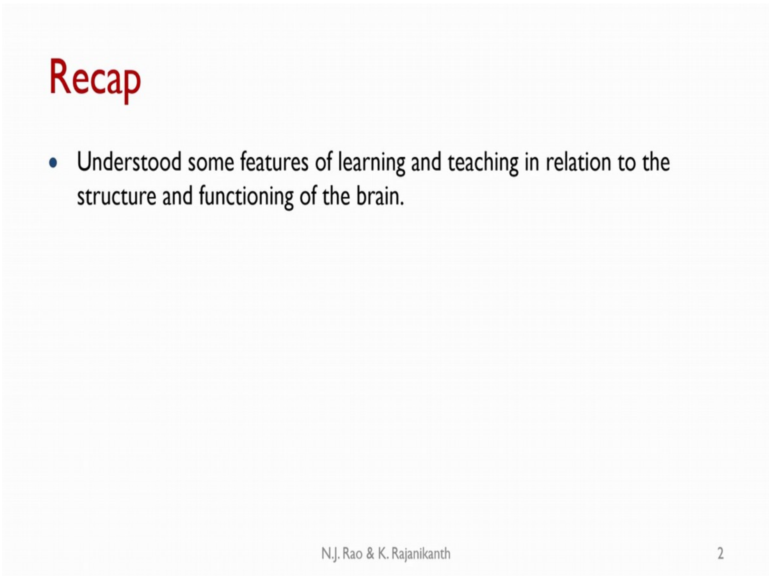
TALE - 2 Course Design and Instruction of Engineering Courses
Prof. N. J. Rao
Department of Electronic Systems Engineering
Indian Institute of Science, Bengaluru

Lecture – 22
How Brains Learn 2

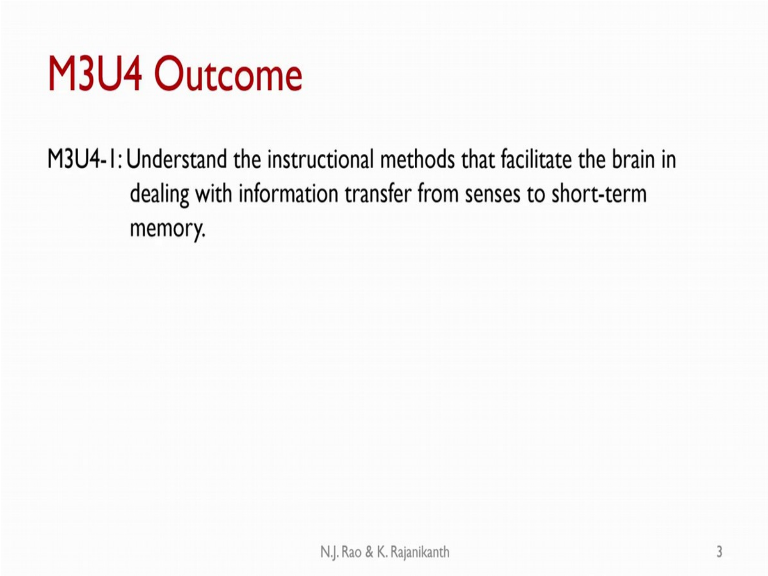
Greetings, and welcome to TALE Module 3 Unit 4. This is also related to understanding How Brains Learn. In the earlier unit, we tried to understand a little bit about the anatomy of the brain. Obviously, half an hour session is not sufficient to understand all the aspects of the brain which is the most complex thing in the world as of today.

(Refer Slide Time: 01:07)



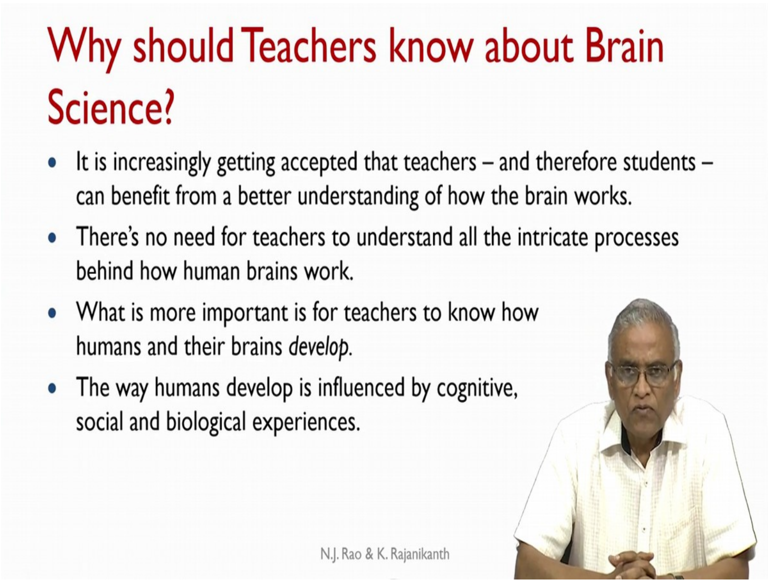
Based on the little bit of the very superficial, very simple structure of the brain and the anatomy of the brain, we are trying to see how some features of learning and teaching can be related to the structure and functioning of the brain. That is what we tried to do in the earlier unit.

(Refer Slide Time: 01:31)



In the existing unit, we will continue with the process. Some of the instructional methods that facilitate the brain in dealing with information transfer from senses to short-term memory. When we receive any information, we try to understand how the brain is likely to process. What are the issues that come in that processing, and whether we can use instructional methods that facilitate processing the information in the short-term memory? All these terms will be defined.

(Refer Slide Time: 02:15)



Before we move onto these questions, we need to address another issue. As teachers, we have been working and teaching, and we have taken many decisions intuitively based on our personal experiences, which seem to be working; why should we teachers know anything about brain science?

It is increasingly getting accepted through the research that is going on - the teachers, and therefore, students can benefit from a better understanding of how the brain works. So, the recommendation is you can have a short course of a one-credit course that can be offered at some suitable point even to the students facilitating them to understand how the brain works could be a good idea.

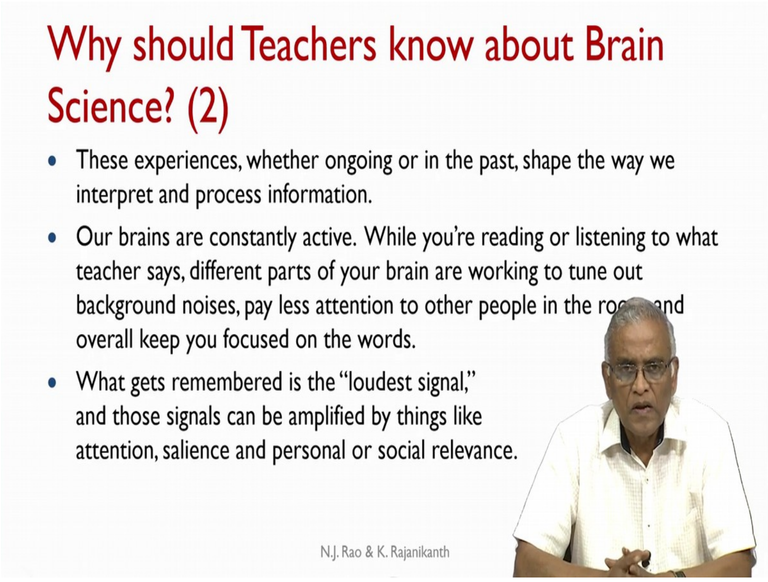
But neither the students nor teachers need to understand all the intricate processes behind how human brains work. For example, there are about 100 billion neurons, along with about 900 billion glial cells. How the energy gets transferred from glial cells to the neurons; how all the electrochemical and the biochemical process happen - need not be understood. We look at the whole thing at a certain level that can make sense to us.

What is more important for teachers is to know how humans and their brains developed. The way humans develop is influenced by cognitive experiences; that means some information is getting transferred or being given to us by various means by the teacher, but while this is taking place, there are social and biological experiences simultaneously happening.

Whenever we are learning, there are all the three-dimensions exist - cognitive, social and biological. All these experiences together decide whether (whatever word that you want to use) you can make sense of what the teacher is teaching or it is meaningful to us, whether it will be transferred to our long-term memory so that we can recall whenever we want.

How do we integrate our cognitive experiences? (we have looked at in the TALE 2 how to design the course and how we understood something about the cognitive dimension in TALE module 1 as well)? If a teacher knows something about these he can do much more satisfactory or effective instruction.

(Refer Slide Time: 05:49)



Let us look at a little more of this. Cognitive, social, and biological experiences, whether they are ongoing or in the past (because the past significantly influences what we learn right now), will have a significant impact. That means the experiences through which we have gone through already and whatever that is going on in the classroom shape the way we interpret and process information.

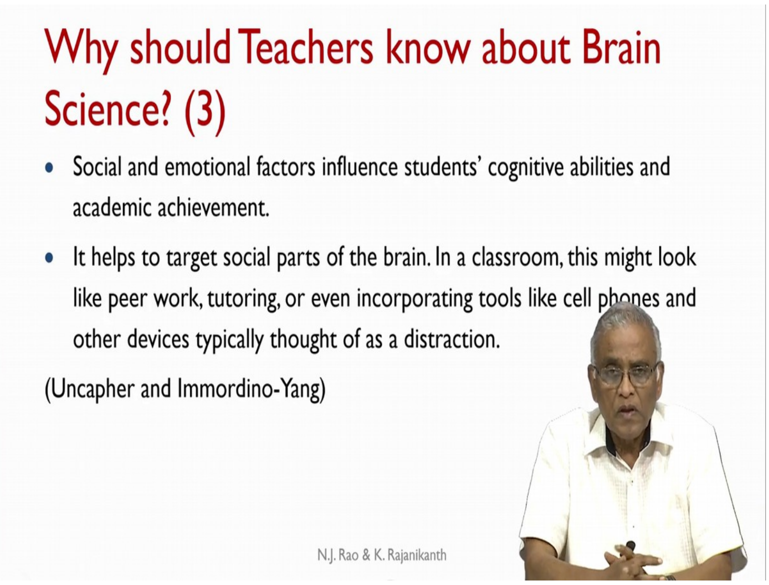
One thing should be remembered - our brains are not passive and always active. While you are reading or listening to what the teacher says, different parts of the brain are working on tuning out background noises, pay less attention to other people in the room, and overall keep you focused on the words. If the other people are disturbing you, obviously, you cannot focus on what the teacher is saying. There could be disconcerting loud background noises: something happening outside the classroom, some construction is going on, a drilling machine switched on. The background noise will significantly affect whether you can pay more attention to what the teacher is saying.

That can be interpreted as what gets remembered is the loudest signal, and that means, which is the most dominating signal, whether it is background noise or somebody next to you talking to you or what the teacher is saying. These signals can be amplified by things like attention and personal and social relevance.

When the teacher is presenting something, you want to make that as the loudest signal in spite of many things happening around and that can be done by paying attention to what the teacher is saying and also what you consider is salient to what that particular course and also you find both personal and social relevance to the topic that is being addressed.

If a teacher considers these four aspects, he can make whatever that is being taught as the loudest signal. For example, another background noise - fans keep running in many classrooms because it is quite hot and the associated noise is always disturbing what is being presented.

(Refer Slide Time: 08:53)

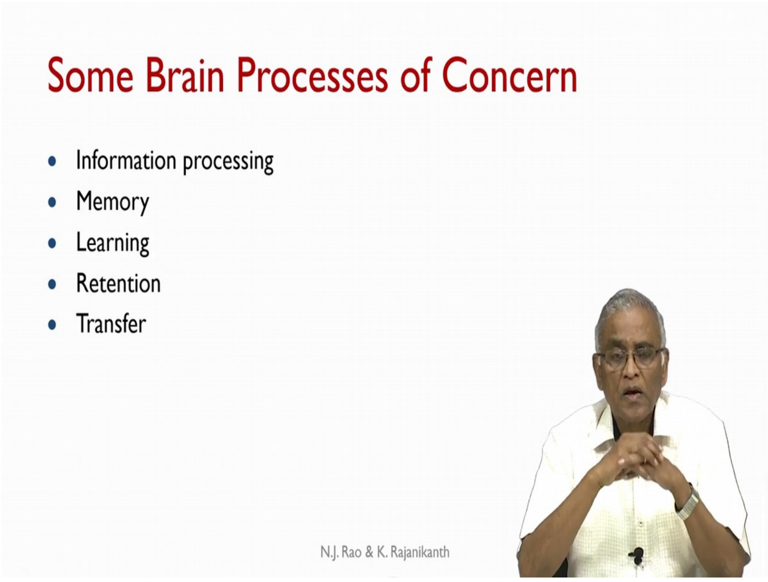


Still, there is another issue, social and emotional factors influence student's cognitive abilities and academic achievements. Emotional factors that we see will also influence cognitive abilities. For example, the emotional factor can influence you not to pay attention to what is being taught.

An understanding of what is happening, how the information is going to get process will help the teacher to target social parts of the brain. In a classroom improving the social part of the brain, how do you take care of it? Like you introduce peer work; that means, you give a small assignment to two or three people to work on or you are tutoring one to one instruction or even incorporating tools like cell phones as a part of this or other devices or internet devices, but presently though typically as a distraction. One can use a cell phone very effectively, provided you are able to get his attention to use the cell phones properly. This will be a challenge.

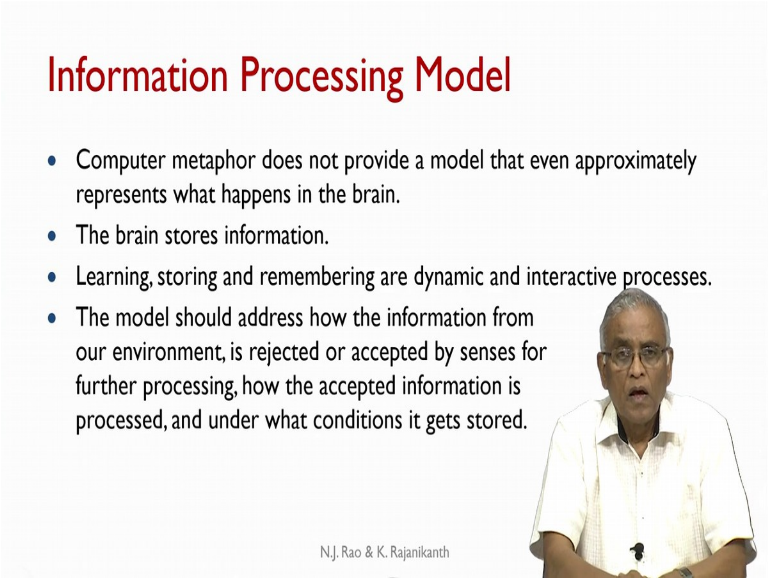
These are some reasons why the teacher should know about brain science and in my opinion, even the student should know something about it. So, when you understand what is happening inside, however, superficially, you will be able to react to that situation and see that you benefit from that in terms of learning.

(Refer Slide Time: 10:55)



We will not be looking at all dimensions of brain processes. We will only look at these five, namely information processing, memory, learning, retention and transfer. These are the five processes of immediate concern. There is an endless number of other things that influence our learning, but we will mainly look at what these five processes are. Notably, in this unit, we will be focusing on information processing and memory.

(Refer Slide Time: 11:41)

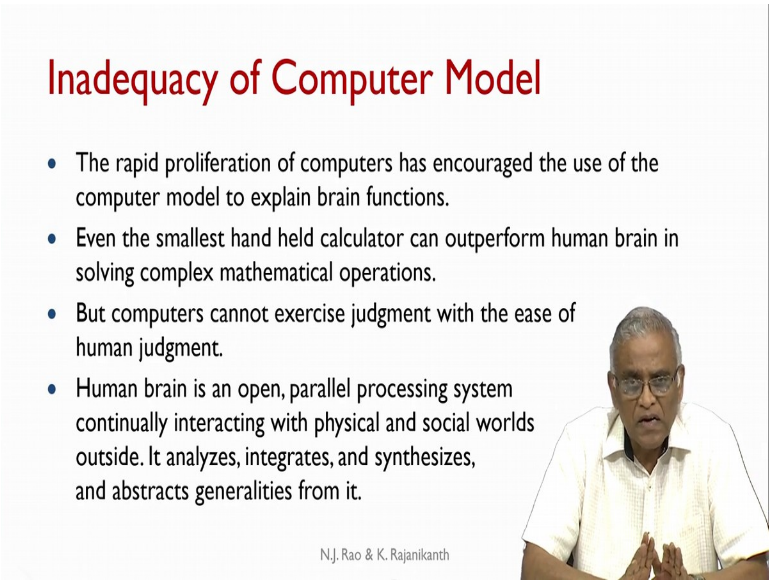


Once the computers came into being in the 1950s and 1960s and the computer metaphor is being used to model the brain, that means you are there is some input device that where information is coming through senses. So, these are all input devices, and then you have a memory, something that is processing this information and so on. It looks like a computer metaphor is an appropriate one. People still use the computer metaphor to explain how the information is being processed.

The first thing is the brain stores information. But the problem is learning, storing and remembering are not fixed processes as they happen on the computer. Some part of the memory is used and then there is a CPU, then you process that information and put it back in the memory - it does not happen just like that in the brain. Therefore, you cannot afford to use the computer metaphor for everything. These processor learning, storing and remembering are dynamic and interactive processes. Possibly each time you do any of these things, you are not necessarily doing exactly the same way.

We require a model that should address how the information from our environment is rejected or accepted by senses for further processing and how they accepted information is processed, under what conditions it gets stored. For example, if you look at what brain receives information from the environment in all ways (there are endless number of things outside the visual part is continuously changing which cone to our notice) from a computer perspective, less than a minute possibly the amount of information that is getting accepted or rejected will far exceed a big computer that can do maybe handling over the year. That means the brain is designed to reject possibly 99.9 percent of the information that is coming to you because you cannot help it all senses keep on accepting the producing the data.

(Refer Slide Time: 14:31)

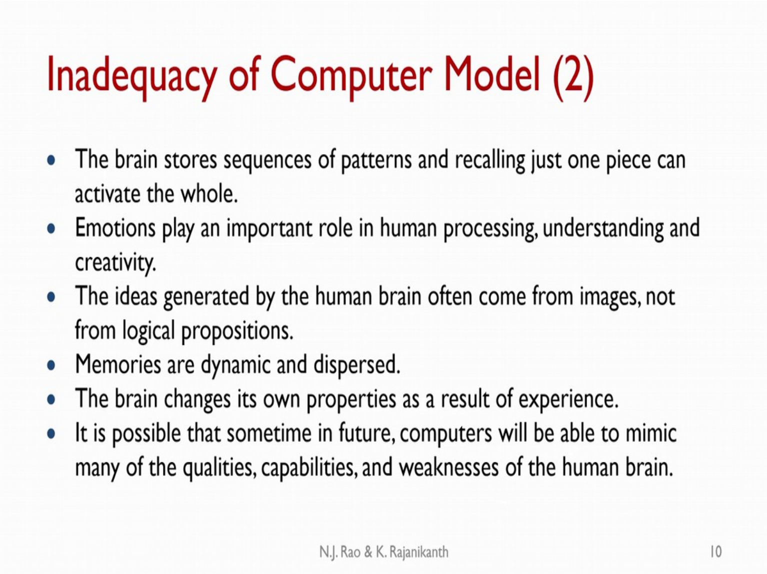


Because there is a rapid proliferation of computers, it has encouraged the use of computer model to explain brain functions and if you look at even the smallest handheld calculator cannot perform human brain in solving complex mathematical operations. So, the brain is not designed to perform complex mathematical operations and cannot be in competition with a computer.

But, computers as of today cannot (it may happen sometime in the future we do not know with all this talk about AI and machine learning and all that,) exercise judgment with the ease of human judgment. The way humans make a judgment, computers cannot do that kind of thing right now. The human brain is an open, parallel processing system continually interacting with physical and social worlds outside. It analyses, integrates, and synthesizes, abstracts generalities from it all the time. Every time a new experience comes, we take that information into our existing thing, and if I find it meaningful, I will re-abstract my generalities; that means my conclusions whatever I was doing earlier now can get modified.

The way I keep abstracting can change, provided I find the information that is coming to me is meaningful. We will talk about this meaningfulness presently.

(Refer Slide Time: 16:25)



Another interesting thing about the brain is if we have visual image possibly in a computer will take care of look at it in terms of pixels and then try to save each pixel with regard to whatever information that you have about the colors, intensity and so on, but the brain does not store that way. Each thing is a sequence of patterns, and somehow these patterns are stored in the brain, and no pattern may be complete (any information whether it is sound or picture or anything it is not complete.)

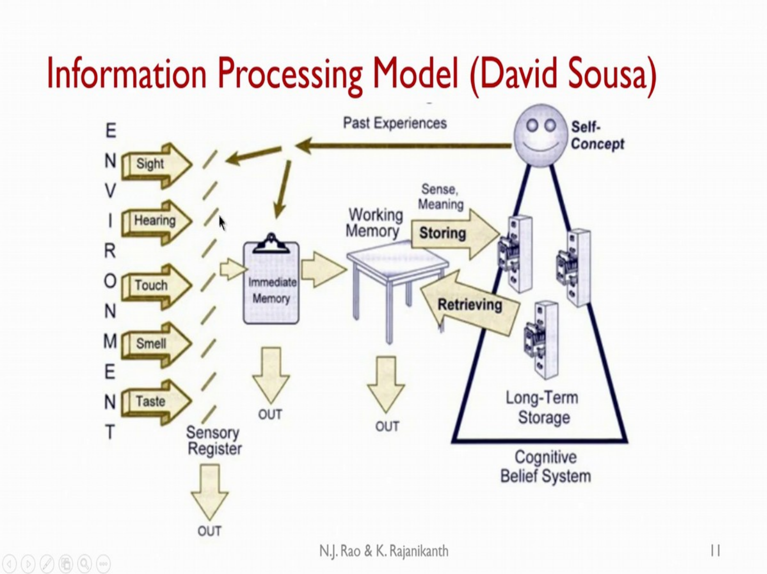
That means a picture is broken into a large number of patterns, and they are stored. The picture is stored at different places, and they are somehow linked with each other; that means the brain connects one pattern of one particular image and links all of them, and any recalling one piece can activate the whole, that is, the interesting part.

Much more importantly, emotions play an important role in human processing, understanding, and creativity. Emotions play a dominant role something like 90 percent of the decisions (I am just giving an approximate number) or decisions are made emotionally. If they are not done every time using certain logic, you do not make decisions like that. If you try to take your decision in everyday activity based on logic, you will never even drink a cup of coffee because if you logically process that information. So, emotions do play a very important role in human processing.

Another facet is ideas generated by the human brain often come from images not from logical propositions. Memories are dynamic; that means they continuously change depending on the new information, and they are dispersed over the various parts of the brain. As new things are getting processed, the brain changes its own properties as a result of every experience the brain changes its own properties.

When you look at the same information after a lapse of time, you are processing it differently because meanwhile, the brain has changed. So, it is possible that sometime in future computers will be able to mimic many of these qualities, capabilities, and weaknesses of the human brain possibly maybe in a decade or we do not know whether or it will take a much larger number of years that computer may be designed to mimic many of these features.

(Refer Slide Time: 19:53)



Given is the approximate model by David Sousa. It is like sliding blind. From the environment, the input comes through any of these five sensors. Possibly 99.9 percent of the information gets thrown out from sensory register because it is not relevant to what we are interested in as they are so many.

For example, if I am sitting here and looking at all a bunch of chairs in front of me, the image that is formed gets filtered out because it is not relevant, then whatever that remains from this will now enter into the immediate memory.

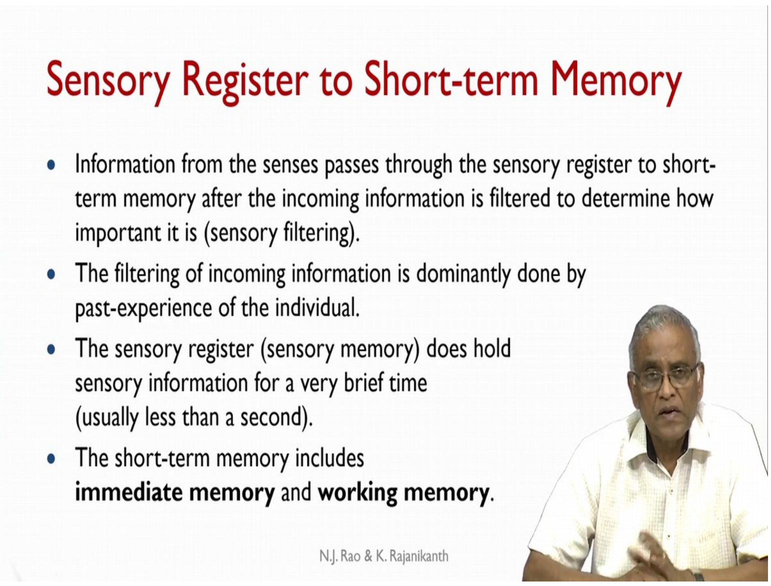
This past experience, we will decide what exactly has to be thrown out. It is a past experience that decides what is to be thrown out and what should get into the immediate memory. Whatever information that I am getting into the immediate memory, quite a bit of it will get thrown out is out, and only some fraction of that we will come into the working memory. This also is decided by the same past experience.

From the working memory, after making sense of it and finding some meaning, then this information will get transferred to long-term memory, they are presented as filing cabinets in the model. For example, with respect to the same thing when you store one element may get into one of the filing cabinets and another pattern may go into/ get transferred, we do not know how exactly it happens.

The whole thing is integrated together. The information that is stored in all these filing cabinets determines what you call self-concept. Whenever you want, depending on what you are expected to do, you retrieve information from here and bring it back to the working memory. Let say to solve a problem - when you are asked to solve a problem, you will retrieve something from the long-term memory, bring it to the working memory and produce an output.

The results of that might be again going back to the storage. Broadly, this is one of the current models. We do not say that this is the entirely accepted model, because all people do not precisely agree whether this is the model; it is kind of evolving as such.

(Refer Slide Time: 23:29)

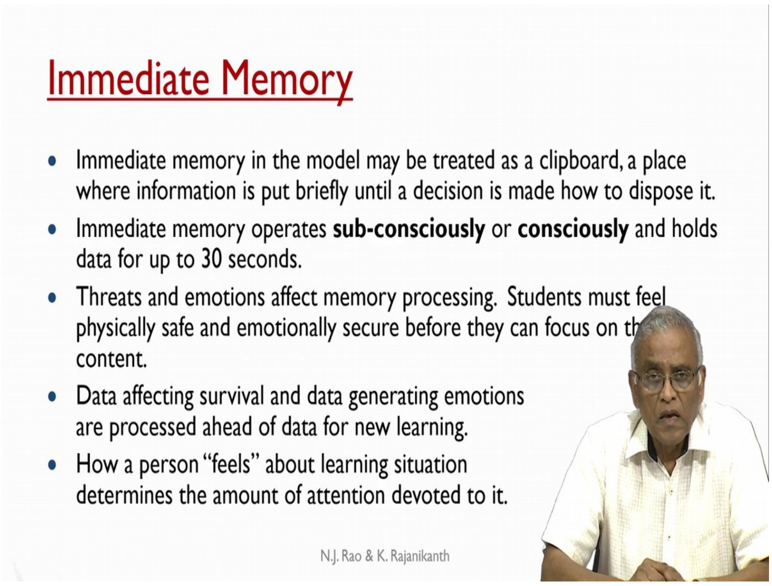


We have already looked at how the whole structure is. Now, we look at it specifically how the information is getting transferred. Information from the senses passes through the sensory register to short-term memory; after the incoming information is filtered to determine how important it is. As it is mentioned earlier, when you are inside the classroom something like 99 percent of the kind of sensory information that comes keeps getting filtered.

The filtering of incoming information is dominantly done by the past experience of the individual. Sensory memory does hold information for a very brief time that means all the images that are there is temporarily comes into the sensory memory. If the individual finds some of it is very important, then the attention will get diverted to that, but usually in less than a second that sensory memory kind of keeps getting cleared.

As it is shown earlier, the so-called short-term memory consists of two parts; one is immediate memory and the other one is working memory. There is a tremendous amount of work that has been done on these two - immediate memory and working memory. Some people want to deal it with a single item like short-term memory. David Sousa considers it is beneficial and convenient to separate these intermediate memory and working memory.

(Refer Slide Time: 25:25)



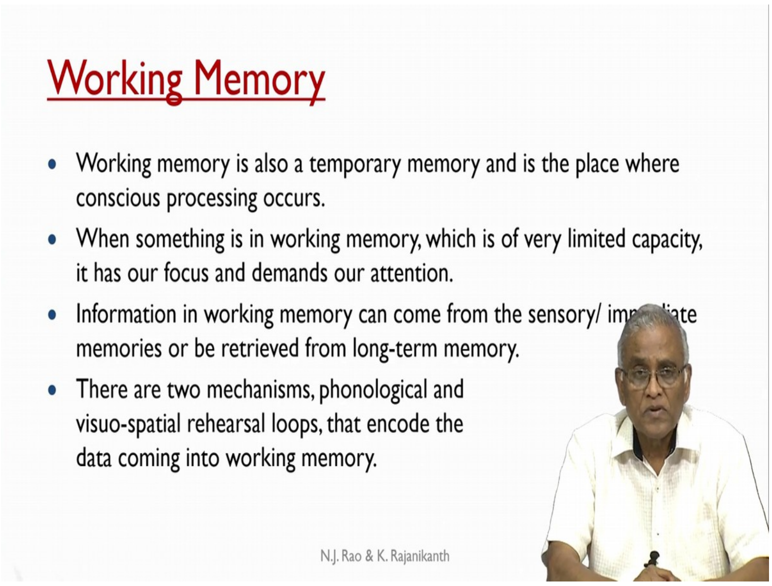
Immediate memory in the model may be treated as a clipboard, a place where information is put briefly until a decision is made on how to dispose of it. Somebody stuck it like a post-it note; somebody quickly considers that and either remove or keeps it. Intermediate memory operates sub-consciously or consciously - holds the data for up to 30 seconds (please take these numbers as indicative not as absolute - these 30 seconds may differ from one individual to the other, but that is the order of the time for which the intermediate memory holds onto the data.)

Most importantly - threats and emotions affect memory processing. Students must feel physically safe and emotionally secure before they can focus on the content. Sometimes people physically may not feel safe, but if there is likely to be a physical threat, obviously, the undivided attention goes, but emotionally secure that is more important. In a particular classroom, the student may not feel emotionally secure. In a sense, he may feel that the subject is too far above or the teacher is very intimidating or what other feelings that he has. For example, the exams are coming, and we are not yet there. So, you are emotionally disturbed; all of them will decide to what extent you can focus on the content.

Data affecting the survival and data generating emotions are processed ahead of data for new learning. So, this is what teachers should really-really remember that if data from these two affecting survival and data generating emotions when it comes first, that means, the teacher should also make sure that the student actually feels comfortable with respect to this, then only he can learn properly.

The feeling about the learning situations determines the amount of attention devoted. In earlier the unit in the same module, we spent something about learning situations. As you can see, learning situations can greatly destroy the quality of learning. Both the management, as well as the teacher, need to pay attention to the situation because that is what makes a tremendous amount of difference whether the student is going to learn or not.

(Refer Slide Time: 28:31)



Working memory; after it is processed out whatever that is considered important, it comes to the working memory. A lot of research is done on the size of the working memory. Is it the same for all? Does it differ from person to person? At what age the size will change? Whether there are many working memories? Still, the tremendous amount of research is going on, but we need not be concerned with that.

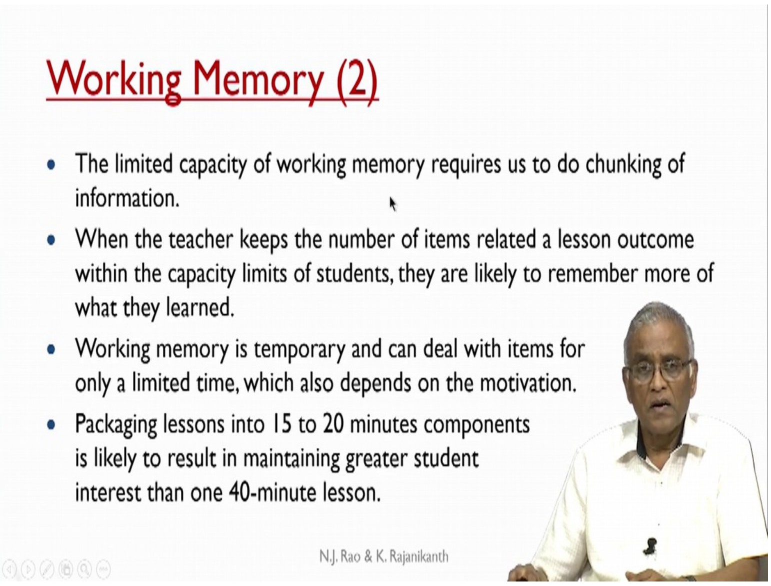
Working memory is also a temporary memory and is a place where conscious processing occurs, whereas, in the case of intermediate memory, it could be conscious or unconscious processing. The only thing that we need to remember about working memory is - it is of very limited capacity. It has our focus and demands our attention.

If we are trying to bring too many things, too many concepts, too many inputs and too many procedures to the working memory - it would not have space. The person has to push something into the long-term memory, deal with the existing one, and then again bring it back that kind of thing he/his mind has to perform. The teacher or every individual has to remember that working memory is of very limited capacity.

Information in working memory can come from sensory and intermediate memories or be retrieved from the long-term memory. (From intermediate memory it comes onto the working memory, it can also come from retrieved information from long-term memory, and it is like a work table. All this information from retrieving to this you process that and if you point it important like it has sense, you can make sense out of it and it has meaning, it gets stored in the long-term memory.)

There are two mechanisms - phonological and visuospatial rehearsal loops. Phonological means any voice type of information that you get, and visuospatial rehearsal loops. These are the two major loops that process the information and encode. As we said, it is divided into different patterns and these patterns are stored elsewhere - all that processing - encoding the data coming into the memory occurs using phonological and visuospatial rehearsal loops.

(Refer Slide Time: 31:39)



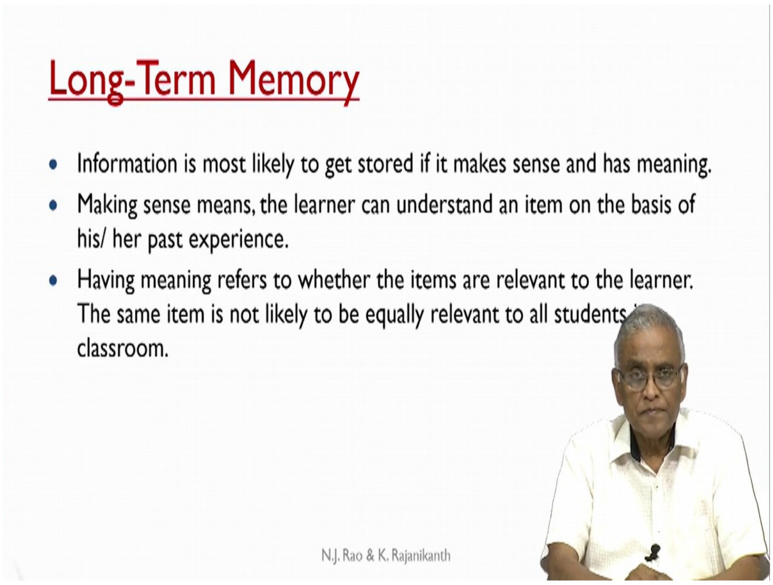
What is the implication of the limited capacity of the working memory? That requires us to do chunking of information. Do not present too many things, a large number of concepts, a large number of procedures in a given period of time and then try to solve a problem or expect student to solve a problem - break it into chunks; each one you complete, solve, fully understand and send it to long-term memory bring the next chunk and so on.

If the teacher can keep the number of items related to a lesson/outcome within the capacity limits of students, they are likely to remember more of what they learn. Actually, many teachers do that intuitively, but if you are aware of it, you will definitely make sure that you chunk the information appropriately.

Even working memory is temporary and can deal with items only for a limited time. You cannot keep information for an extended period because you have to make space for the new information to come in. How much amount of time you are spending on processing that information will depend on the motivation of the student, because that lesson particular lesson does not interest me, I am not motivated I quickly dispose of it. Either I throw it out or only a bit of that transfer into the long-term memory.

Broadly you can say packaging lessons into 15 to 20-minute components is likely to result in maintaining higher student interests than one 40-minute lesson. Some may argue to present something I require 40 minutes at a stretch, yes, and you can do that. It is not as if every time you do 40 minutes session - the student learning decreases, but it is preferable for an average student to break it into 15 to 20-minute components; that means, after that 15 – 20-minute presentation of something, you make the students do something else and then come back to the next chunk.

(Refer Slide Time: 34:07)

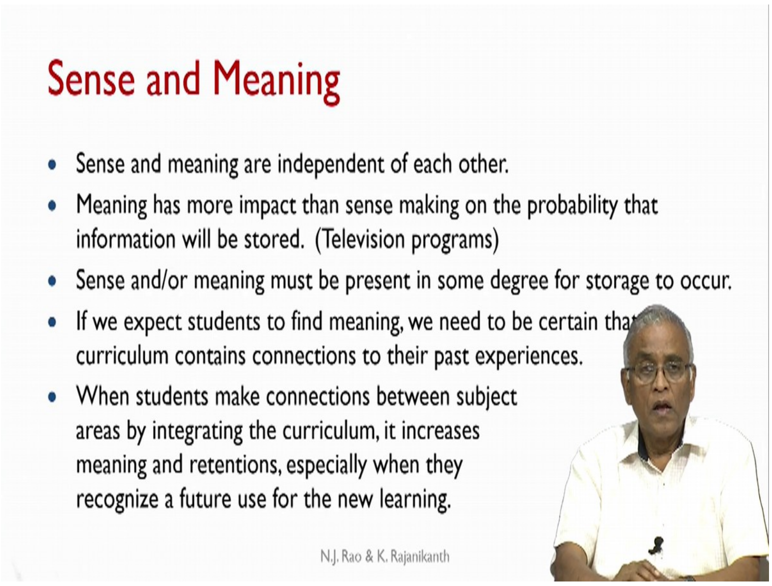


Information is most likely to get stored if it makes sense and has meaning. There are two words - sense and meaning these two are different. Making sense means the learner can understand an item on the basis of his/her past experience. For example, in electrical engineering, let us say you are trying to present Routh Hurwitz criteria. The entire logic makes sense to the student. In a sense, you can follow based on that how the matrix or the equation to be written and how do you graphically determine the number of roots in the left half-plane and right half-plane - all such mathematics of it you may follow.

But, you may not be able to find any meaning to you. Where am I going to use? It does not make meaning to me at that point in time. So, something can make sense to you, but it may not mean anything to you.

Having meaning refers to whether the items are relevant to the learner. If the learner finds it 'yes, I can see where I am going to use,' if you find it relevant, then you will certainly transfer it to the long-term memory. The same item, if it does not has any meaning for you, is not likely to go into the long-term memory. But, the same item is not likely to be equally relevant to all students in a classroom that should be remembered because each student is different, and his past experience is different; some students will find it relevant. Some students do not find it relevant.

(Refer Slide Time: 36:19)



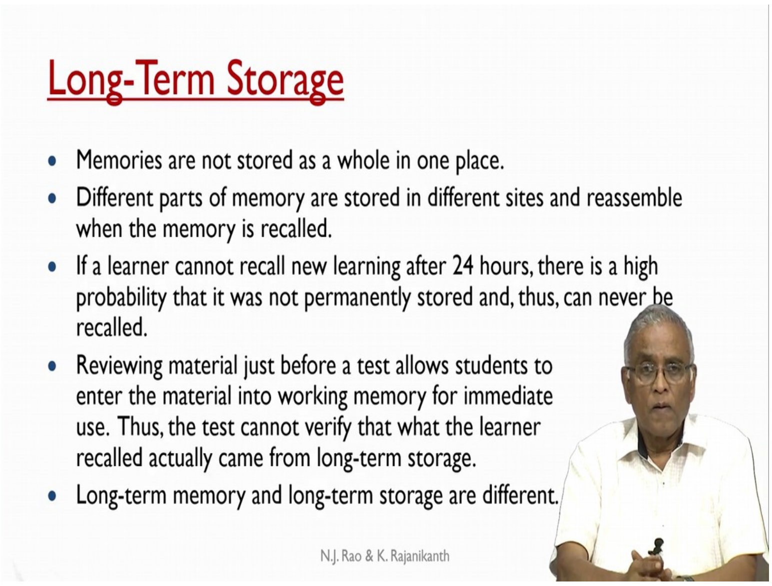
As we said, sense and meaning are independent of each other, and the meaning has more impact than sensemaking on the probability that information will be stored. A typical example is a television program. You may watch a television program, it may entertain you, it makes sense to you, but it does it has no long-term meaning for you. While you get entertained by television programs, you kind of forget all the details; a person will find it wasteful to store it in the long-term memory.

Sense and/or meaning must be present to some degree for storage to occur. (Obviously, if you put on a scale of 0 to 1 for both sense and meaning) Any particular learning that is taking place in the classroom, there should be some sense and some meaning for the storage to occur and that is a challenge to the teacher – how do I make sure that the students can make sense and how do I make it relevant to them so that they find meaningful.

One of the ways we expect students to find meaning is to be sure that the curriculum contains connections to their past experiences. If it is not related to their past experience; it is something very strange and new that is being presented, the students would not find any meaning to that. So, it is not likely to be stored in long-term memory.

When students make connections between subject areas by integrating the curriculum, it increases the meaning and retention, especially when they recognize a future use for the new learning. So, what does this mean? The way the courses are designed, how they are interconnected, how one becomes a prerequisite to the other, the sequencing, all of them will have to be very carefully designed for the student to find meaning. If he does not find meaning he may pass, he may get still a grade, but none of that information will get stored in the long-term memory.

(Refer Slide Time: 38:47)

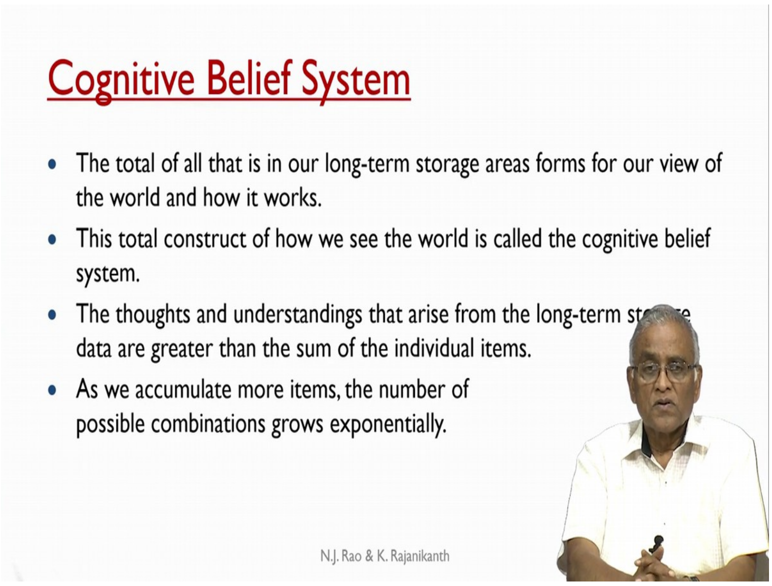


(Memories) in Long-term storage will not be stored as a whole in one place. Different parts of the memory are stored in different places, and they get reassembled when the memory is recalled. (Any numbers that we give are only indicative.) If a learner cannot recall new learning after 24 hours, you wait for something for 24 hours. If we cannot recall, there is a high probability that it was not permanently stored and thus can never be recalled. That means, at the working memory level, all your other factors either threat factor or emotional factor or non-attention etc., the storage has rejected that, and then after 24 hours, you will one do not remember; that means it is not permanently stored at all. That means the student is expected to again go through the whole process if that something is important. You are wasting an opportunity to learn. That experience is wasted - you have to go through that experience once more on your own if you are required to do that.

For example, reviewing the material just before the test allows students to enter the material into working memory for immediate use; that is where the teachers participate. But, there is no guarantee that it is actually stored in the long-term storage; that means, it may be adequate to pass the exam or to perform ok in the exam, but that information is practically forgotten. I am sure that teachers find it very common. Somebody says I have learned something in the two semesters earlier, and I do not remember anything related to that. Precisely it is because the content is not related, they are not connected and the student has not gone through the entire process of transferring working memory to the long-term memory.

Long-term memory and long-term storage are different. There is long-term memory, but how it is stored, where exactly it is distributed, how they are connected, what is the storage mechanism that is very different. We do not have to really fully understand how the storage mechanisms work, but if you are familiar with some features of that, then possibly you can also train yourself in the retrieval process.

(Refer Slide Time: 41:43)

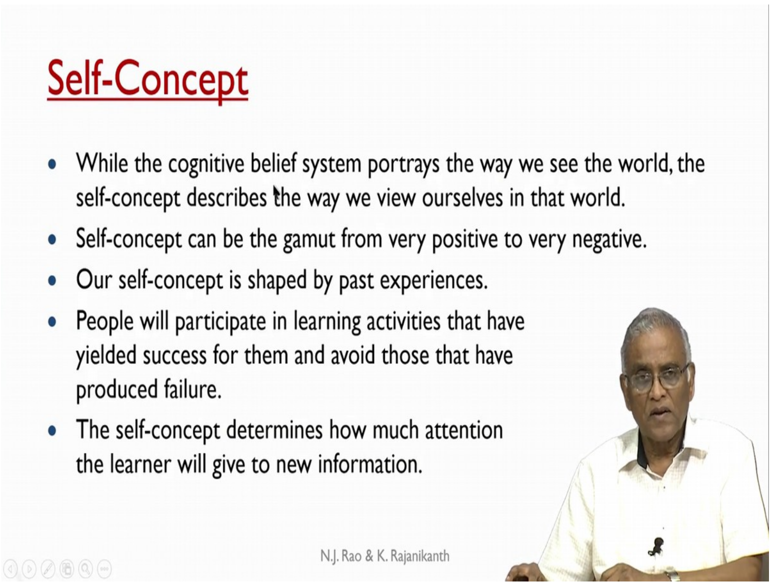


The total of all that is in our long-term storage (right from our childhood the whatever information that is stored) or long-term memory forms our view of the world and how it works; that is what we are. So, we are what our long-term memory is.

This entire construct of how we see the world is called the cognitive belief system, the entire thing. The thoughts and understanding that arise from the long-term storage because we have experiences at various times and our experience also varied. But all of them are somehow integrated into the individuals. They can be combined in so many different ways, and so, the thoughts and understanding that arise from long-term storage or more than the sum of individual items. If we keep accumulating more items, the number of possible combinations also grows exponentially; that is the nature of that.

Just let us recheck what it is. That is where we are calling - this entire triangle is what we call all the long-term storage is the cognitive belief system that is what we called. We now look at we put a face here - self-concept. Here we put a positive self-concept, but it can also be negative; this curve can also be reversed.

(Refer Slide Time: 43:33)

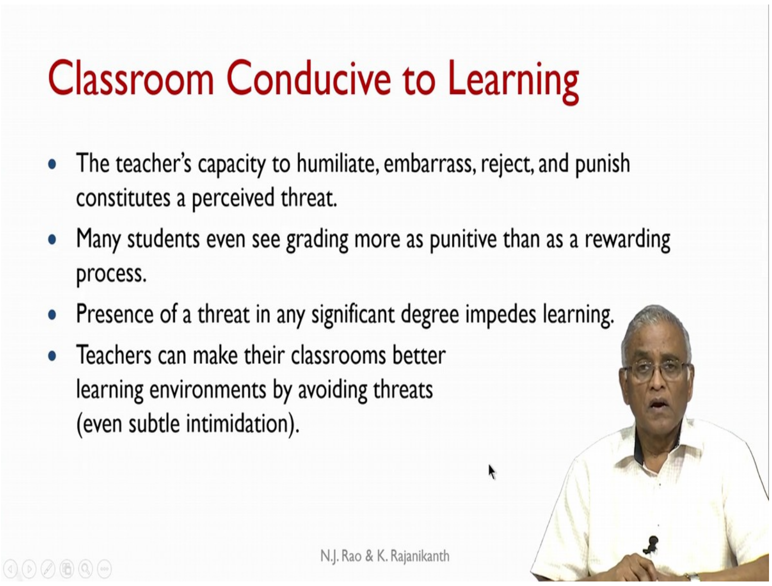


Self-concept: While the cognitive belief system portrays the way we see the world, the self-concept describes the way we see ourselves in that world. Self-concept can be from very positive to very negative. If you feel all the time negative about yourself, the way you will process new information will be very different. This self-concept is shaped by past experiences.

People will participate in learning activities that have yielded success for them and avoid those that have produced failures. For example, in some subjects, let us say you have done poorly, and you have an awful experience with that and a continuation course of that which follows that course; obviously, you will not that effectively participate in that because you have now a negative feeling about that particular subject.

The teacher wants to carry all the students with him or her, and one should be sensitive to the self-concepts of the individual students. Self-concept determines how much attention the learner will give to the new information.

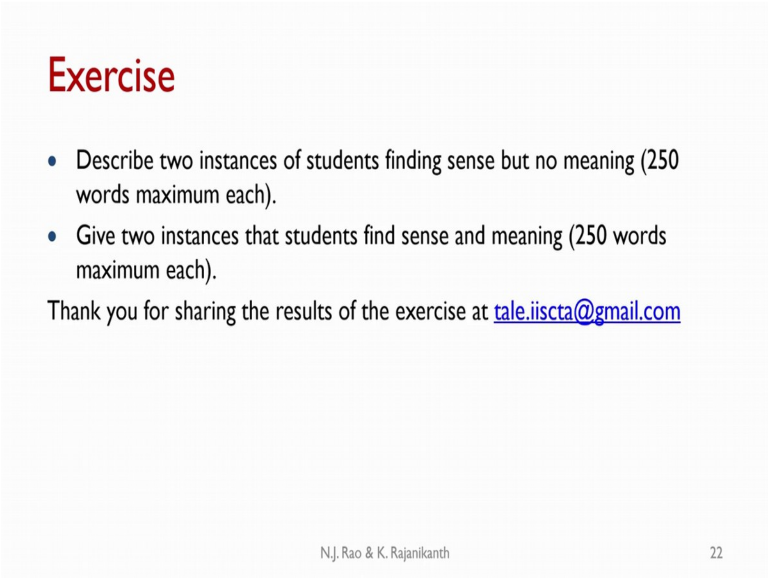
(Refer Slide Time: 45:01)



It should be remembered even at engineering college or higher education level, the teacher's capacity to humiliate, embarrass, reject and punish constitutes a perceived threat. I am sure you all teachers do experience and they have a tremendous capacity for that. Some people, unfortunately, utilize that for whatever reasons, but the students will always see it as a perceived threat; when it is a threat, even they grading that a teacher has to do is also seen as a punitive one than as a rewarding process.

So, the presence of threat in any significant degree impedes learning that should be remembered. Teachers can make their classrooms better learning environments by avoiding threats. Even subtle intimidation, a student feels he will look at it as a threat, and that has an effect on the kind the learning that takes place. So, this is one important lesson for the teachers to make sure that in no way the students feel threatened.

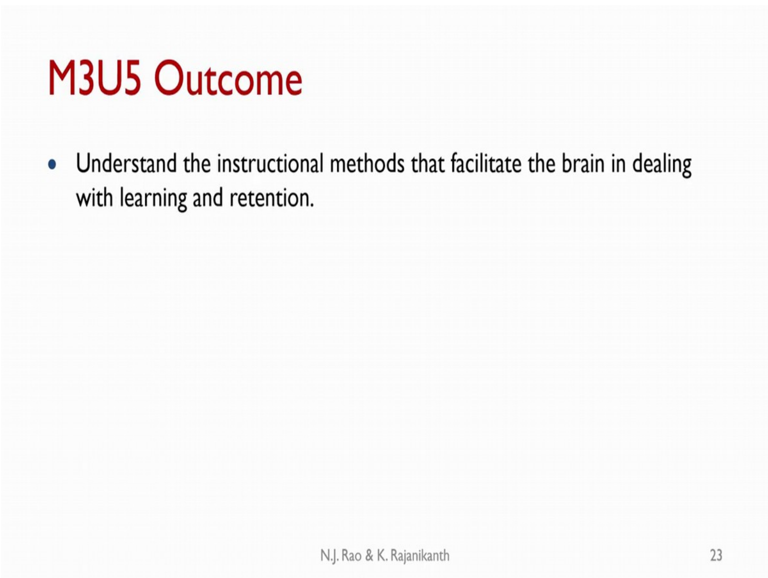
(Refer Slide Time: 46:29)



We have talked about sense and meaning. I am sure you would have experienced that. Students seem to be understanding what is presented, but it has no meaning to them.

Exercises: Describe two instances of students finding sense, but no meaning. You can write a maximum 250 words giving that instance where you have felt that. Give two instances that students find sense and meaning, 250 words maximum each. If you can share it on this particular at the, you can send it by email (tale.iiscta@gmail.com) to this; we will be thankful to you. That will be a lot of inputs for us.

(Refer Slide Time: 47:31)



In the next unit, we will continue with how brains learn, talk about the instructional methods that facilitate the brain in dealing with learning and retention.

Thank you very much.