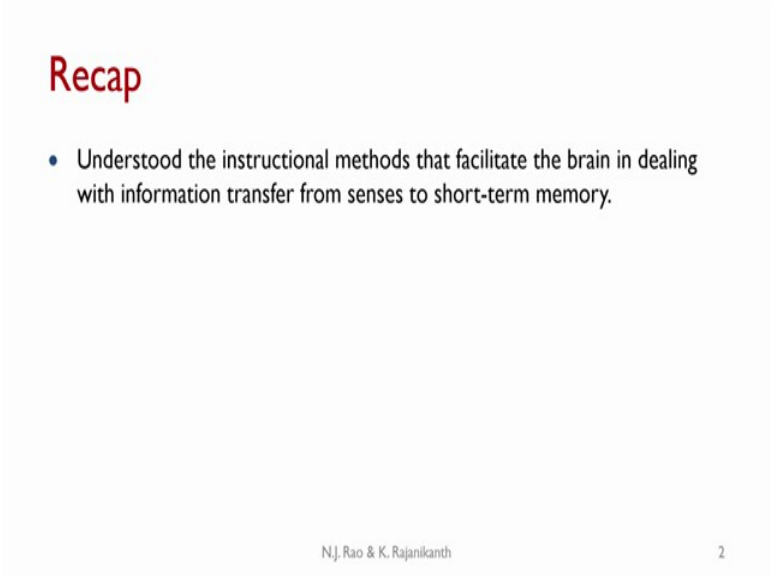

In the previous units, what we understood is based on our limited knowledge of the anatomy of the brain or how things work to whatever extent we understand. There are specific instructional methods that can facilitate the brain in dealing with information transfer from sensors to short-term memory.

We assumed a model of the brain with respect to how the memory is formed and how the information from memory is retrieved by a model given by David Sousa. We looked at how the sensory information passes onto immediate memory and then to working memory. Even this process can be facilitated by using some instructional methods which we looked at in the previous unit.

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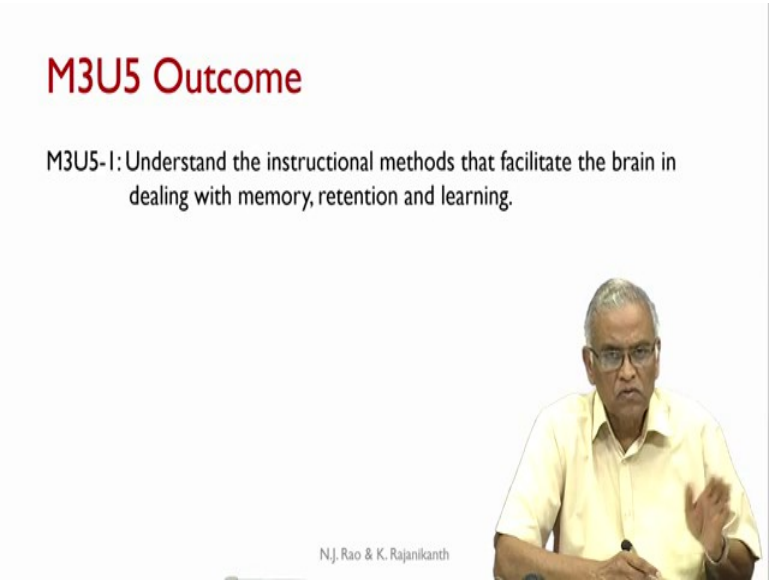

In the current unit, we continue with the process. Having got the information into the working memory, how do I facilitate the brain in dealing with what is inside the working memory; transfer it to long-term memory and keep it there. Even to retain it in the long-term memory, it requires specific processes we will look at.

Of course, there are many other processes, for example, 'how do I retrieve something?' There are many more aspects we are not going to address. We will only be dealing with the formation of long-term memory and retention.

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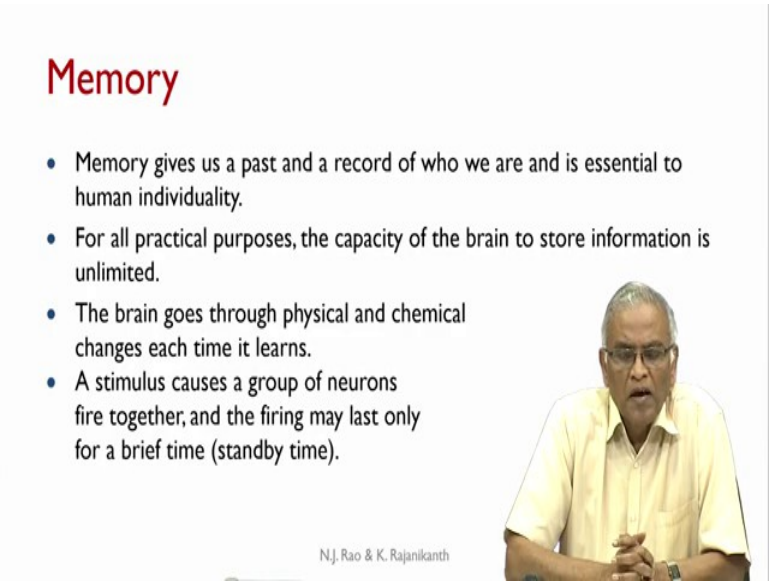

Memory gives us a past. What is stored in the memory is the sum of all our past experiences. Memory gives us a past and a record of 'who we are' and is essential to human individuality. Who we are is mainly decided by what is stored in our memory? If some part of the memory for some reason is removed, then we become a different individual.

Therefore, memory is effectively saying 'what we are. We can also make an assumption; for all practical purposes, the capacity of the brain to store information is unlimited, Nobody has yet come with a figure or anything to say that the brain cannot handle information beyond this capacity. Therefore, there is no constraint in learning new things. Whenever you learn something, the brain goes through both physical and chemical changes. That means our brain is not the same or what it was yesterday because, in this past few hours, we would have gone through some experiences, and those experiences would have been stored or reinterpreted, or some old memories might have been thrown out. The brain is today is different from what it was yesterday.

Whenever there is a stimulus, it causes a group of neurons to fire together (it is not one neuron that gets fired). The firing may last only for a brief time; that means the group of neurons that were fired stay together as a group for a brief time, which is called standby time.

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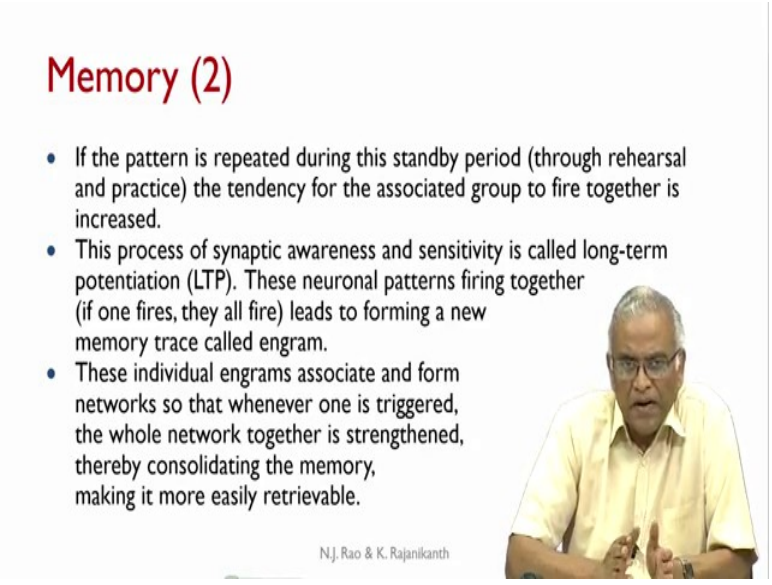

During the standby time, if the pattern is repeated, through processes called rehearsal and practice. The tendency for the associated group to fire together is increased. That is, some groups of neurons fire together whenever some stimulus comes. After the standby period, I have no memory of what has happened.

If you want to transfer something as a result of stimulus into the long-term memory, you have to go through specific processes - practice and rehearsal. This is also called the process of synaptic awareness and sensitivity, which is called long-term potentiation. That means, these neural patterns firing together, (if one fires, they all fire,) leads to forming a new memory trace called engram. These individual engrams associate and form networks so that whenever one is triggered, the whole network together is strengthened, thereby consolidating the memory making - it more retrievable.

Let us assume one engram is formed during a stimulus, and through specific processes rehearsal and practice, we strengthen them, that is only part of the story. If this network that we formed is now linked to other networks which are already formed in our past experience, that means, we are relating the new memory to the existing networks. These networks may come from a wide range of our past experiences. If a number of networks get associated, it makes the retrieval of that particular memory easier.

The process of good learning is to associate any new learning to many things from our past. Anything that is triggered with all the things that are connected to that will also get triggered, and then immediately, that information comes to your working memory when you require it. If you want to call it moral of the story is that whenever you learn, try to associate whatever you learn which you consider important to as many things in your memory as possible. The more associations you create, the more networks get triggered by one stimulus. That is where you can relate one aspect to something you may consider initially totally unrelated.

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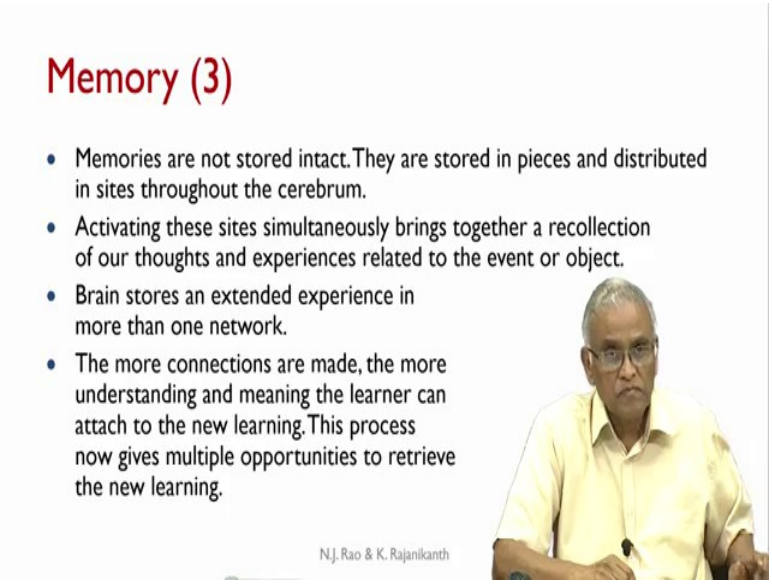

Another aspect of memory - memories are not stored intact; they are stored in pieces and in sites distributed throughout the cerebrum. As if the memory is cut into pieces and each piece is stored at different places, and they all get connected with each other. Those networks of engrams, they somehow get connected while storing. Activating one engram brings together a recollection of our thoughts and experiences related to the event or object.

If you trigger one element, all the other elements will come together, and that is where you feel the past experience completely. The brain stores extended experience in more than one network; it is not restricted. If you have learned how to solve a different ordinary differential equation, while we recall that experience, this ordinary differential equation can be related to many things of your past. For example, anything that changes with time can only be modeled like a differential equation; all phenomena where the variables change with time can be modeled with that.

Even our view of the world continuously changes with time. A trigger keeps invoking all the associated networks, and that is why we can call it extended experience. The more connections are made, the more understanding and meaning the learner can attach to the new learning. This process now gives multiple opportunities to retrieve new learning. Because if you cannot retrieve it, it is of no use at all; even if it is stored, we do not know whether it is stored or not; even if it is stored, if I cannot retrieve it, it is of no use.

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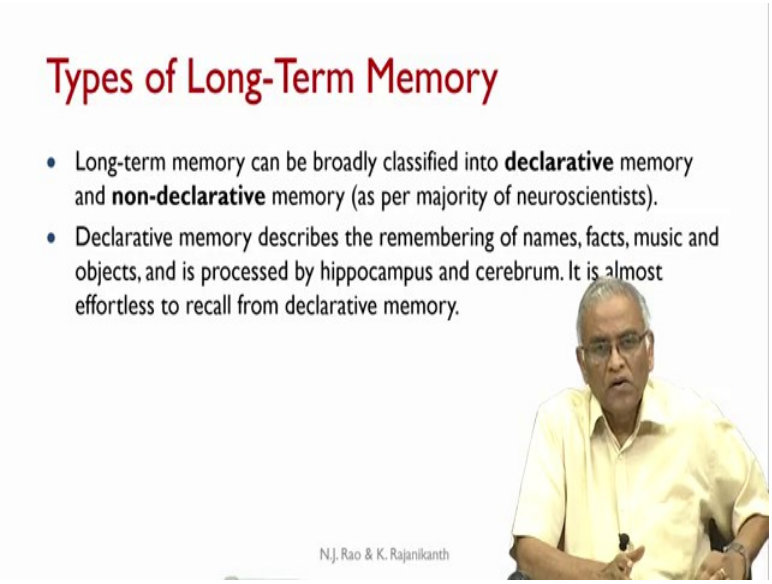

Long-term memory can be broadly classified into declarative memory and non-declarative memory. The majority of the neuroscientists, as of today, believe it can be classified into these two categories. After a few more years, neuroscientists may change this classification or add more classes or merge them; we do not know.

Declarative memory describes the remembering of names, facts, music, and objects and is processed by the hippocampus and cerebrum. We mentioned that the hippocampus is the one that processes from working memory, transfers into long-term memory. It is almost effortless to recall from the declarative memory. Unlike non-declarative memory, it is easy to recall whatever that is stored in the declarative memory.

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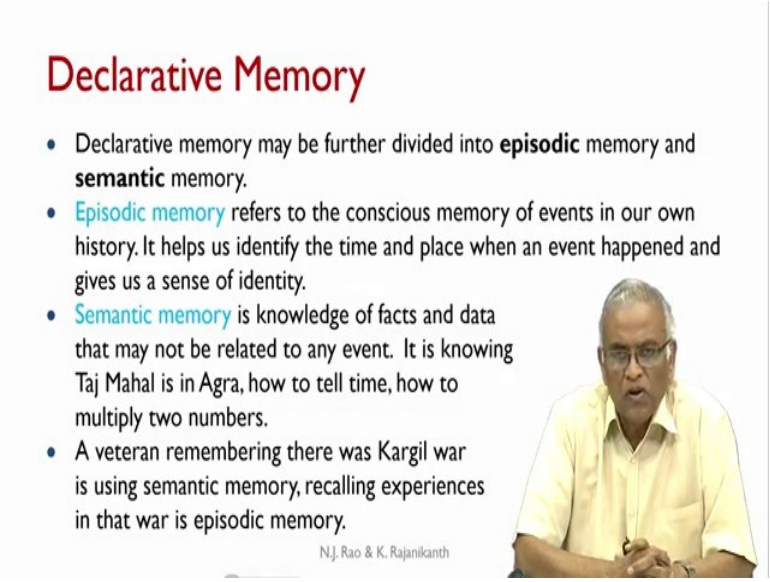

Declarative memory may be further subdivided into episodic memory and semantic memory. Episodic memory refers to the conscious memory of events in our own history. It helps us to identify the time and place when an event happened and gives us a sense of identity. I remember the experience either as positive or negative. The entire thing is an episode, I went and saw a movie whether I remember all the details or not, but I can remember some aspects of the event that I experienced.

Semantic memory is knowledge of facts and data - that may not be related to any event. We know the Taj Mahal is in Agra, it is a semantic memory. How to tell time, how to multiply two numbers, and you can call a whole bunch of things as semantic memory.

Difference between the two: ‘a veteran from the army remembering there was Kargil war’ is using semantic memory. As an ex-soldier, he remembers the Kargil war happened. But if he participated in that, recalling experiences in that war is episodic memory. He knows if they were compelling experiences: he will remember possibly every minute of the experience in that, and it constitutes an episodic memory.

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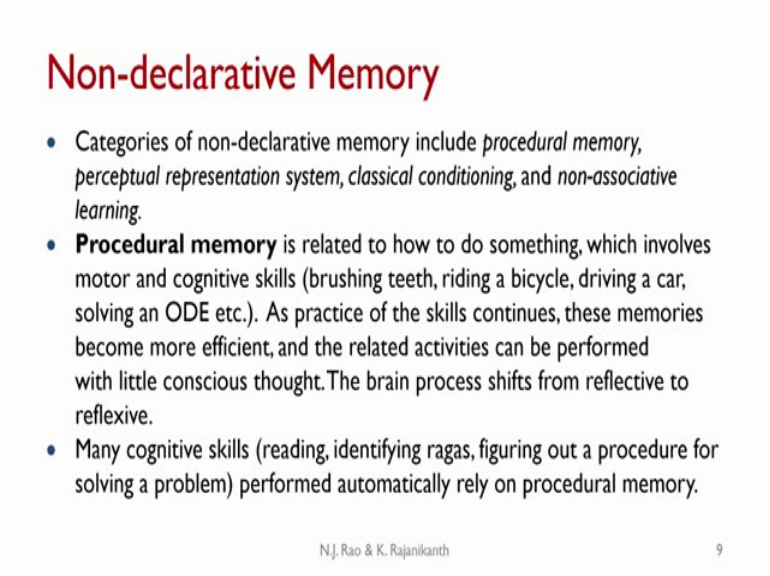

Categories non-declarative memory are procedural memory, perceptual representation system, classical conditioning, and non-associative learning. Procedural memory is related to how to do something which involves both motor and cognitive skills. Take a simple thing like brushing teeth; brushing teeth is a motor skill or something that you have practiced, and also there is a cognitive dimension to that to how long you want to brush and what toothpaste you use, at what time you want to do which are all cognitive decisions.

Generally, procedural memory will have both motor and cognitive skills. Examples are brushing teeth, riding a bicycle, driving a car, or solving an ordinary differential equation, etcetera, and you can list as many as you want. As the practice of the skill continues, these memories become more and more efficient. If for example, your profession calls for solving ordinary linear differential equations every day, then obviously, you do not have to exert yourself to find out what exactly the procedure to use.

The related activities of the procedural memory once it becomes efficient because of repeated practice. The related activities can be performed with little conscious thought. You do not have to think consciously of what exactly I do now; what is the next step. That means the brain process shifts from what is called reflective mode to reflexive mode.

That means, if I have done something like solving a differential equation quite some time ago, I may not remember all the details. Now, I need to reflect on what exactly is to be done, what are the sequence of steps, and then only I come to a conclusion. Whereas if I am doing something every day, I do not have to think about it, it becomes reflexive, and it just happens once you trigger the event.

Many cognitive skills that are performed automatically rely on procedural memory. What are these cognitive skills? Reading a book, identifying ragas, figuring out a procedure for solving a problem, are generally performed automatically, and they depend on procedural memory.

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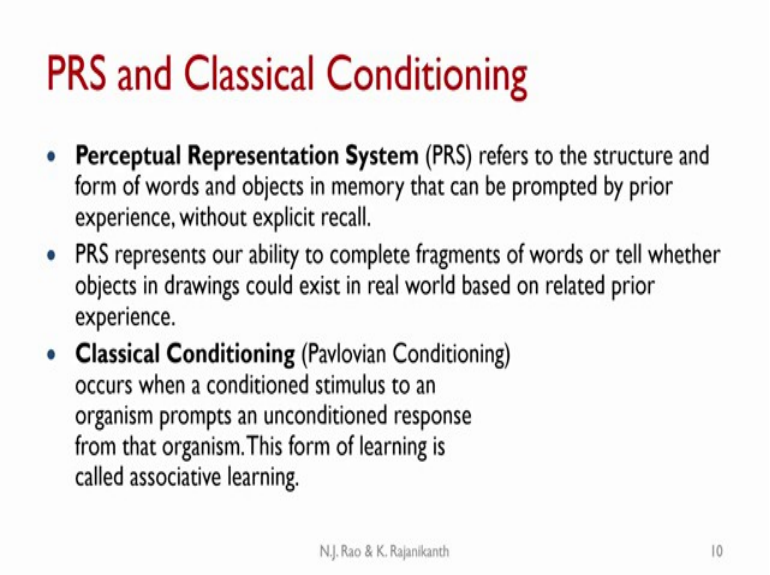

There is another interesting thing about the perceptual representation system (PRS.) It refers to the structure and form of words, and objects in memory that can be prompted by prior experience, without explicit recall. How does it work? For example, somebody gives a five-letter word in which two letters are missing. Based on your prior experience, you will be able to fill in that gap. You do not require all the five letters of that word.

Some drawing is shown with different/odd object is drawn. For example a human figure with two horns on the head, then immediately you will be able to say that object cannot exist in real-world based on your related prior experience unless you have actually seen a human being with two horns, which I do not think any of us would have seen or at least

there is no report that has happened that there are people with horns. This is what we call the perceptual representation system.

Then you have famous well-known classical conditioning – '(Pavlovian Conditioning)' occurs when a conditioned stimulus to an organism prompts and unconditioned response occurs from that organism. This form of learning is called associative learning.

Consider you are working on something intensively, and you suddenly hear an alarm in the same building. If it happens to be associative learning, then you can relate that alarm to a warning 'fire.' Then if we have learned the procedure we need to follow when the fire alarm comes, we will immediately follow the steps. This kind of condition stimulus that the alarm and the sequence of things that an individual will do are associated with each other is called classical conditioning.

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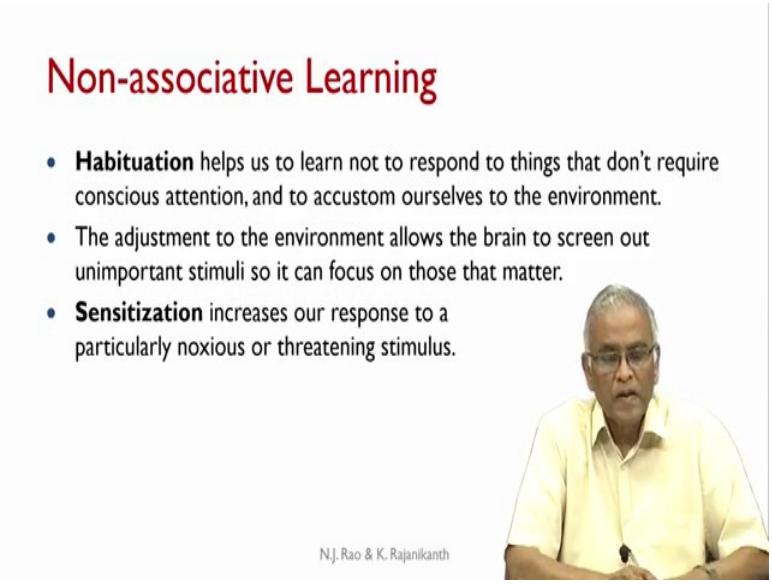

Non-associative learnings are two - habituation and sensitization. Habituation helps us to learn not to respond to things that do not require conscious attention and to accustom ourselves to the environment. What do you mean by accustoming to the environment? I do not respond to every sensory input that comes. Generally, when you go to a totally new place which you have never visited your attention is taken by so much detail just to get yourself there. But if you are working there or if you are doing something, we do not want all those inputs to come and bother us.

Through habituation, we learn to ignore unnecessary stimuli that have no use for us for the task that we are doing. But whenever there is something that is entirely different, after we get habituated, we respond. The adjustment to the environment allows the brain to screen out unimportant stimuli, so it can focus on those that matter. That we do all the time when we sit in our office or when we are in the classroom, we need to (and it is also required) screen out unimportant stimuli.

Sensitization: it increases our response to a particularly noxious or threatening stimulus. We know when such and such a sound comes, it represents something breaking down, or it is a fire alarm, or there is a major electrical burn out, etc.; it becomes a threatening stimulus. We build memories that identify that it is a threatening stimulus and through associative learning, we know what exactly to do.

For example, if you take the fire, in many of the Indian contexts while we may have fire extinguishers and so on and I do not think many of the people do get trained to use them. While we know if it is a fire alarm that we need to do something, if you do not have the related associative learning, we cannot really respond to that threatening stimulus.

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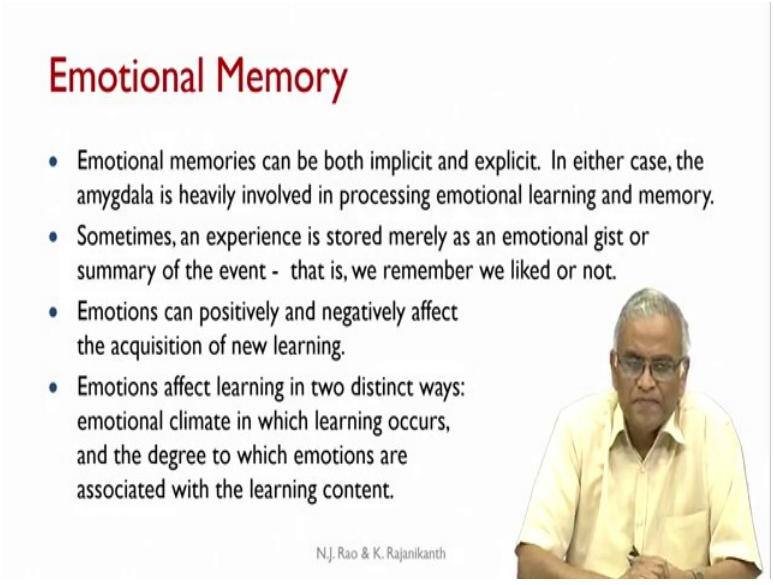

Emotional memory plays a very-very dominant role. Emotional memories can both implicit and explicit. We mentioned in the earlier unit - amygdala is heavily involved in processing emotional learning and memory; it plays a central role. Sometimes an experience is merely stored as an emotional gist or summary of the event - that is, we do

not remember the details, but we remember whether we liked it or not or at that time we felt good or bad or sad or angry something, etc - we remember only that part. I am sure all of you can recall such experiences while we do not know and cannot remember the details, but we can remember whether we like that or not.

Emotions can positively and negatively affect the acquisition of new learning. The teacher has to ensure at least that when he walks into the classroom, the majority of the students do not have a negative emotion about the classroom. There are two ways emotions affect learning, one is the emotional climate in which the learning occurs, and the other one is the degree to which emotions are associated with the learning content.

For example, I am sure all of you would have experienced in your own areas, you like some subjects, and you do not like some subjects. What do you mean by liking or disliking the subject? At the cognitive level, there is no feature that says liking or disliking, but we still develop an emotion about the content.

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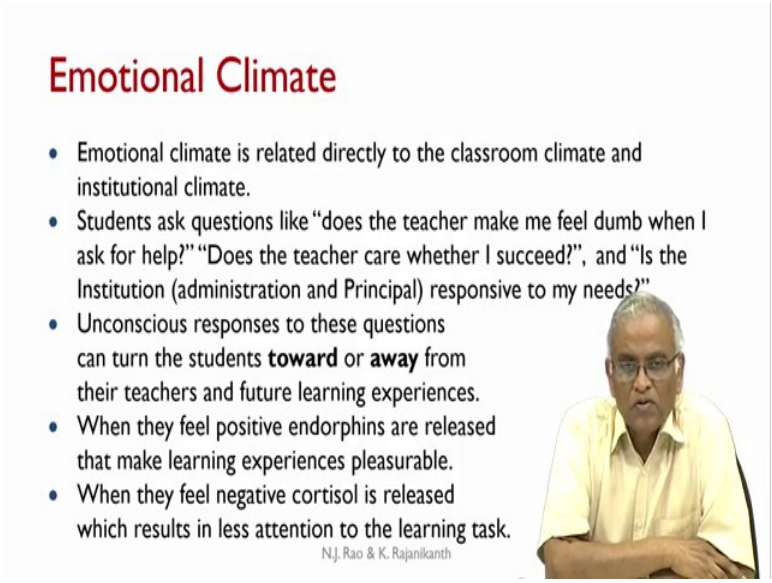

The emotional climate is related directly to the class classroom climate and the institutional climate. For example, the students will ask questions to themselves for which they have to have an answer, 'does the teacher make me feel dumb when I ask for help?' People ask if the answer is kind of negative, that is, the teacher makes me feel dumb, then I will not even approach the teacher. A negative answer to 'Does the teacher care whether I succeed?' also acts as a very negative emotion on student learning. 'He

does not care whether whatever I do, why should I; why should I care myself?' is a kind of implicit thing that happens.

'Is the institution responsive to my needs?' What do you mean by the institution? It could be administration and principal are they responsive to my needs indirectly or directly. This is what we call the emotional climate, and this is very central. We mentioned this in the context of the second Unit - instructional situations. One aspect of the situation is the emotional climate.

Unconscious responses to these questions can turn the students toward or away from their teachers and future learning experiences. What should the teacher or the institution do? You need to regularly somehow communicate. That they care about the students, and we are responsible for their learning. I do not blame a student if he is not able to understand, and the system blames him as a dumb. If they do not keep on giving reassurances directly or indirectly, the students can turn away from their teachers, and obviously, that will affect future learning.

There is a chemical phenomenon (just for the completion, it is included that we do not have to understand the mechanism.) When we feel positive, endorphins are released (it is a hormone) that make learning experience pleasurable. If endorphins are released in the brain, then I feel pleasurable. When we feel negative, cortisol is released which results in less attention to the learning task.

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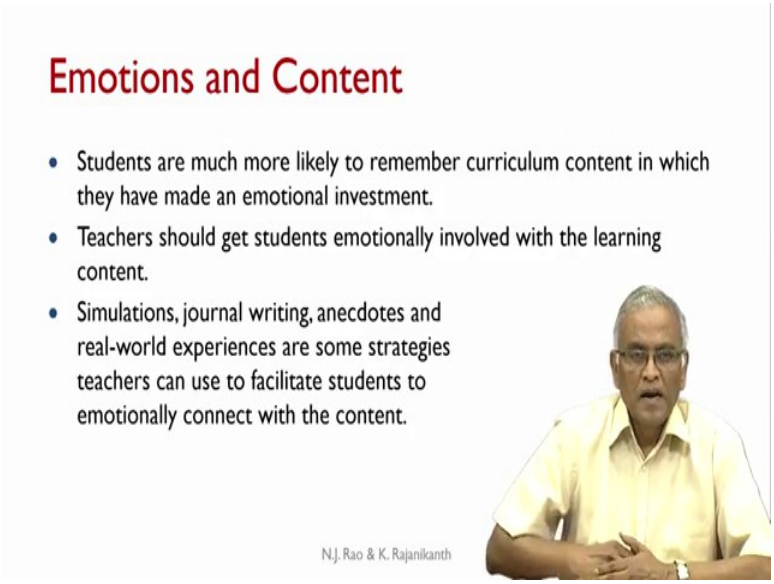

Students and content: students are much more likely to remember curriculum content in which they have made an emotional investment. There is something I like about that particular topic or that particular subject (we do not have to worry about the reasons.) I put emotional investment in terms of saying 'I like' or 'I want to spend more time' because it leads to pleasurable experiences and so on.

What does it mean? The teacher should get students emotionally involved with the learning content, and it is not all cognitive. How do we do it? By using simulations, journal writing, anecdotes, real-world experiences.These are some of the strategies the teacher can use to facilitate students to connect with the content emotionally.

The first thing is the teacher himself needs to get connected to the content emotionally, and that gets reflected in the way he speaks to the students. When the teacher is connected emotionally to the content, there is a possibility at least a majority of the students also will get emotionally connected to the content. That means, if there is a positive emotion with respect to that content, it is possible that the students will transfer that information from working memory to the long-term memory and retain it there.

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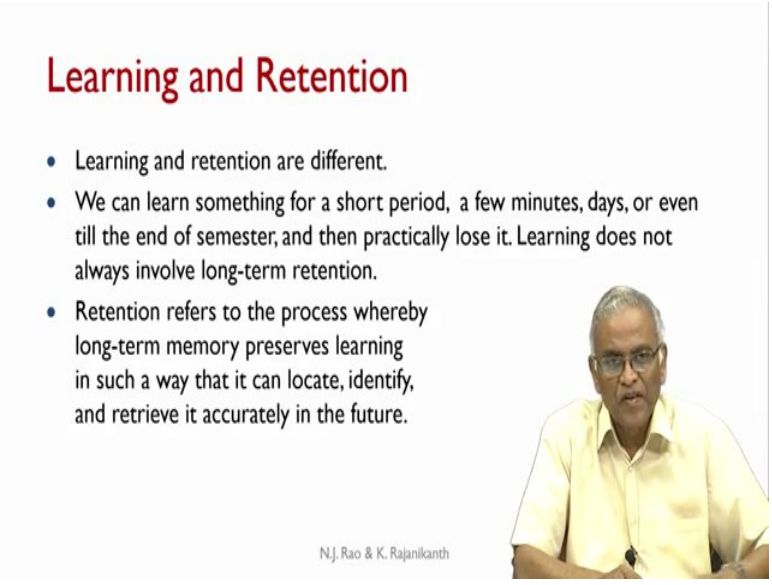

Now, we look at the issues of learning and retention. These two are different phenomena. We can learn something for a short period by just either mugging up. We can learn something for a short period by specific processes (period can be a few minutes, days, or even till the end of the semester) and then practically lose it. I am sure all of our

experiences of something that is taught to us let us say 5 or 6 years ago, and if you are not using that information regularly, maybe you will remember some trace of it, but you will not remember the details.

We will have to reinforce our memory continuously. Learning does not always involve long-term retention. If you have learned something during that semester, it does not mean that you are retaining it for the long-term. What does retention refer to? It is a process whereby long-term memory preserves learning in such a way that it can locate, identify, and retrieve accurately in the feature.

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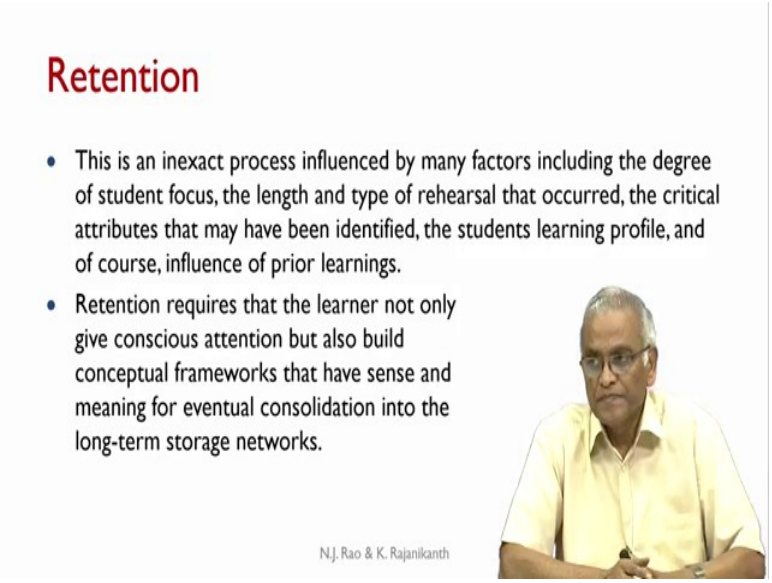

Retention is an inexact process influenced by many factors, including the degree of student focus, the length, and type of rehearsal that occurred, the critical attributes that may have been identified, the student learning profile, and the influence of prior learning. What exactly the process that goes on, we do not have that amount of detail, but we can think of some positive and negative processes or processes that have either positive or negative influences. Retention requires that the learner give not only conscious attention but also build conceptual frameworks that have sense and meaning for eventual consolidation into the long-term storage networks.

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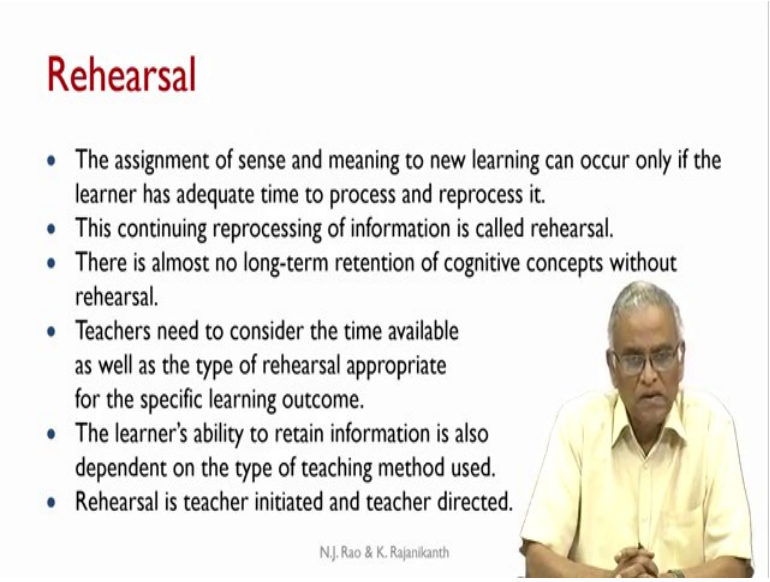

The process of retaining in the long-term memory, both transfer as well as retention, we broadly call a rehearsal. The assignment of sense and meaning to new learning can occur if the learner has adequate time to process and reprocess it. That is, if you do not give time to the students to practice or process that information and you move onto a new topic, the rehearsal will not be adequate, and it is unlikely to be retained in the memory.

This is what happens in the Indian context as the teachers/curriculum overenthusiastically overload the content. Have more courses, and the amount of material that needs to be taught in each course is phenomenally increased, so that leads to not having time to process and reprocess any information which is transferred in the classroom. This continuous reprocessing of information is called a rehearsal.

There is almost no long-term retention of cognitive concepts without rehearsal. If you have not ensured that it practiced again, there is no chance of long-term retention at all. The teachers need to consider the time available as well as the type of rehearsal appropriate for specific learning outcomes. What kind of rehearsal is required? Some may require simple ones; some may require long rehearsals, it depends on the content, and the decisions the teacher makes.

The learner's ability to retain information is also dependent on the type of teaching method that is used. That is why in the later units, we are going to spend a lot of time on various elements and strategies used in teaching that can lead to retention. The rehearsal

itself is teacher-initiated and teacher-directed. Rehearsal is not entirely the responsibility of the student. The student needs to be supported or helped to say what kind of rehearsal he should be doing, and the teacher should be able to direct that. The main conclusion is - the rehearsal initiation and direction are to be done by the teacher.

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There are two rehearsal strategies; one is rote rehearsal strategy (with which all of us are familiar) simple repetition. I am sure all of us have gone through this in the school system. If you want to remember a poem, if you want to remember some content, verbatim something, then you keep repeating. And if it is a very long one, there are several stanzas in a poem, then each one, one by one you repeat and after you feel that you have retained it completely, then you move onto the next one, and combine this into what was already retained. This is what we call cumulative repetition. These two are simple rehearsal strategies everybody uses.

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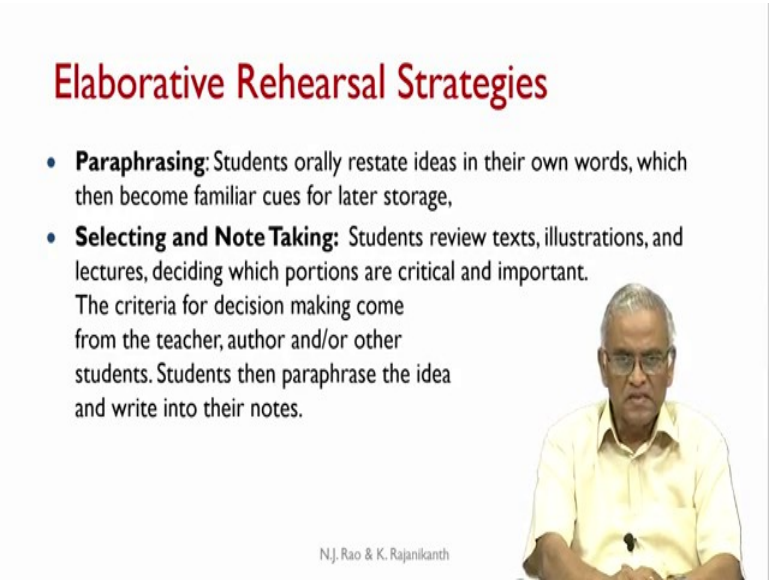

The elaborative rehearsal strategy is one of paraphrasing. Students orally restate ideas in their own words, which become familiar cues to later storage. If each student is able to rewrite in his/her own words, those words/phrases will become cues for later storage. The moment you come across any of the cues, you will be able to recall the idea and other ideas or the activities associated with that idea.

Another strategy is selecting and note-taking. Students review text illustrations and lectures, deciding on the portions that are critical and important. The criteria for decision making come from the teacher or the author and/or other students, students then paraphrase the idea and write into their notes.

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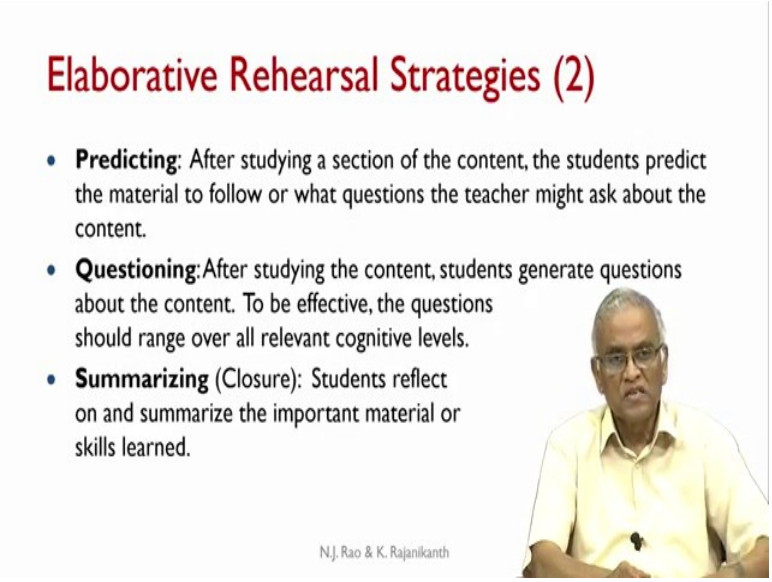

Predicting: After studying a section of the content, the students predict the material to follow; and what questions the teacher might ask about the content. That is one way of rehearsal. If a group of students is looking at the content and they are able to/try to predict the questions, the teacher might ask you and re-review the content and come with the answers.

Questioning: after studying the content, students generate questions about the content. The question should range over all the relevant cognitive levels to be effective.

Summarizing or closure: students reflect on and summarize the important material or skills learned. We have only just shown some instructional components or rehearsal strategies. You can design your own rehearsal strategy. There are 30 - 40 such rehearsal strategies in the literature.

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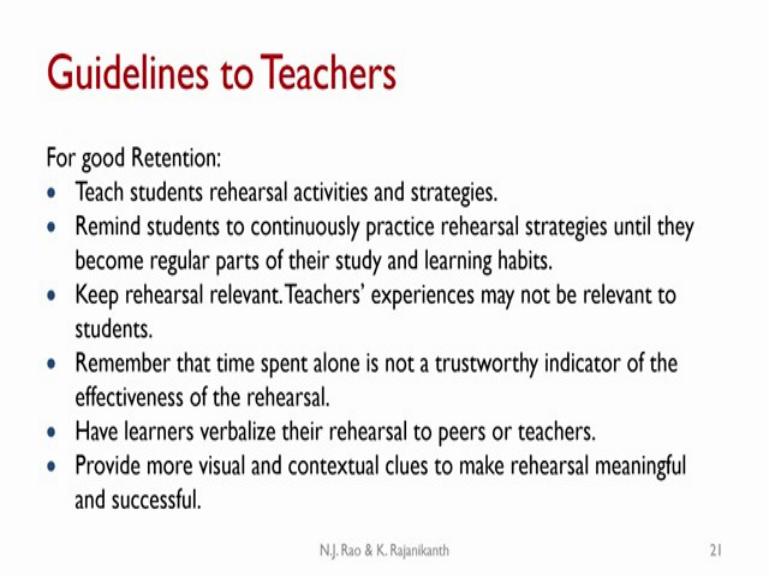

Guidelines to teachers: Based on all the things that we have now talked about for good retention, teach students rehearsal activities and strategies, or give the instructional components and strategies. Strategy means in what sequence you want to use instructional components.

Remind students to continuously practice rehearsal strategies until they become parts of their study and learning habits. They should get habituated to that, or it should go into reflexive mode rather than the reflective mode. Keep rehearsal relevant. If it is an irrelevant type of rehearsal, it does not lead to retention. For example, the teacher's experiences may not be relevant to students' learning. So, you need to find what you consider is your rehearsal strategy.

Remember, if you keep on repeating the content, that alone is not a trustworthy indicator of the effectiveness of the rehearsal. Another guideline to teachers: have learners verbalize their rehearsal to peers and teachers. Whatever you are doing, you can verbalize it to your peers sometimes if time permits to teachers.

Provide more visual and contextual cues or clues to make rehearsal meaningful and successful. That means, can I create other clues around those visual clues. I can draw a diagram, and I can put a textbox. Visual cues are always very effective.

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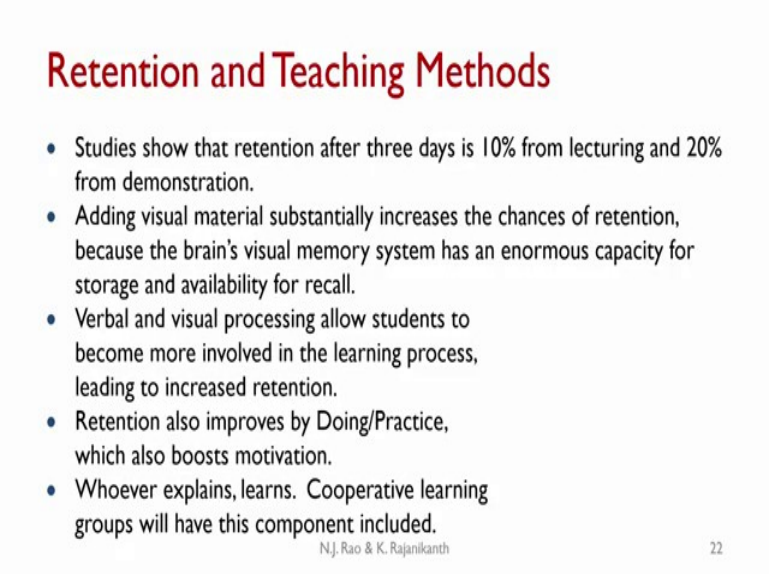

Studies show that retention after 3 days is 10 percent from lecturing and 20 percent from the demonstration. If you solved a problem or if you have shown something working, the retention is still 20% after 3 days. Adding visual material increases the chance of retention substantially because the brain's visual memory system has an enormous capacity for storage and availability for recalling. One should remember that you have a significant part of the brain (at the backside of our cerebrum is visual cortex) has an enormous capacity to both process and store visual information. So, you should make use of that capacity.

Verbal and visual processing allows students to become more involved in the learning process leading to increased retention. Retention also improves by practice or actually doing things, and the process also boosts your motivation. It will enhance your motivation. Another aspect is whoever explains also learns. The best way to learn is to explain it to someone else. The cooperative learning groups will have this component included.

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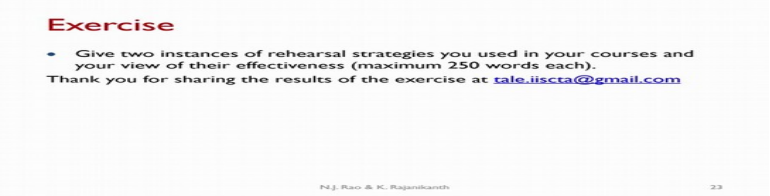

These are some retention strategies. This subject is vast, and there is a lot of literature on this topic. The teacher should explore this and find out rehearsal strategies that work best with respect to their group of students/ subject/ institute.

Exercise: we request you to give two instances of rehearsal strategies that you used in your courses, and your view of their effectiveness. Write a maximum of 250 words each. If you can share your results on this mail, we would appreciate it, and possibly we can also continue our interaction through that.

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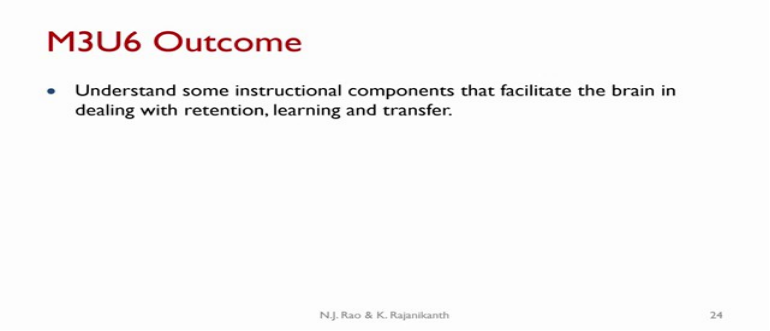

In the next unit, we will try to understand the instructional components that facilitate the brain in dealing with retention, learning, and transfer. We have seen briefly three or four instructional components. We will now more systematically identify those components and how to implement them in the classroom.

Thank you very much for your attention.