NBA Accreditation and Teaching – Learning in Engineering (NATE)
Professor N. J. Rao
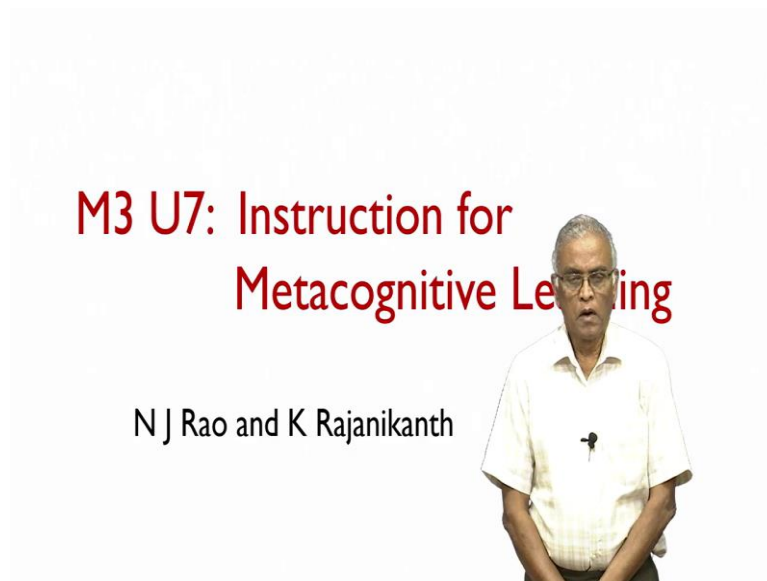**Department of Electronics Systems Engineering**
Indian Institute of Technology, Bengaluru
Lecture 47
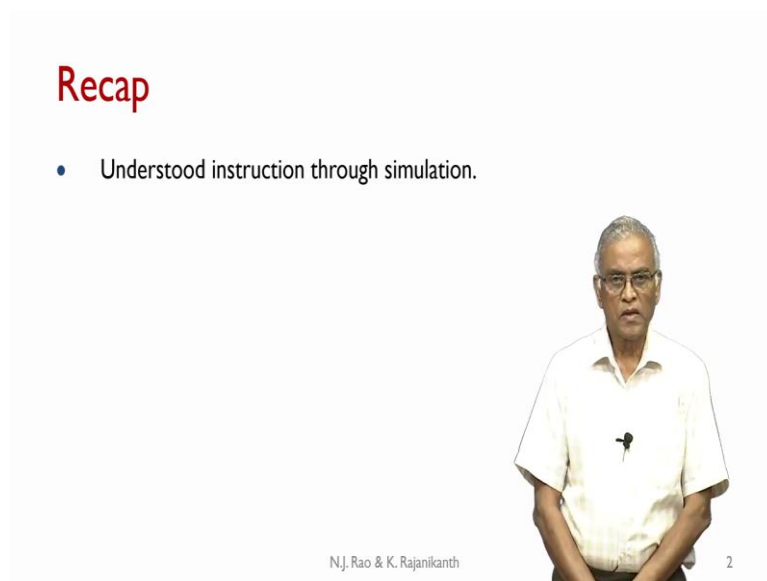**Instruction for Metacognitive Learning**

(Refer Slide Time: 0:28)

Greetings and welcome to NATE module 3 unit 7 on Instruction for Metacognitive Learning.

(Refer Slide Time: 0:38)

M3 U7: Outcome

- Understand the need for and methods for instruction for metacognitive learning.
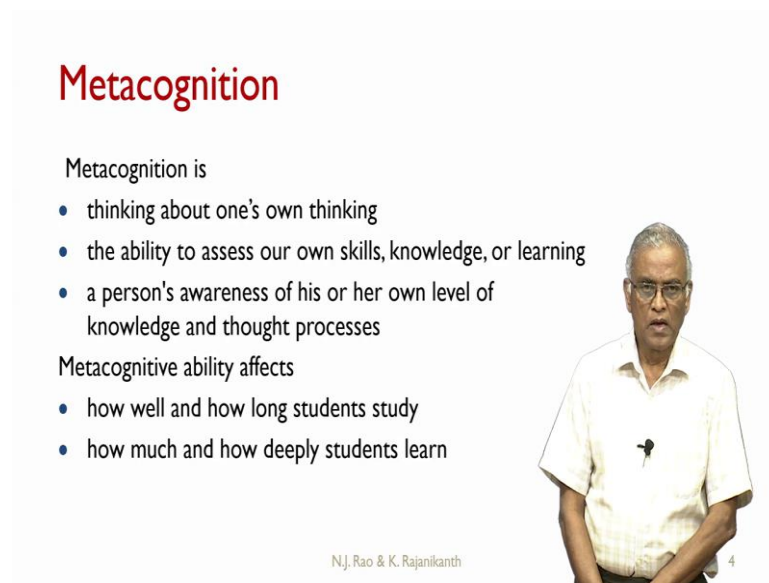
In the earlier unit, we understood the instruction method of using simulation to instruct in engineering courses and in this unit will try to understand the need for and methods for Instruction for Metacognitive Learning, while we mentioned a little bit about metacognition, in the taxonomy of learning, once again, I would like to emphasize the metacognitive call it dimension becomes very important in today's context.

That is because, because of the requirement of equity, we get students with very widely varying cognitive abilities, and what you can say with metacognitive abilities, and that is a reason why in many of the institution, the teacher has to take the metacognitive abilities of the students into consideration and also facilitate them to learn besides that the are some of the program outcomes. More importantly, PO12 related to lifelong learning requires significant abilities of student with respect to metacognition.
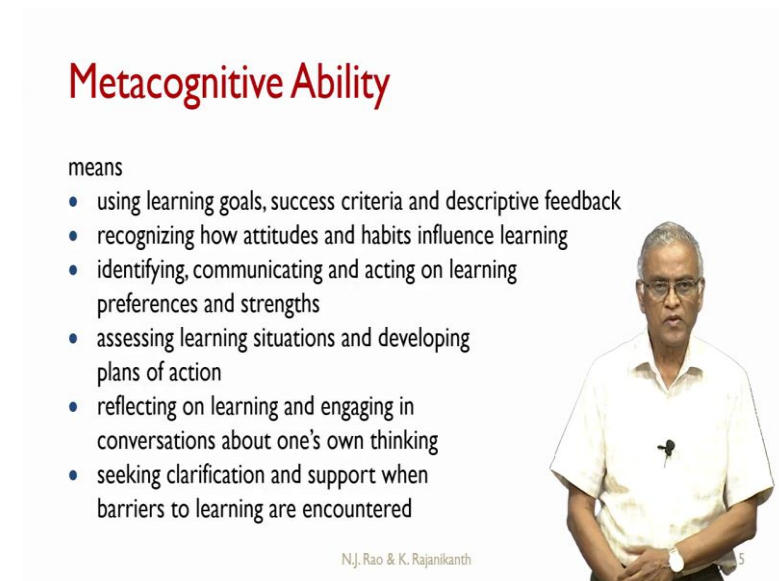
(Refer Slide Time: 2:19)

And first let us briefly define, what metacognition is? It is thinking about one's own thinking. Simply stated, but you need to spend some time in understanding what that is. It is also the ability to assess our own skills, knowledge or learning. That means every individual should be able to assess one's own skills and one's own level of knowledge, and also how he learns in any particular situation. If we do not have awareness of that, it becomes difficult to improve in that dimension and also it is a person's awareness of his or her own level of knowledge and thought processes.

So, all of them are the state the same thing, but stated in different ways. So, metacognition is really your own awareness of how you think, or what you already know, what you do not know, and how you actually think about something. All these processes are considered to be part of metacognition.

So, this ability of being aware of these processes, or contents will affect how well and how long the students study how much and how deeply students learn. So, both these shoes are very important, especially in institutions where you have a wide spectrum of students with cognitive abilities spread over a wide range.

(Refer Slide Time: 4:11)

And let us look at a little more informally what metacognitive ability means, it means using learning goals, success criteria and descriptive feedback. So, first thing is students should know, what is the goal of his learning? For example, in any subject, he should be able to be very clear, what is it that he needs, you should be able to do at the end of some learning.

Which we call stated as these learning goals are stated as outcomes in the case of a course, the course outcomes. And when do you say that you have attained them, what are the success criteria? And also when a when somebody gives you feedback, how do you make use of it. So, metacognitive ability means you are aware of all these things.

And it also means recognizing how attitudes and habits influence learning. Obviously, our habits and attitudes have a significant role in learning, and identifying, communicating and acting on learning preferences and strengths. And this is a habit that one should acquire over a period of time. Some people do, some people do not.

But when you are when it is mentioned to you, each student, or including the teacher should make an attempt in identifying, communicating and acting on learning preferences and strengths. It also means assessing learning situations and developing plans of action, all learning situations are not the same. For example, you can have a descriptive course you can have a laboratory course you can have a mathematical course. So, what happens each learning situation is different. And for each situation you should be able to develop it a different plan of action. So, that is a metacognitive ability.
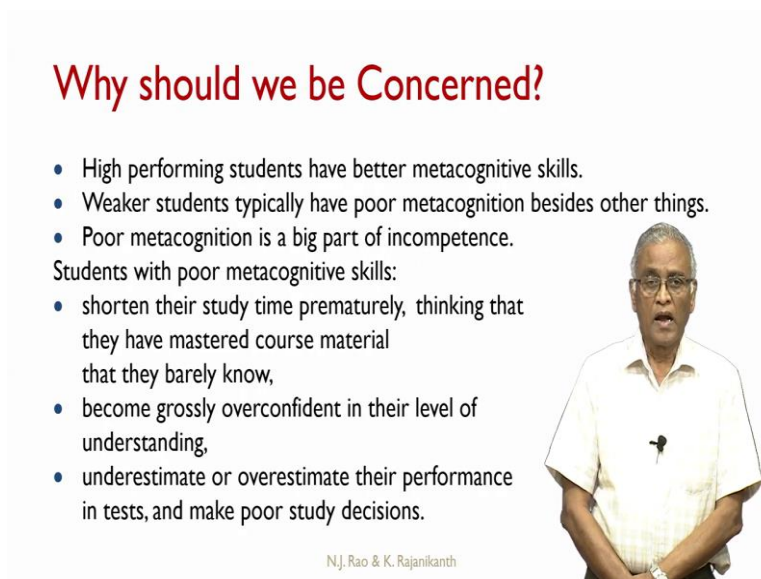
Good students have these abilities they may not be aware of them. They may not be using this language but good students seem to be having this metacognitive ability. It also means reflecting on learning and engaging in conversation about ones own thinking. Normally, people do not prefer to keep talking about this.

But if you have a a learning group, where you feel safe and comfortable with then you may not mind having a conversation with your pairs about once one thinking, and in fact students should feel very comfortable with the teacher in engage in engaging such conversations. If they feel safe with the teacher, they are likely to talk about these issues.

And it also means seeking clarification and support when barriers to learning are encountered when I seem to have some difficulty in crossing certain barrier, let us say I do not understand that kind of concept, it is not cognitive part, maybe I seem to be approaching it in some wrong way.

So, whenever such barriers are encountered, first thing is the student should be willing to seek clarification and support and that should be encouraged by the teacher. So, metacognitive ability as you can see, it consists of many, many issues related to the process of learning.

(Refer Slide Time: 8:03)

And why should we be concerned about metacognition high performing students have better metacognitive skills. It is a, it has been observed that you do not have to particularly focus on their metacognitive skills they learn, they learn, or when they have barriers, they will ask questions discuss with them.

And, and you have no issues about this teacher does not have to spend too much time about facilitating this metacognitive learning, whereas weaker students typically have poor metacognition, besides other things, he may have weaker cognitive abilities, but also has poor metacognition.

Poor metacognition is a big part of incompetence. All, students are not equally competent. So, metacognition happens to a big part of incompetence. And if a teacher is aware of it, teachers may find some ways of helping the students when they have issues related to metacognition.

So, students with poor metacognitive skills, sharp shorten their study time prematurely, thinking that they have mastered course material that they barely know, you read for a little while, and then you think a mastered and then move on. And they become grossly overconfident in their levels of understanding. And also they underestimate or overestimate their performance in tests and make very poor study decisions. So, P students with poor metacognition are likely to do some or all of these errors in in their learning.

(Refer Slide Time: 10:00)

Now, let us formally approach metacognition. Metacognitive elements of these metacognition are metacognitive knowledge, metacognitive monitoring and meta cognitive control. Sometimes the monitoring and control are together referred to as a regulation by many researchers in this area. So, you can treat it as the elements as to knowledge and regulation or knowledge monitoring and control.

So, let us look at what is metacognitive knowledge metacognitive knowledge is knowledge of tasks and content that means, I should be able to really know what is the task that needs to be performed and what are the contents of the task and also this knowledge consists of knowledge about cognition and cognitive strategies.

So, further classifying that, so first part is declarative knowledge, what different types of strategies are available for memory thinking and problem solving etc? That means, what are the strategies that I have that I know of, I am not practicing it, I know these are the strategies that are available for doing that is putting it in the long term memory or for thinking or problem solving, I know that these are the strategies available.

And then what do I need to know procedural knowledge, how to use an act two different strategies. So, if I know a strategy, I know the procedure, procedural knowledge of that how to actually use that strategy and there is a third aspect namely conditional knowledge, when and why to use different cognitive strategies.

Actually, if you look at the procedural and conditional knowledge, they are also part of what we call the cognitive level of applying something, how to use and enact different strategies, I should have the procedural knowledge. That means the student should know that he has or does not have the procedural knowledge, or that conditional knowledge.

And also metacognitive knowledge is related to ones own strengths and weaknesses as a learner or a thinker. So, everyone must know what their strengths and weaknesses are in their

capacity to learn or to think. Essentially, what it means is we should know at what level we are and what we are with respect to learning and thinking that is what cognitive knowledge.

(Refer Slide Time: 13:08)

Now, let us look at metacognitive monitoring, it is defined as assessing the current state of a cognitive activity. That means, assessing how easy or difficult a learning task will be to perform. First I must know that, that means I must be able to judge how difficult a learning task will be to perform, I must know that monitoring learning that means, I must be able to judge to what extent to have learned I should make a judgment of my own learning.

And also we have we do have feelings of knowing something but we are unable to recall it completely so that is also a monitoring, that is feelings of knowing or being aware of something that we know something and seem to be familiar with, but I cannot recall it completely.
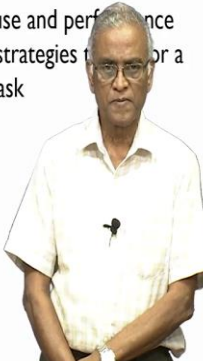
That happens because we are aware of something, but we do not remember all the details. We will come to that later. Then you have confidence judgment that is making judgment of the correctness or appropriateness of the response. So, monitoring consists of making a judgment of the correctness or appropriateness of the response.

Now, let us look at the third element metacognitive control metacognitive control is regulating some aspect of cognitive activity based on cognitive monitoring. So, control will follow monitoring, what does control consist of, one is setting goals for learning, how much time do I use for each part of the learning and what is the goal for my performance?

That means, I should be able to say that okay let me aim at solving problems of this difficulty level towards that, how do I plan my time, the and the second part is making decisions about strategies to use for a task and when to change strategies for performing a task. I should solve this kind of problems. This variety of problems before we get into a particular problem of choice.

That means, one strategy is solve easier problems before we move on to the more difficult problems. That is a kind of a strategy selection, and also a student should be able to allocate resources, what are the resources he has, like time that he can he wants to spare and the amount of effort he wants to put in and also the pace of learning all these are his resources, and he should be able to control and regulate regulating these three these three resources we are talking about time, effort and pace.

There is also another dimension, another way of another aspect of metacognitive control, what we call volitional control. There is control and regulation of motivation, emotional and environment. Let us take the first two motivational emotion. And whenever we have mild difficulties, we suddenly say you get irritated, you get bored or you do not like it and suddenly because of that, you lose motivation to continue.

So, this volition, volitional control is something that every student will have to master. That means, there will be so many instances where such experiences leading to irritation because of the task or the environment that come, you should be able to sail through that, that means, he must have volitional control.

Some people do have, some people do not have, it depends on how strongly they feel about irrespective of the environmental issues or situational issues, that you are willing to put the effort, earned obviously, metacognitive control decisions influence the direction and the way learning will continue. So, all these activities have significant influence on the way the learning continues.

So, one of why we are getting into this level of detail is if you know all the detail processes and all the things that can happen with regard to this, the teacher may be able to help at least with some of them. Of course, teachers are not trained psychologists, but at least if you are aware, aware of all these different processes, maybe intuition or by experience, you may be able to help the students to overcome some of the limitations in this.

Otherwise, some good teachers intuitively may have that ability without formal training, but we are not you cannot afford to say that we are on intuitively great teachers one will have to spend time to learn many aspects of the issues related to the students.

(Refer Slide Time: 19:07)

Why Examine Metacognition?

In the today's context
- We require the ability to engage with and transform increasingly more information across single and multidisciplinary contexts.
- As access to information is continuously increasing the process of accessing, choosing and distilling information will become a major task.
- Institutions and educators require students to undertake independent learning in increasingly less directed environments (autonomous learners).
- Improving and fostering metacognition learning is one way of doing this.

N.J. Rao & K. Rajanikanth

And now once again, we want to ask the question why examine metacognition? Having known the elements of it. Let us re-ask the question, why metacognition. In today's context, we require the ability to engage with and transform increasingly more information across

single and multidisciplinary contexts. That is one of the requirements today, because the kind of information that is available on the internet and our requirements to engage with much much more knowledge than what is required.

One of the reasons why we need to examine metacognition as access to information is continuously increasing the process of accessing choosing and distilling information will become a major task. In today's world, for everyone, irrespective of the discipline, that is a major task. Otherwise, you will end up spending any amount of time reading and working with some unrelated and useless information for you. Institutions and educators require students to undertake independent learning in increasingly less directed environments.

At every stage, for every part of it, some buddy like a teacher is not available to make a decision for you, you do this or do not do this. So, we have to become autonomous learners. When you want to become autonomous learners, your metacognitive knowledge should be improved. Otherwise, you will not be able to become an autonomous learner. So, improving and fostering metacognition learning is one way of doing this to meet the requirements of today's world, that is you must become autonomous learner to become an autonomous learner, you should have a better metacognition.
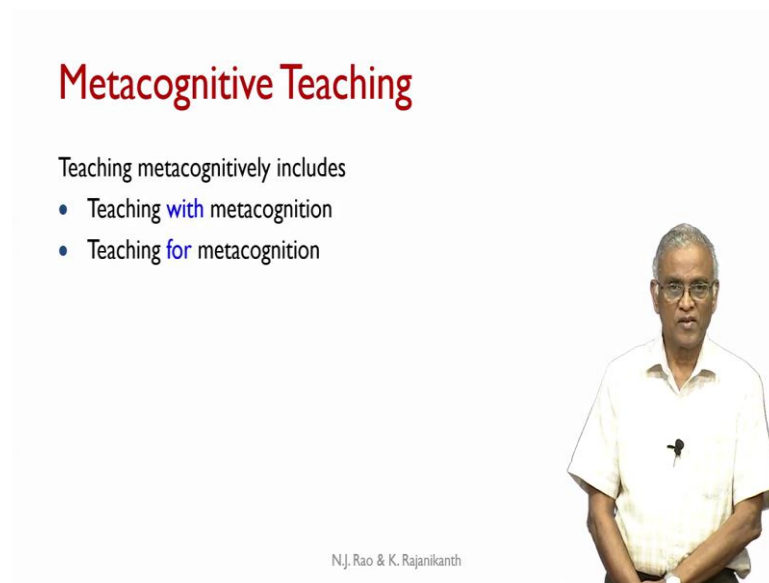
(Refer Slide Time: 21:20)

So, who is a metacognitive person? Metacognitive person is someone who monitors his or her understanding and uses strategies to regulate understanding, that is what we have been telling him, he monitors his understanding and use the strategies to regulate understanding

So, when you have a metacognitive person, it also means there is also a non-metacognitive person. And if one of the goals of education is to foster independent learning, in case of engineering programs PO12 is related to lifelong learning, then it is necessary to prepare learners as metacognitive persons. So, as all engineering programs have to attain this PO12, so the program itself should be designed to make all their students metacognitive persons to attain PO12. So, teachers need to understand how to improve a learner metacognitive, metacognition.

(Refer Slide Time: 22:37)

Now, the metacognitive teaching, teaching metacognitively includes teaching with metacognition teach it himself should be should have metacognition, that is teaching with metacognition and also teaching your students for metacognition. So, you have to improve the metacognition of your students. And you yourself must have metacognition about your subject or with respect to your learners.

(Refer Slide Time: 23:14)

So, teaching with metacognition, what does it mean? So, the teachers should think about their own thinking regarding their teaching. So, each teacher will have to say, How am I how am I teaching? Why should I follow? Why am I following certain procedure? What should I teach? So, all the thinking process related to their teaching is what we call metacognition of the teacher.

Teaching with metacognition includes reflecting on instructional goals. First of all, you must have very clear instructional goals and these will include the course outcomes and the P was they are mapped into how much time we have at what cognitive level are we talking about. So, he must have clear instructional goals, and think about that.
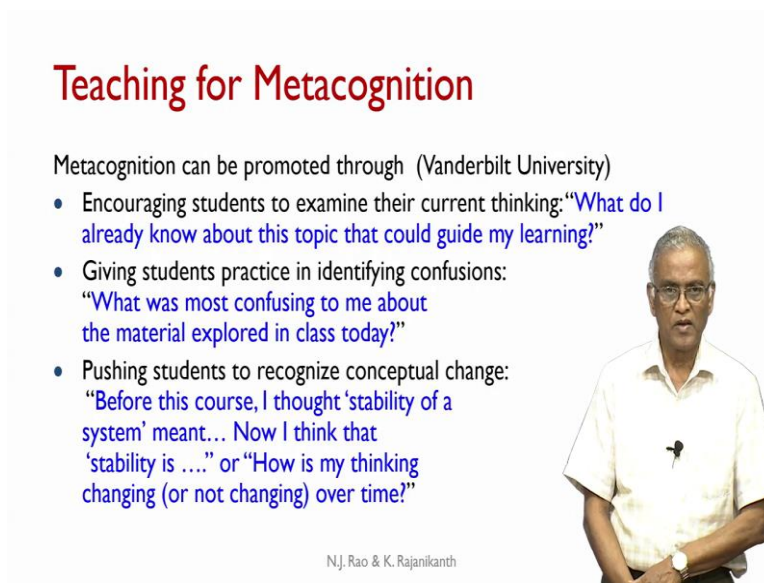
And also what kind of students do I have? That means their characteristics and needs, I must have an idea and how is the content organized, what level it is, and how should I sequence my instruction, as I said, as we already said, sequencing may consist of going from simple to complex, or abstract to concrete, concrete to abstract and so on.

Each teacher depending on the nature of the subject, he may have he or she may have their own preferences and he must also think of the teaching strategies. I may be following something but I should say what is the strategy I am following? Is this adequate for this? So, if you think about it, then you are as a consequence of that you will be teaching with metacognition and nature of materials and other issues related to curriculum, instruction and assessment.

So, if you if you are able to reflect on all these aspects, then you are likely to teach with metacognition and such thinking occurs before, during and after lessons in order to maximize instructional effectiveness. So, if you start with my goal, that I must continuously improve, and I must make my instruction effective.

That means the learners are my students are able to attain the outcomes that are stated. So, if you want your students to keep doing that, then you have to continuously think about, about all these aspects before, during and after lessons. And we have taken all these factors into consideration and presented many of these things as part of implement phase of Addie. Though we did not mention metacognition word prominently in writing those templates for you.

(Refer Slide Time: 26:40)

Now, we look at not only we should have metacognition, the teacher should have metacognition, but now you want teaching for metacognition. That means you want to promote metacognition in your students. So, one methodology that was developed by us Vanderbilt University we can present here, like encouraging students to examine their current thinking, like asking a question, what do I already know about this topic that could guide my learning?
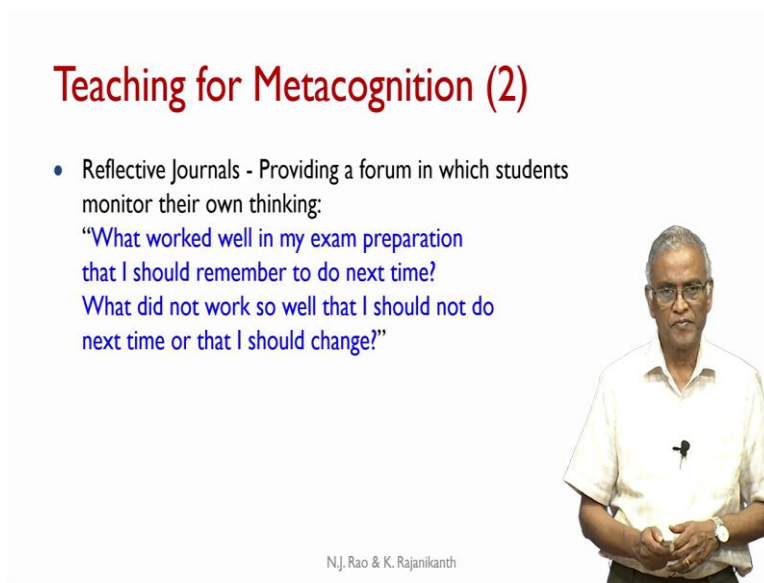
Let us say, at the very beginning of a lesson, you ask this question and make people write one sentence two sentences about it. Or you can have it kind of discussion in the class, but you have to make everyone do this. And the best method to do that will be to use something like Google Forms or Google Docs something some tools like that. If you can use the tools and

the students have internet devices with them, then such things can be done more efficiently without taking too much of time.

And also giving students practice in identifying confusions. For example, after something is presented, you can ask them what was the most confusing about the material explored in class today? If they can point out, these are the concepts that I find some contradiction or variance between them or I find it difficult if they are able to find that even the process of pointing out that itself is good, it leads to metacognition.

Or if they passively write down the notes from the board, obviously that does not lead to metacognition. And another part pushing students to recognize conceptual change. Like before this course I thought stability of a system meant if we can point out that and now I think stability is so there is a conceptual change that has occurred and this has occurred over time. So, if the student is able to recognize that conceptual change, then metacognitive knowledge has taken occur.

(Refer Slide Time: 29:14)
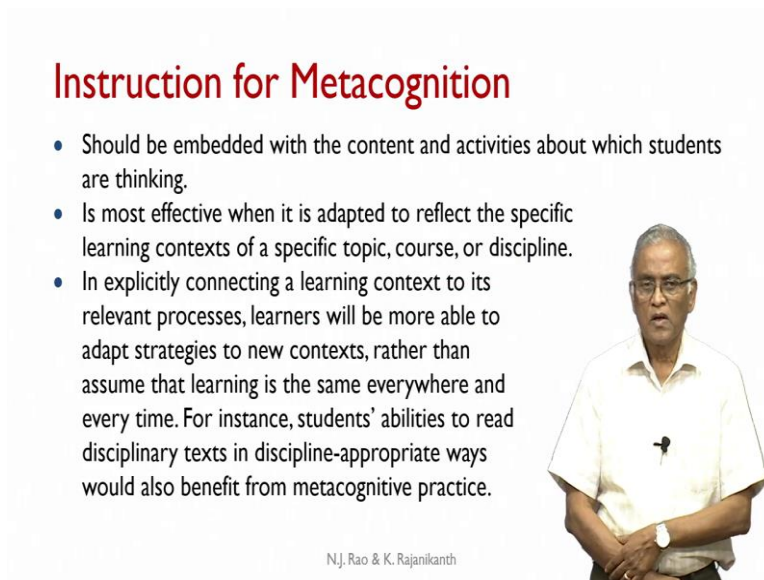
Further, another method is reflective journals, providing a forum in which students monitor their own thinking, like they write for themselves, if they can write for themselves, like what worked well in my exam preparation that I should remember to do next time. If I am able to identify and point it out, if I can write actually when you write, you will realize that the kind of weaknesses that we have, will have to be addressed before you can put a sentence on a piece of paper.

So, if you can write a reflective journal, that writing reflective journal itself is a process to improve metacognition, like another example, what did not work so well that I should not do next time? Or that I should change? It is this kind of questions if you ask, then the you are training yourself in metacognition.

(Refer Slide Time: 30:18)

Instructions for Metacognition should be embedded with the content and activities about which students are thinking. So, the teacher should be able to make embedded the instruction for metacognition with the regular content of the course or activities that you are following. It is not as if you are having a separate set of hours dedicated to addressing metacognition.

If you are able to view these things that promote metacognition, it will be good. It is most effective when it is adopted to reflect the specific learning context of a specific topic course or discipline, there is always a context that is associated with anything that you learn. And they should be able to reflect on the specific learning context.

For example, if you have solved a problem, what is the context of the problem, how many assumptions have been made. If you are able to reflect on that, then your metacognition improves in explicitly connecting a learning context to its relevant processes, learners will be able to adopt strategies to new contexts rather than assuming that learning is the same everywhere and every time.

This is most important in especially in engineering, where you are applying your knowledge to or you are doing your cognitive activities in a context that is very different from what was

done in the classroom. And to do that, if you are aware of the context in which you have learned, you will realize that you need to change that the strategy to be adopted to solve the new problem or a real world problem that has to be different from what you have learned earlier. For instance, students abilities to read disciplinary texts in discipline appropriate ways would also benefit from metacognitive practice.
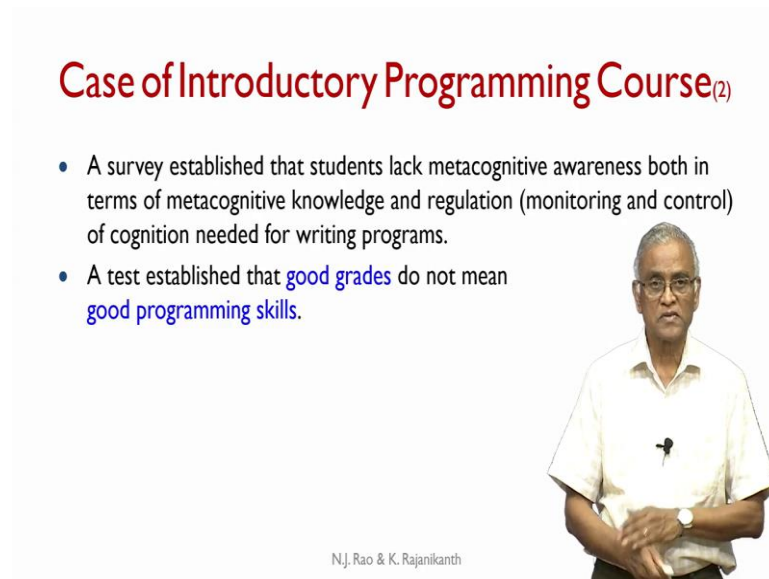
(Refer Slide Time: 32:44)

Now, we will try to present a case of introductory programming course internationally, this particular course that is whatever name you give, problem solving through programming using C or Java or whatever, Python or anything like that is a compulsory course for practically all people. And internationally this has a very high failure rate and a dropout rate.

But in India dropout, dropping out is not an option. And most engineering institutions in India achieve high pass percentage in this course. And dropping out of the course is not an option. Institutions achieved this by making students learn a fixed set of programs. Some other store over a period of time all the institutions have by trial and error came to the conclusion practically, this is what is followed in most of the affiliated colleges. That is what do you call non autonomous institutions, they learn a fixed set of programs, some 20 programs or 25 programs are given covering all aspects of the course.

And assessment methods are also based on the student's ability to reproduce these programs in the lab. That means, the code is given in the classroom and they have to reproduce this code. They cannot even give an alternate code which works. If you change the code from

what was given in the class, you will not get marks, so what happens by the process? You are not allowing the students to explore, so but this seems to be a assuring high pass percentages.

(Refer Slide Time: 34:47)

So, what is the issue? A survey established that students lack metacognitive awareness both in terms of metacognitive knowledge and regulation of cognition needed writing programs. So, the very process of conducting this course prevents them from having both metacognitive awareness and regulation.

And a kind of a test established the good grades in this course do not mean good programming skills. And I am sure all of you are aware of that many IT industries find that the people with good grades are not necessarily employable because they do not have good programming skills.

(Refer Slide Time: 35:34)

Learning Programming

- involves the acquisition and effective use of three inter-related types of programming knowledge,
    - o Syntactic (specific facts about a programming language and rules for its use)
    - o Conceptual (computer programming constructs and principles)
    - o Strategic (programming-specific versions of general problem-solving skills)

N.J. Rao & K. Rajanikanth

Now, learning programming is also it is a subject different from others, and a study has been done. So, they have identified it involves the acquisition and effective use of 3 interrelated types of programming knowledge. One is syntactic specific facts about programming language and rules for its use, that everybody is clear and that is what they teach.

Then you have conceptual computer programming constructs and principles. This may be there in the textbook, but it is not focused upon and then there is you have strategic aspect programming specific versions of general programming solving skills. So, even if you have related conceptual knowledge, now you are you must have you must be able to use strategies, different strategies for it, even this part of the course is not particularly what do you call, you pay attention.

(Refer Slide Time: 36:45)

Now, what are the instructional practices that you have? Most introductory programming courses seem to foster the development of syntactic knowledge and not put enough emphasis on the development of concepts knowledge, not strategic knowledge, which is left to unguided discovery. Students have to some of some people will find by trial and error reading more or trying to solve problems, sometimes they give up, but that discovery is unguided. So, obviously all students will not be able to do.

And a large amount of instruction programming involves letting students proceed by trial and error and as if the ultimate instructional goal was to simply to get programs to work, somehow you have to make the programs to work. First of all, very rarely in this colleges, you are even asked to write a program to solve a problem which has not already solved in the classroom. Very rarely, if it is given here to some whom is the program work that was the ultimate instructional goal.

(Refer Slide Time: 38:04)

Instructional Practices (2)

- Students tend to develop a "fragile" knowledge of programming, described as garbled or inert knowledge, knowledge used inappropriately, or knowledge not spontaneously accessed in the context of need because it is still welded to the initial context in which it has been acquired.

N.J. Rao & K. Rajanikanth

And students tend to develop it through these processes what we call fragile knowledge of programming, described as garbled or inert knowledge, knowledge used inappropriately, or knowledge not spontaneously accessed in the context of need, because it is still welded to the initial context in which it has been acquired. What was the initial context, you have to just remember the code of it as set of programs that is it. If it does not fit into that context, you are unable to even approach the problem properly. And once you get into this habit to come out of that will take a lot of effort.

(Refer Slide Time: 38:50)

What can be Done?

Working with several groups of students at different institutions established:
- Metacognitive formative assessment helps students plan and invest time in learning programming even in the social context where learning programs will be enough to pass and get a good grade.
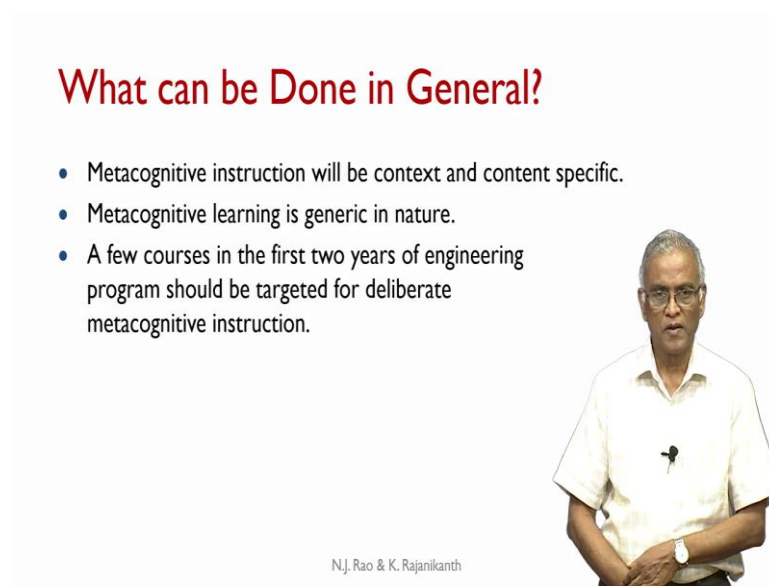
N.J. Rao & K. Rajanikanth

And, what can be done? And working with several groups of students at different institutions established metacognitive formative assessment helps students plan and invest time in

learning programming, even in social contexts where learning programs will be enough to pass and get a good grade. So, you have two situations. One is learning programming, and the other is learning programs.

So if you learn programs that is ability to reproduce code that is given to you in the classroom, it is enough to pass and get a good grade. But some students do really want to go beyond that they want to learn programming, not learn only some programs. And that is where metacognitive formative assessment will help students to plan and invest time in learning programming. This is what we found through studies at several institutions.

(Refer Slide Time: 39:53)

And what can be done in general metacognitive instruction will be coming context and content specific, metacognitive learning is generic in nature. So, if you accept these two statements, if you courses in the first two years of engineering program should be targeted for deliberate metacognitive instruction. So, if two or three courses in the first two years are targeted for that, then their metacognitive knowledge and regulation will significantly improve and they will be able to carry on with the other subjects in the later semesters.

So, we would like you to write a few instances of metacognitive instruction in your course even though you did not use or were unaware of the terminology associated with metacognition. So, based on what is presented here, if you can relate to your own classroom in instruction and identify few instances of metacognitive instruction, if you can do that, and communicate to us it will be of great value.

And in the next unit having looked at the entire course design as well as instruction and in the current context, what should a teacher do or how should a teacher organize instruction with all the limitations that is what we will explore in the next unit. Thank you very much.