TALE - 2 Course Design and Instruction of Engineering Courses

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Lecture – 29
Project Based Approach to Instruction

Greetings! Welcome to Module 3, Unit 11, on Project-Based Approach to Instruction, an extremely important and popular approach these days.

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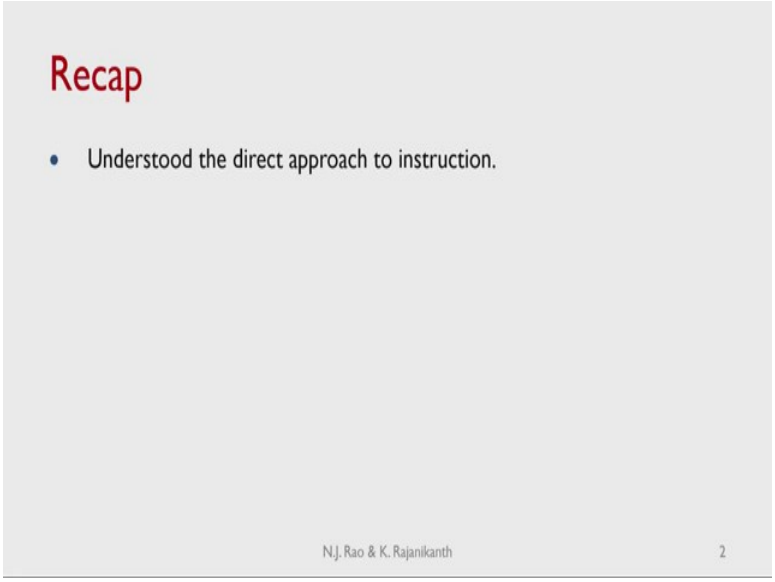

In the earlier unit, we understood the direct approach to instruction based on a transactional model of instruction. In this unit, we will understand project-based approach to instruction.

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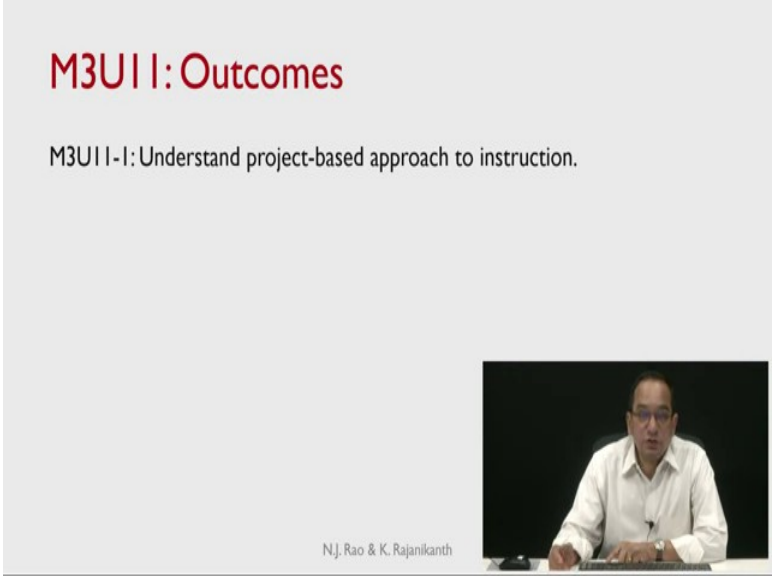

The project-based approach: This term is being used in several broad senses these days. Sometimes the term is used interchangeably with terms like problem based approach, enquiry based approach and so on.

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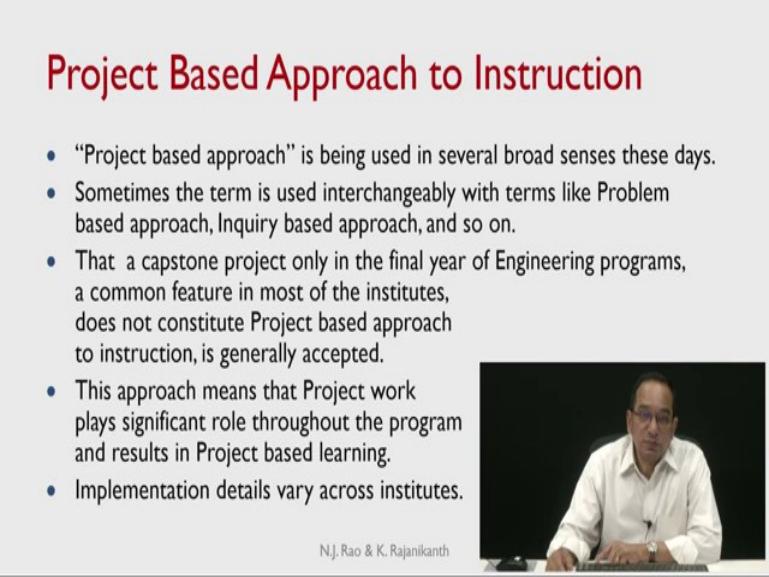

But, hopefully at the end of this unit, we will see that there are very distinctive features of project-based approach to instruction which makes it different from problem based approach or enquiry based approach or even experience based approach. Though these terms do look similar, each has certain distinctive flavor and it makes that approach

unique. A capstone project, only in the final year of engineering programs, is a very common feature in most of the institutes particularly in India. But this by itself does not constitute a project-based approach to instruction. That is generally accepted i.e., just one final year project does not make the instruction as project-based approach to instruction.

Yes, that particular activity is project-based. But the project-based approach means that project work plays a significant role throughout the program, not just in the final year or final semester. This should result in project-based learning by the students. In fact, in the literature, PBL is much more common term; or PrBL sometimes, people use that to make it distinct from problem based learning, which is generally abbreviated as PBL. Project-based learning is generally called as PrBL.

The project-based approach or PBI to instruction essentially means that project work plays a very significant role throughout the program, throughout all the 4 years and this result in project-based learning. Implementation details do vary across the institute. But the general philosophy is that the approach should be implemented throughout the program.

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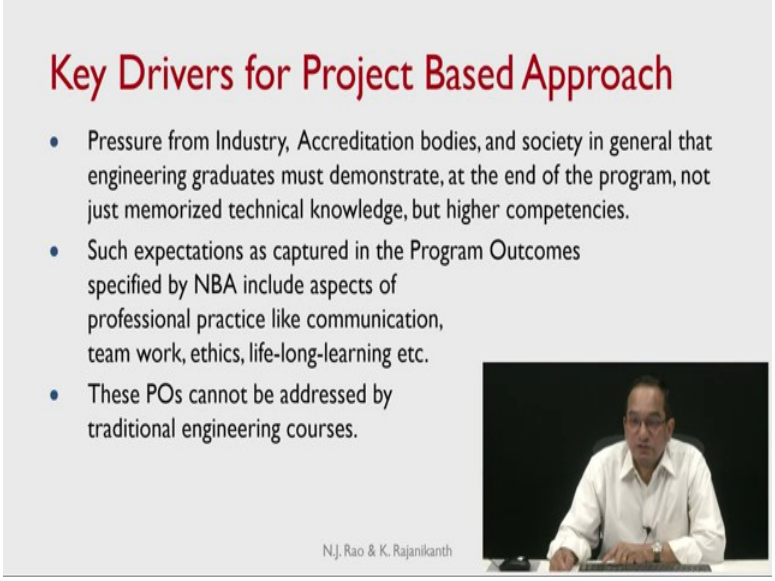

The key drivers for project-based approach over the last few years, couple of decades, have been: pressure from industry, accreditation bodies worldwide, and society in general that engineering graduates must demonstrate, at the end of the program, not just memorize technical knowledge, but higher competencies. They are not necessarily only

engineering knowledge-based competencies, but they are also related to the professional practice. Such expectations as captured in the program outcomes specified by NBA include aspects of professional practice (as I just now mentioned) like communication, team work, ethics, and life-long-learning etc.

The fast changing pace of technology today demands that the engineering graduates must be capable of adapting to this changing scenario and industry expects this kind of professional practice - related competencies to be developed in the students. Such POs cannot be really addressed by the traditional engineering courses which are essentially lecture-based, probably supplemented in some cases by a very restricted laboratory practice. This need a different approach to instruction and that has led to the innovation of project-based approach on a wide scale.

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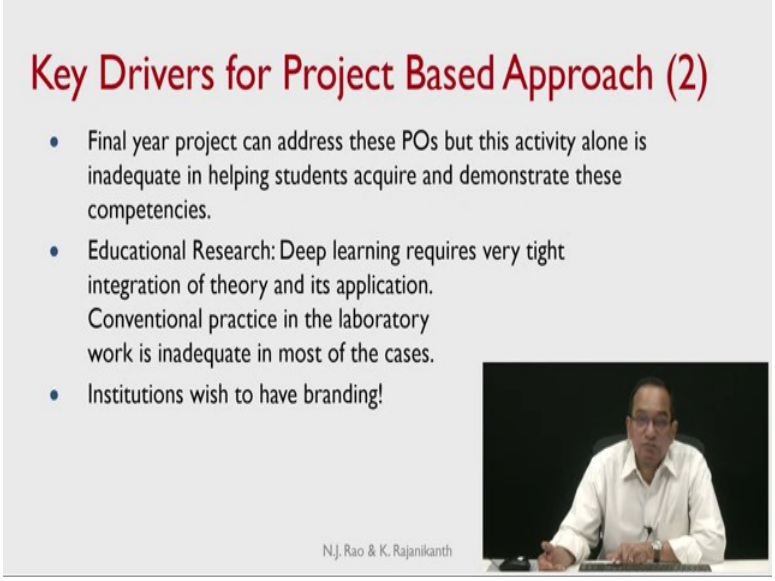

Final year project can address these POs. But this activity alone is inadequate in helping students acquire and demonstrate these competencies to the extent that the industry or society is in general expecting. Certainly final year project is helpful, but it is found to be inadequate. Educational research has shown that deep learning requires very tight integration of theory and its application. Conventional practice in the laboratory work is also found to be quite inadequate in most of the cases.

Yes, it does help the students in practicing, in applying the theoretical principles to practical scenarios, but the way the laboratories are conducted most often, the kind of

experience that the students get, is found to be quite inadequate. Also, institutions wish to have some kind of branding in the today's world of competitive educational opportunities; so they would like to enhance their prestige by claiming that they are adopting modern innovative practices to teaching.

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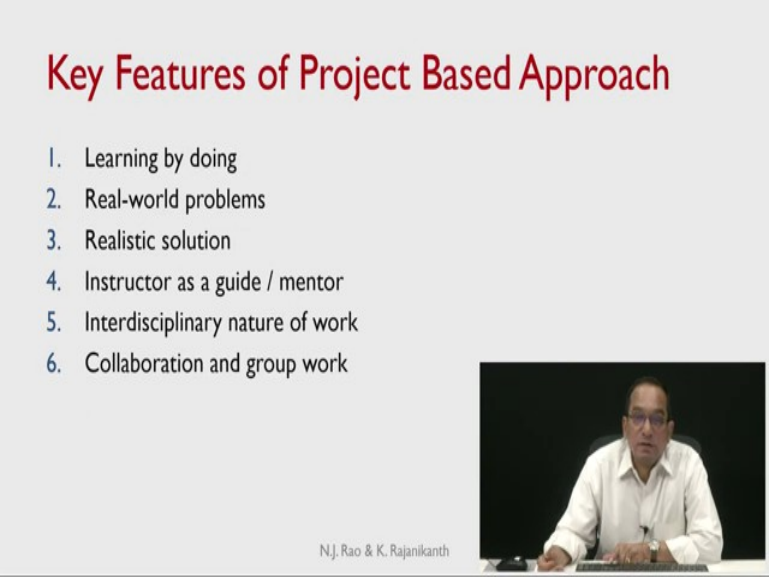

The key features of project-based approach: Learning by doing, real-world problems, realistic solution, instructor as a guide/mentor, interdisciplinary nature of the work, collaboration and group work. There are many other features, but these are the key features of PBI, project-based approach to instruction.

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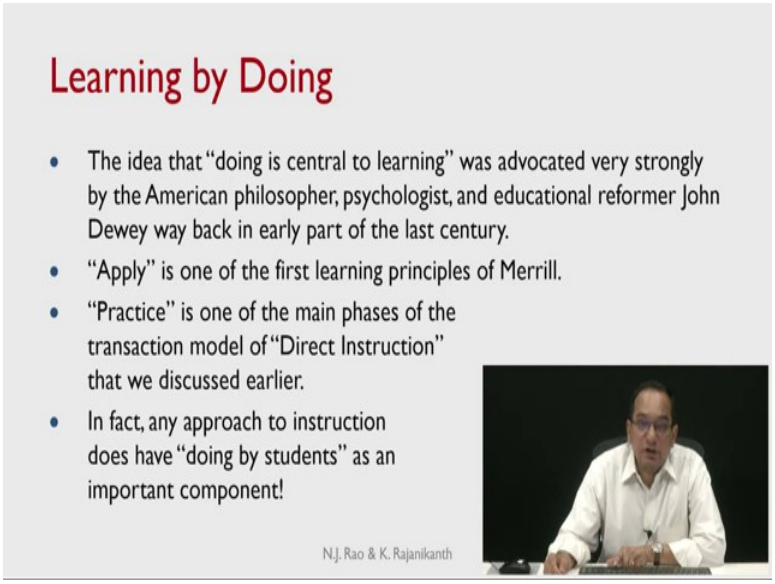

The first principle, "learning by doing" - the idea that doing is central to learning is fairly old. It was advocated very strongly by the American philosopher, psychologist and educational reformer John Dewey, way back in the early part of the last century.

'Apply' is one of the first learning principles of Merrill. 'Practice' is one of the main phases of the transaction model of 'Direct Instruction' (that we discussed in the earlier unit.) In fact, any approach to instruction does have 'doing by students', as an important component. Then where does project based approach differ?

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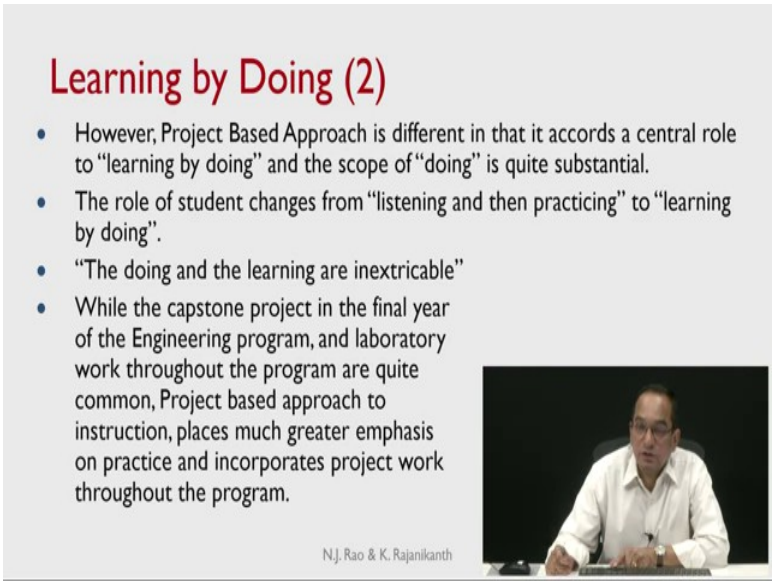

The project-based approach is different in that it accords a very central role, a key role, to 'learning by doing' and the scope of 'doing' is quite substantial. That means, the practice in which the students engage is quite substantial. It is much beyond what happens in the laboratories or in the classrooms when they solve end-of-the-chapter exercises.

The "doing" is on a much more extensive scale. So, the central role accorded to learning by doing and the scope of activities implied by "doing" - these are the distinguishing features of project-based approach. The role of a student changes from listening and then practicing to learning by doing. That means that, essentially, doing and learning are inextricable – they are very tightly integrated.

While the final year project of engineering program and laboratory work throughout the program are quite common, Project-based approach to instruction places much greater emphasis on practice and incorporates project work throughout the program. What is the extent to which actually we are able to incorporate project work throughout the program? (We will discuss this issue when we come to the implementation of these ideas.)

We will see that while in principle, in theory, project-based approach to instruction makes certain demands; the situational constraints may force us to adopt a slightly lighter version of the rigorous project-based approach. Still, that is quite useful! We will see what are these constraints and compromises as we move along.

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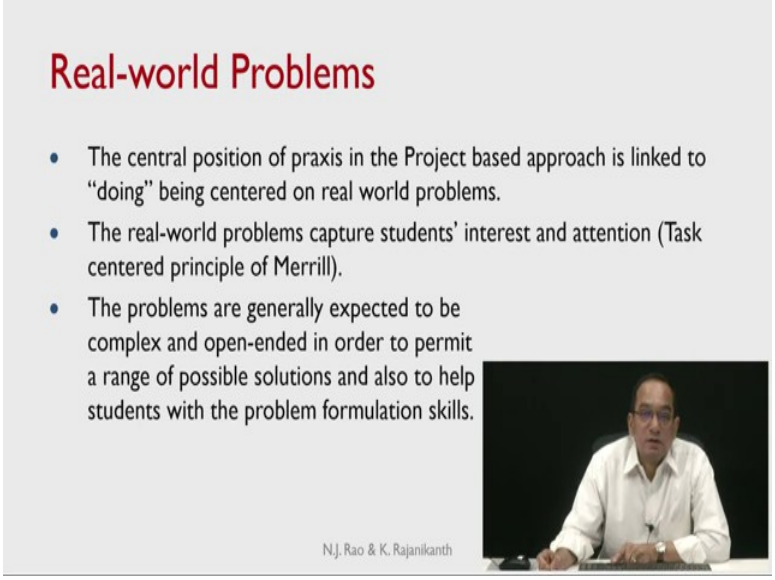

The central position of praxis in the project-based approach is linked to doing based on, centered on, real-world problems. This is the next key feature of project-based approach. The real-world problems capture student's interest and attention. This corresponds to the task centered principle of Merrill. The problems are generally expected to be complex and open-ended in order to permit a range of possible solutions, and also to help students with problem formulation skills.

In a majority of learning contexts, it has been observed that students do not have problem formulation skills, because in most of the conventional formal programs, the instructor provides a highly structured problem already formulated. 'Solve the following problem using this method'- that is how the exercise is stated. The problem is formulated in all rigor; there is no ambiguity; there is no open-endedness; there is nothing fuzzy about the way the problem is stated; there is nothing unclear about the kind of solution that is expected from the students. So, the problem statement as well as a solution expected is all strictly along pre-fixed directions, whereas in real-world it rarely happens like this.

So, one of the complaints from industry has been that students are not being trained in the skills required to formulate a problem in engineering terms from a description given of the real-world scenario. There is a lot of vagueness, fuzziness in the real-world problem and engineers need the skill to formulate a problem first. So, the problems that are generally given to the students in project-based approach are expected to be complex and open-ended in order to make the students practice even the problem formulation skills.

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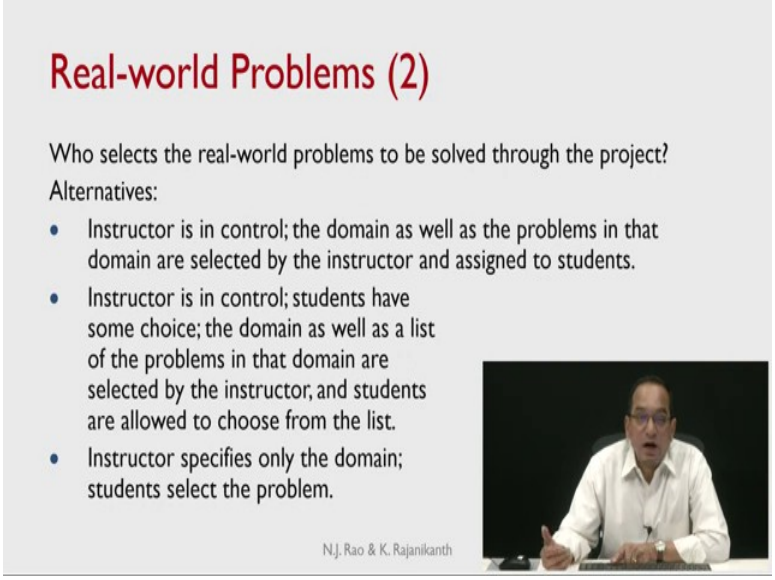

Who selects these real-world problems to be solved through the project? Again, depending upon the situation, there can be several options. The first option/alternative is instructor is in total control. The domain as well as the problems in the domain are selected by the instructor and assigned to student teams. Actually, you can call this as assigned projects. The instructor is in total control. The problem, its statement, the team to which it is assigned - they are all dictated by the instructor. This is obviously, very efficient and probably quite simple to implement, but it has its limitations. But this is one possible alternative.

The second alternative is that instructor is still in control, but students have some choice. The domain as well as a list of problems in the domain is selected by the instructor and students are allowed to choose from the list. Of course, we need to resolve conflicts when multiple students, multiple student teams, want the same project and all that kind of issue, but essentially students do get some choice.

The third alternative which is probably difficult to implement, but which gives the maximum freedom to the student is that instructor specifies only the domain and students select the problem. In this case, instructor has to moderate to ensure that the problem selected by the students is of right complexity level as well as open-ended enough to permit the learning experience to be really significant for the students. But students do get considerable choice in the selection of the problem.

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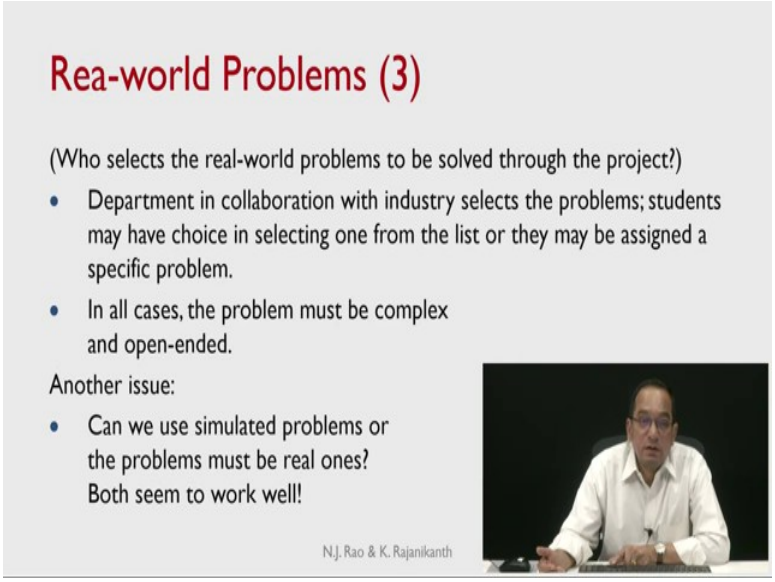

It is also possible in some cases that the department in collaboration with industry selects the problems. This is particularly possible if there is an existing MOU with an industry or more industries, where by the departments and industry collaborate and then there are certain problems which automatically offer themselves as the candidates for the projects. The department in collaboration with industry selects the problems. Students may have a choice in selecting one from the list or they may be assigned a specific problem. In all cases, the problem must be complex and open-ended.

Yet another possibility is that the department has an engagement with the community around which the institute is located, and as a part of their activities of interaction with the community, as a part of their extension activities, they may come up with problems which need to be solved by the engineering students. So, the possibilities are many. The possible choices for selecting the real-world problems are many.

And there is yet one more choice. Can we use simulated problems or the problems must be real ones? The empirical research actually carried out in several institute seem to indicate, surprisingly, that both approaches work well. As long as the problems are complex enough and open-ended enough, the learning seems to be substantial in both the cases. So, the way the problem is formulated has to be very carefully evaluated by the department and the instructor. The problem must be formulated in a fuzzy way. It must

be complex. It must be open-ended. And then the learning of the students seems to be fairly substantial.

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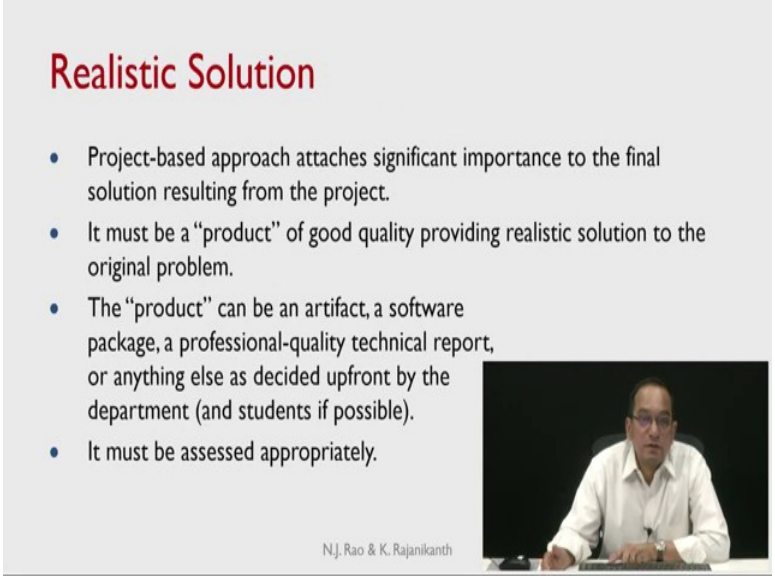

Then, the third feature is that the solution must be realistic. Project-based approach attaches significant importance to the final solution resulting from the project. It must be a product of good quality providing realistic solution to the original problem. The product can be an artifact, a software package, a professional quality technical report or anything else as decided upfront by the department. And if students are allowed to participate in the discussion regarding what should be the final product - that is also great. But this must be of a good quality.

If it is an artifact, the students must be able to demonstrate that - that particular final solution does solve the original problem, validate the product. That is considered as very important feature of the solution that the students must aim at and it must be assessed appropriately.

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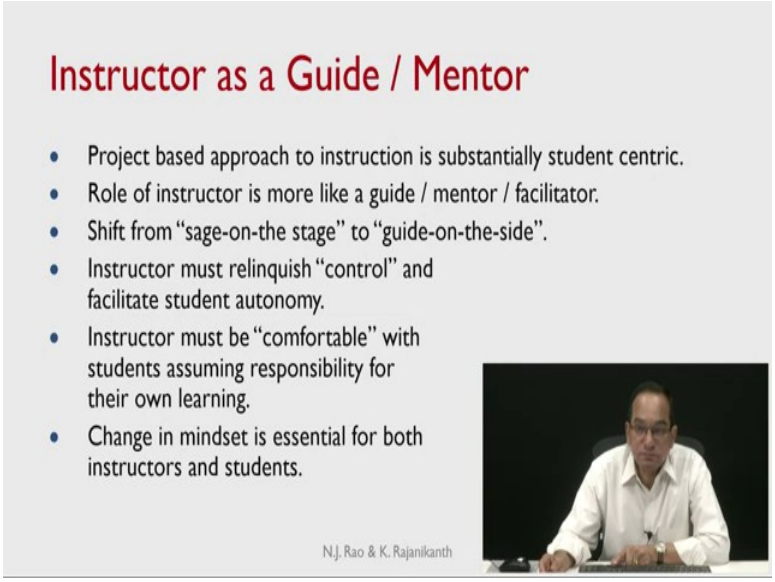

Obviously, the role of the instructor here changes in project-based learning; what is generally called as a 'sage on the stage' to a 'guide on the side'. It is shift from an information provider to a kind of a mentor or a kind of a guide who works along with the student and helps the student. So, project-based approach to instruction is substantially student-centric and the role of instructor is more like a guide, mentor or facilitator essentially.

Instructor must relinquish control and facilitate student autonomy. To the extent possible, students must be allowed to make their own design decisions. Even if they lead to some errors, the students learn from those errors! So they must be allowed to have considerable freedom in the way they execute the project. Of course, instructor must always be available to ensure that no harm takes place; but other than that, the instructor's role is more like a facilitator.

Instructor must be comfortable with the students assuming responsibility for their own learning, and change in the mindset is essential for both instructors and students. Later, we will see that this is particularly a challenging issue both for faculty as well as students, particularly when the students are in the earlier years - first year or second year or third year. By the time they come to the final year, it looks like most of the students have understood the nature of engineering as a collaborator activity and as an activity at solving the realistic problem; so they are much more comfortable with executing a

project in the final semester or final year. But doing this in earlier years does seem to pose certain challenges.

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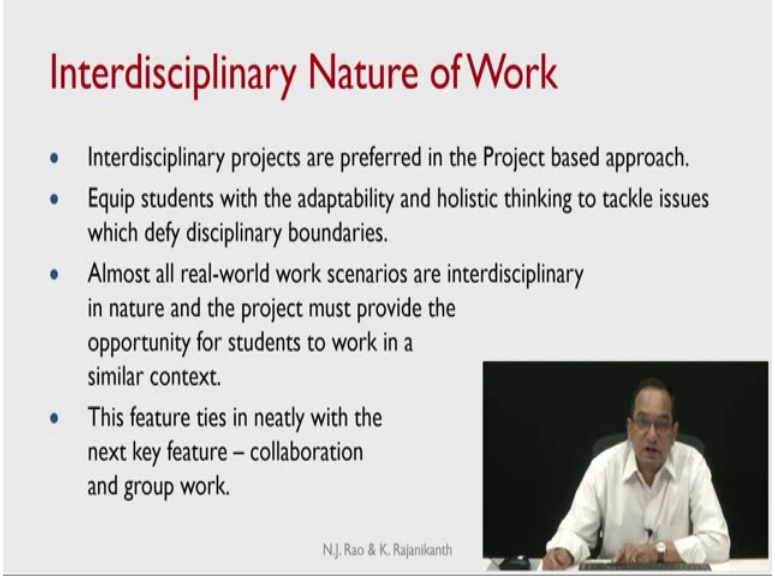

Then, another key feature of this is that the work should be interdisciplinary in nature. Interdisciplinary projects are preferred in the project-based approach. Essentially, any real professional work now-a-days happens to be interdisciplinary in nature and industry demands that students become comfortable with working in groups which are diverse in terms of culture, in terms of specialization, in terms of their personal backgrounds.

So, equip the students with the adaptability and holistic thinking to tackle issues which defy disciplinary boundaries; cross-boundary problems - they must be able to solve and they must feel comfortable with that. It is not that they become experts in the other domains, but they learn how to cooperate, collaborate with experts from different domains working towards a common solution to the problem at hand. So, almost all real-world work scenarios are interdisciplinary in nature and the project must provide the opportunity for students to work in a similar context.

In an engineering institute, this implies that there must be a considerable collaboration between different departments. And this would require certain level of administrative intervention because most often, in most of the institutes, most of the departments function in isolated silos, whereas providing interdisciplinary nature of work to the students would require collaboration on a much higher level between departments. (This

issue - again we will look into later.) This feature ties in neatly with next key feature which is collaboration and group work.

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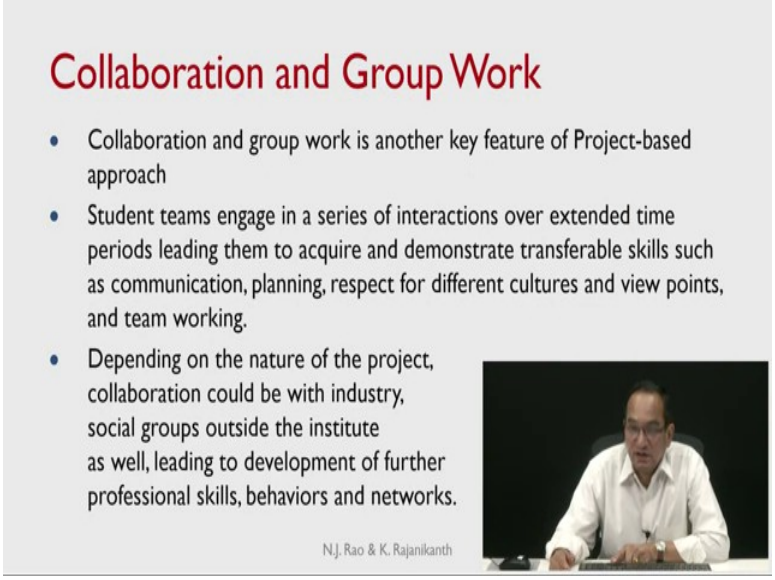

This is the last key feature of the project-based approach to instruction. Collaboration and group work is very essential. Student teams engage in a series of interaction over extended time periods leading them to acquire and demonstrate transferable skills such as communication, planning, respect for different cultures and viewpoints and team working.

This is considered as an extremely important competence that engineering students must acquire and demonstrate if they are to be valued as professionals. Industry expects the students to come with these kind of transferable skills, and the project-based approach to learning provides an extremely good opportunity for students to acquire and demonstrate these transferable skills.

Depending upon the nature of the project, collaboration could also be with industry. If the department has picked up a problem in collaboration with the industry, the students may also be allowed interact with the industry. Or, it may be even with social groups outside the institute as a part of their reach to the community. If the project is related to the community, the students teams may be interacting with social groups outside the institute as well. All these kinds of interactions lead to the development of further

professional skills, behaviors and networks. So, this is a great benefit from widespread use of project-based approach.

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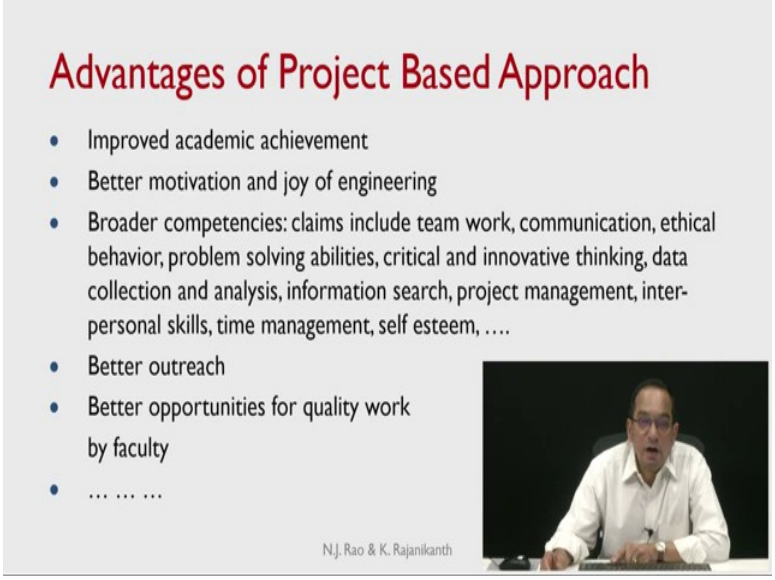

The advantages are plenty; only some typical ones we are listing here. Improved academic achievement, in fact, when the students learn under this approach they seem to be performing better in the assessments which are based on the traditional models of instruction. That means, even if the assessment is based on the traditional model, the students seem to be doing extremely well. So, improved academic achievement and obviously, better motivation and joy of engineering which the students experience.

Broader competencies: Claims (there is a empirical data to support these claims) include teamwork, communication, ethical behavior, problem solving abilities, critical and innovative thinking, data collection and analysis ability, information search capabilities, project management skills, interpersonal skills, time management, self esteem - the list seems fairly long and many of these are related to some of the program outcomes stated by the National Board of Accreditation also.

Better outreach for the department also, both with respect to the industry as well as the community in which the department is existing. Better opportunities for quality work by faculty also, because faculty can include projects which are relevant to their own research work which is related to the industry problems and this can lead to better

opportunities for quality work by faculty also. So, it can be a win-win, both faculty and students can benefit from this approach.

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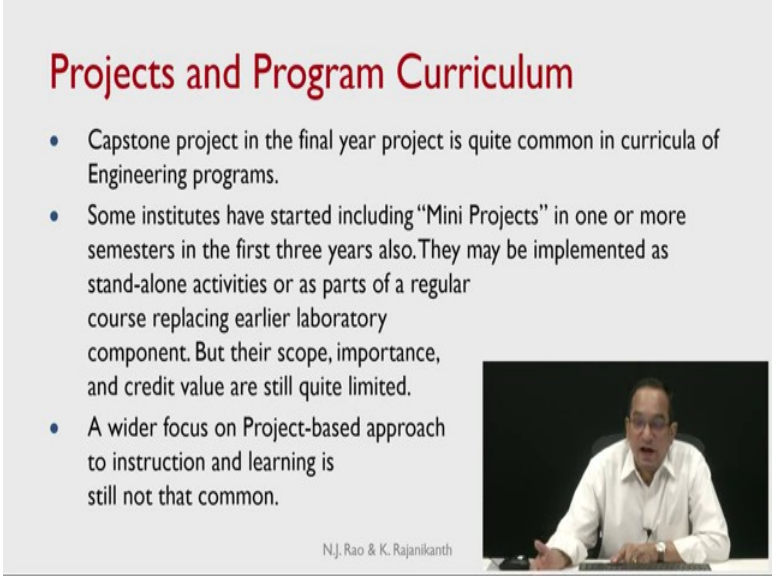

The key issue of where do the projects come in the program curriculum is something which needs to be resolved. A final year project alone (that is quite common in the curriculum of engineering programs) does not make the program as project-based program. Some institutes have started including mini projects of, let us say two credits or one credit, very rarely three credits, in one or more semesters in the first 3 years also. Some institutes have introduced this even in first year, the very first semester also.

A limited form of project activity with one or two credits - they may be implemented as standalone activities, a course by itself with one or two credit value or as parts of a regular course replacing the earlier laboratory component. There are certain courses for which there is an attached laboratory. Now some institutes, instead of making the laboratory work as a part of the practice by the students, are asking the students to do a project related to that course work. In some courses the traditional laboratory work is getting replaced by a mini project related to that course content; even that implementation approach is being tried in several institutes.

But still the scope, importance, the credit value seem to be fairly limited. A wider focus on project-based approach to instruction and learning is still not that common in engineering institutes in India; that means, a much more significant role for project-based

approach still is not very common. But it is a healthy sign that more and more institutes are turning to project-based approach in greater and greater focus over the last decade particularly, and that needs to be made more extensive if the engineering students need to derive the complete benefit from project-based approach.

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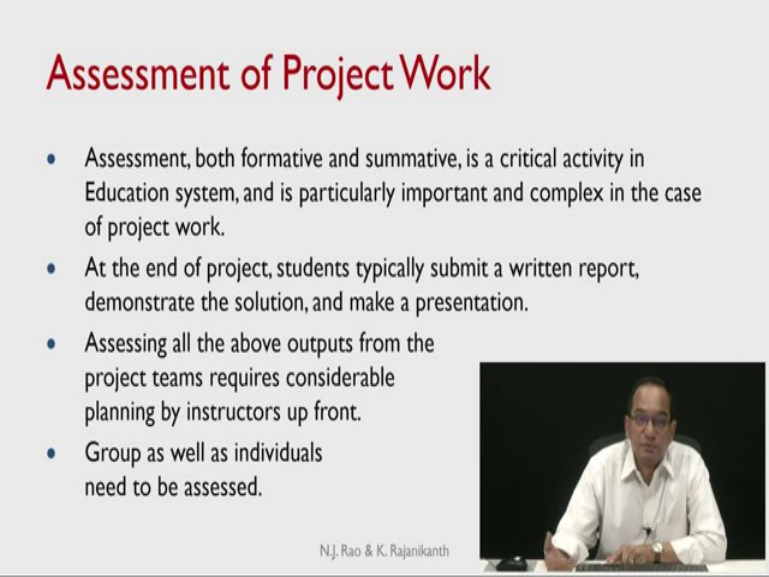

The assessment of project work is also very essential and crucial and difficult also. Assessment, both formative and summative, is a critical activity in education system, and is particularly important and complex in the case of project work. At the end of project, students typically submit a written report, demonstrate the solution (a product or a software system), and also make a presentation.

All these three components need to be properly assessed and evaluated and this requires considerable planning by instructors upfront. We have to develop suitable rubrics. In one of the earlier units we discussed rubrics for assessing the project work. We need to do that and we must share those rubrics upfront with students. We also need to assess group as well as individual contributions.

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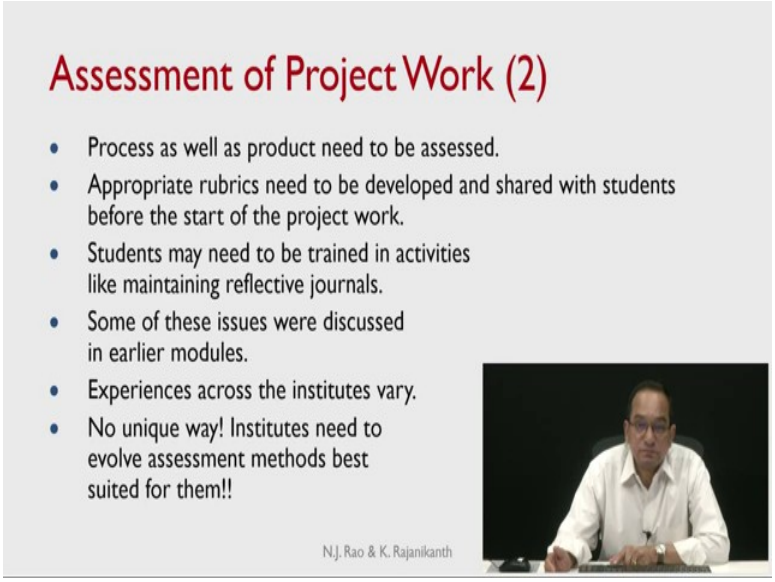

We also need to assess the quality of the final solution produced as well as the process followed by the student teams. We need to assess both aspects. The rubrics (as I mentioned) must be developed and shared upfront with the students. Students may need to be trained in certain activities like maintaining reflective journals to get a kind of understanding of what is the process through which the students are going while learning from the project-based approach. Merely doing a project is not adequate! Students must develop the capacity to reflect on their work and draw appropriate lessons from that work.

A reflective journal helps in this process greatly. Not all students may be familiar with maintaining reflective journals. So we may have to provide some kind of instruction to the students on how to maintain these reflective journals which are very helpful for the students also to learn how to draw correct lessons from their experience. Some of these issues were discussed in earlier modules also, as I mentioned. Experience across the institutes seems to be varying dramatically in this particular project-based approach. There does not seem to be any unique way. Institutes need to evolve assessment methods best suited for them.

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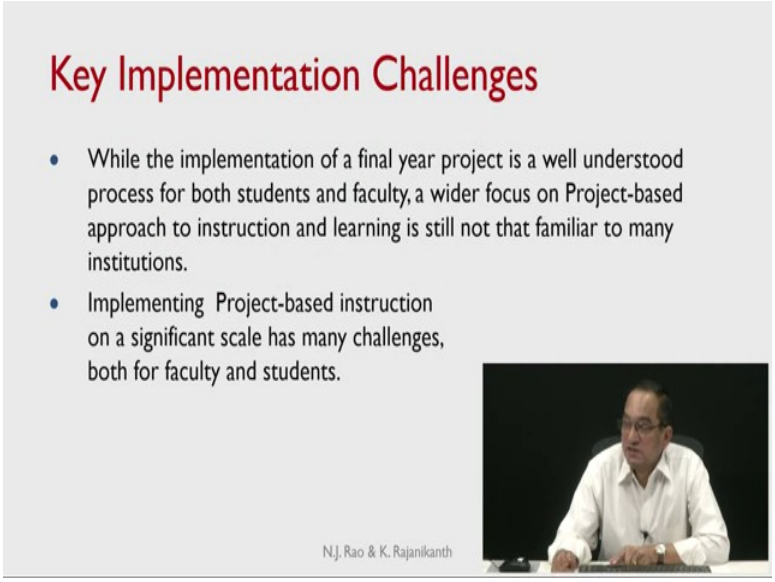

Key implementation challenges: While the implementation of the final year project is a very well understood process both for students and faculty; for the department and institute (The entire administrative mechanism needed to implement a final year project successfully (most of the time) is in place. This is quite familiar.), a wider focus on project-based approach to instruction and learning is still not that familiar to many institutions.

Implementing project-based instruction on a significant scale has many challenges both for faculty and students. (When I say faculty it also means that departments, the institute, and the administrative missionary broadly.)

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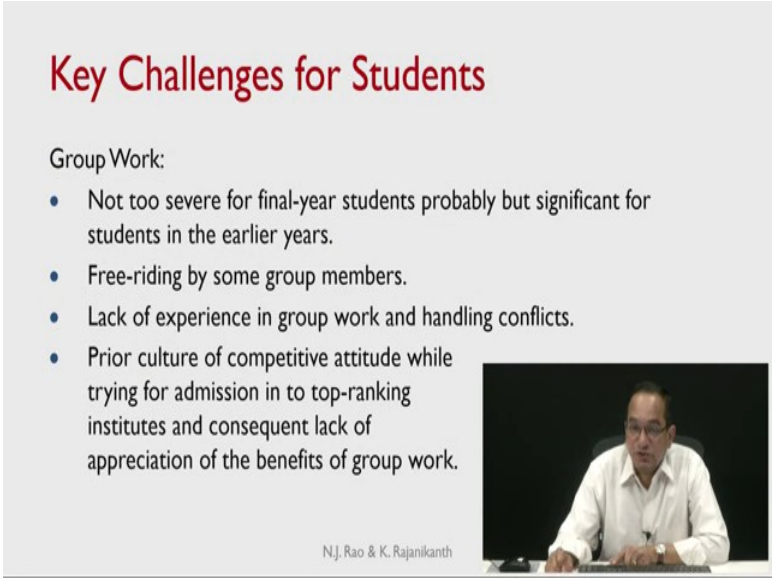

Key challenges for the students: (some of the key challenges) Group Work - This group work may not be very difficult for final year students because already they have been through 3 years of the program; they have participated in a variety of co-curricular/extracurricular activities; departmental activities; and they already have acquired certain of the skills required to become successful engineering professionals. So, they have begun to appreciate the importance of group work, collaborative work and any small gaps can easily be overcome through proper mentoring by the instructors. It may not be very severe or difficult for final year students to appreciate group work.

But it may be significantly different for students in the earlier years, particularly first year and second year. Probably by the time they come to third year, a transition begins to take place. Of course, there are some problems which exist even with final year - free-riding by some group members has always been a complaint. When a group size is something like 4 or 5, occasionally it is possible that some of the group members really do not contribute to the effort but they want a share in the credit; and this essentially leads to certain tensions and conflicts which need to be resolved.

Lack of experience in group work and handling conflicts is also an important issue. The prior culture of competitive attitude particularly at plus two level; most of the students are accustomed to working in a highly competitive mode - that is because they are trying to get admission into top ranking institutes. They essentially live their life in a

competitive mode throughout that 12th standard/plus two phase, and then immediately coming into the first year of engineering - it may be very difficult for them to see the benefits of group work. It may be very difficult for them. It may take some time for them to come out of the intense competitive mode to see that engineering is a group work. Instructors have to really device strategies to overcome these challenges if they notice them in their students.

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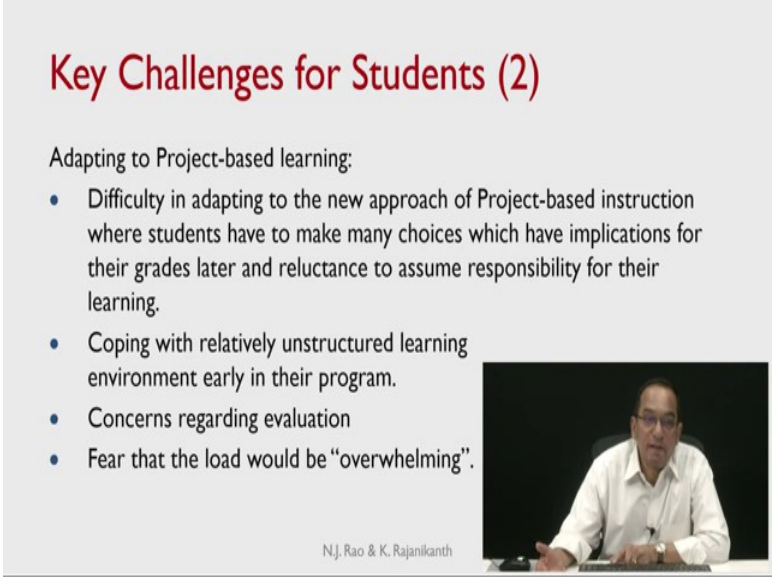

Adapting to project-based learning: Difficulty in adapting to the new approach of project-based instruction - for student this difficulty can be very real. In this approach, students have to make many choices which have implications for their grades later and many of them may be very reluctant to assume responsibility for their learning. Particularly because, until then, probably they are accustomed to a learning scenario in which everything is fed to them by the teacher, and they play a very passive role. They have not assumed really any responsibility for their own learning. They have not made choices. So it may be very difficult to suddenly assume such a more mature role and they may prefer a traditional instructional mode where the teacher is essentially a provider of information and the student is essentially a receiver, a passive receiver. Some of the students may actually like that mode and they may insist that that is how a course should be taught. So, the instructors will have a challenge in motivating the students properly.

Coping with this relatively unstructured learning environment early in the program: Again, as I said, with final year it may not be that challenging because of the history behind it. But if this is to be introduced in earlier years, third year, second year or first year, it may be really a challenge - coping with relatively unstructured learning environment early in the program; may be a challenge for the students.

Concerns regarding evaluation also may be there because there are lots of things which are little bit rubrics based, subjective evaluations. Students may be concerned about it and tfear that the load will be overwhelming compared to traditional courses. Students may have that fear.

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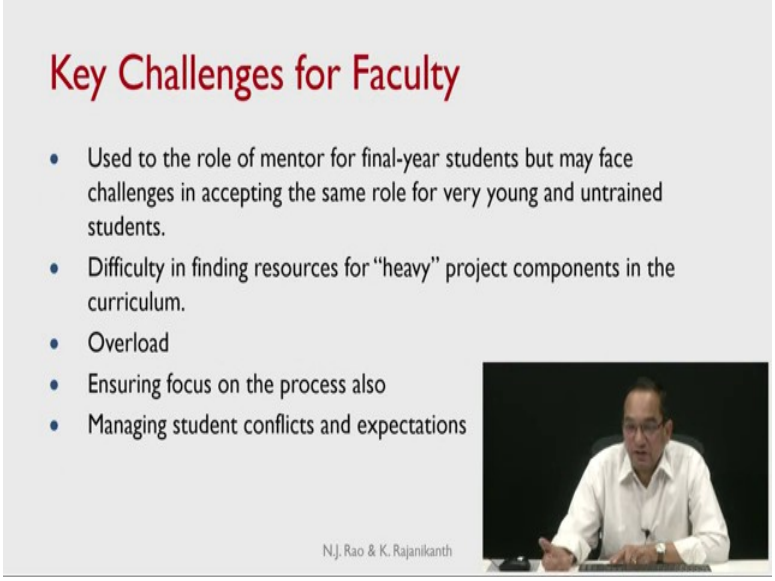

There are key challenges for faculty also. They are used to the role of mentor for final year students; that is quite common in India at least. So, faculties are accustomed to the role of a mentor for the students in the final year. But they may face challenges in accepting the same role for very young and untrained students in first year or second year; in particular where the students come from a different kind of a mindset, different kind of a learning mode. And faculty also may face challenge in mentoring those students.

Difficulty in finding resources for heavy project components in the curriculum: If it is just one final year project it is a different story; but if every year/every semester project needs to be introduced and there are multiple project teams, finding the resources both in

terms of the actual physical resources - the hardware components, software packages, the other essential components - as well as appropriate connections to the industry, appropriate problem sets - all kinds of resources; funding them may become very challenging for the faculty. Faculty themselves may find this as an overload because the assessment is considerably more difficult. We need to develop rubrics and we need to evaluate each project team, contribution of individual students and this may be seen as quite heavy overload by many of the faculty.

The faculty must also ensure that the process is implemented properly - the student teams go through the correct process and learn from that process. For project-based instruction to succeed, it is not enough if finally a project produces a product. The process through which the students go through must also enable them to learn from the project experience and for this instructors may have to play a stronger role as a mentor. This also may look challenging to the faculty. Of course, the human problem is always existing; managing student conflicts and expectations can be a challenge for the faculty.

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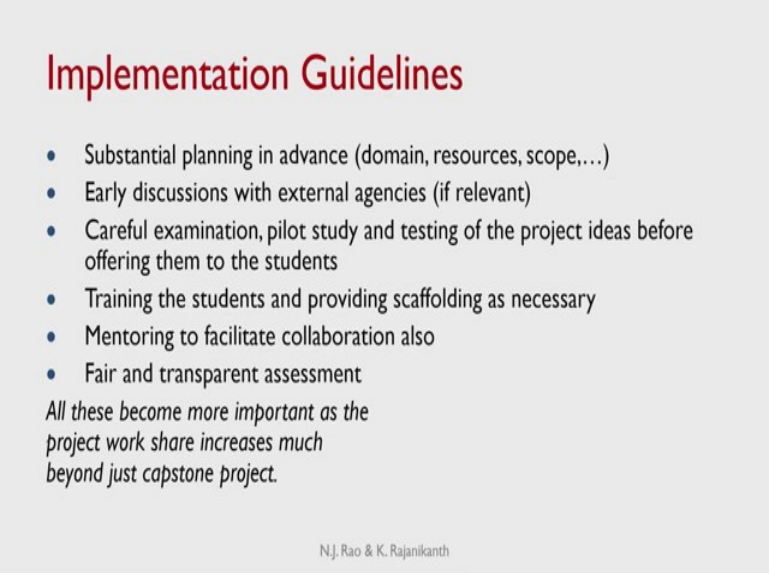

Some of the implementation guidelines in the context of this: At the outset it is very difficult to come out with a kind of a recipe, kind of panacea for all the problems in implementing the project-based approach to instruction. But based on different case studies (The reference to some of these case studies - we will look at the end of this unit; dealing with different approaches.); based on these experiences, some of the guidelines

can be that, (the first thing is that) it requires substantial planning in advance. Much before the commencement of the semester, we need to plan, we need to decide on the domain in which the student teams are going to work, what will be the resources required, what will be the time frame required to procure those resources in case they are not immediately available, what are the budget implications and what will be the scope of the project to be implemented by different teams. Regarding all these we need to do substantial planning well in advance.

If external agencies are to be involved - an industry or a community, then the discussions with external agencies must happen again well in advance. If the student teams are working on a project that is relevant to the community, then proper engagement with the community leaders must happen well in advance. Careful examination, some pilot study and testing of the project ideas may be necessary before offering them to the students. Particularly, if we are looking at very radical ideas, it may be really very difficult to implement that as the project. And without understanding the risk involved, if we offer it to the students, the students may find it very frustrating.

We are not saying that it should be something which can be solved very easily. But at the same time, something which is going to lead to a frustration will be counterproductive. So, the balance between the challenging nature of the project and ease of the implementation must be a very fine balance. And for faculty to judge this - a lot of planning upfront with respect to examining the idea, may be sometimes even a pilot study and some kind of a preliminary test - they all maybe essential. This becomes more challenging because now we are talking of a large scale implementation of project-based idea. It is not just the final year; earlier semesters also, we need to introduce projects. So, this kind of upfront planning is very essential.

Training the students (as we mentioned), particularly in first year and second year, may be essential to make them understand how to search for resources and how to work in a team - this training maybe necessary, some kind of a scaffolding may be necessary. This will include providing certain trial experiences and learning materials to the students and this scaffolding must be planned again very carefully. Mentoring to facilitate collaboration also would be required; fair and transparent assessment is absolutely essential.

All these become more important as the project work share increases much beyond just the final year project.

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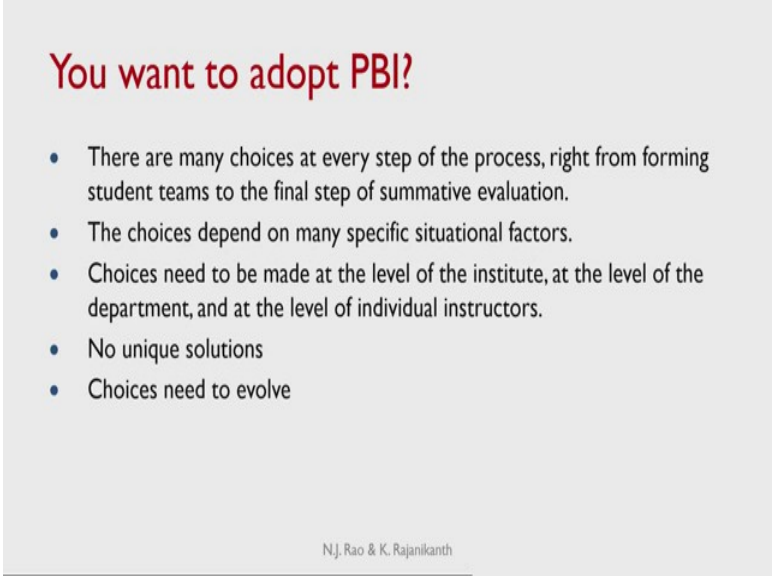

With all these, you want to adopt PBI? Then what? As a faculty what would be the issues that you want to really look at? The challenges? You want to adopt PBI? There are many choices at every step of the process, right from forming student teams to the final step of summative evaluation. These choices depend on many specific situational factors. There cannot be any generalization. Though there are certain general concerns that can be explained, there are many other situational factors.

Choices need to be made at the level of the institute/department/ individual instructors. For these choices, there is no unique algorithmic solution approach. They all need discretion; they all need collective brainstorming; they all may need even a trial and error phase; they may need the scenarios where the choices evolve over a period of time. In fact, most of the practical experiences seem to indicate that choices need to evolve for each institute based on its own unique position.

Essentially you need to be prepared for a little bit rough ride at least in the initial stages of implementing project-based approach to instruction. It will take some time for the process to stabilize - initial days, the ride can be pretty rough and the institute/department/faculty must be prepared for it, if the project-based ideas have to be implemented on a much wider scale.

Final year project - there is not really much of a concern; but on a much wider scale if these ideas need to be implemented, we need considerably more resources.

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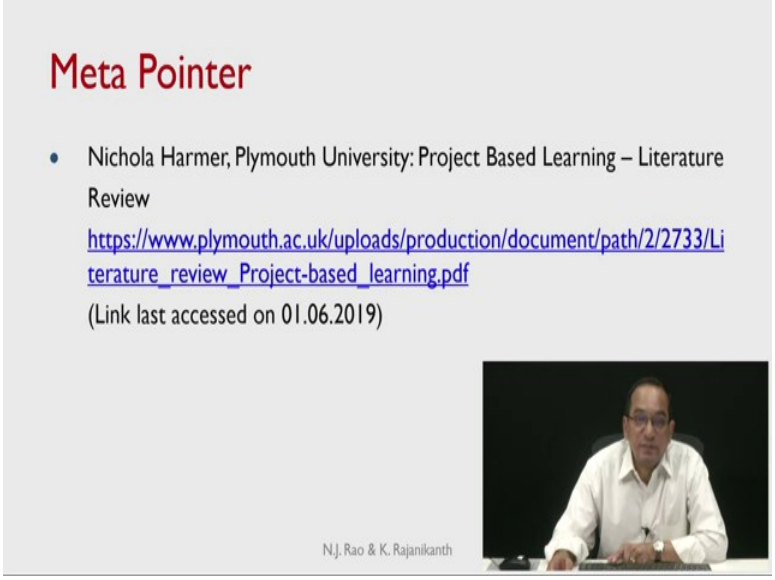

Extremely good meta pointer is Nichola Harmer, Plymouth University: Project Based Learning – Literature Review (https://www.plymouth.ac.uk/uploads/production/document/path/2/2733/Literature_review_Project-based_learning.pdf) The link was last accessed on 01.06.2019. You can examine these for some of the ideas.

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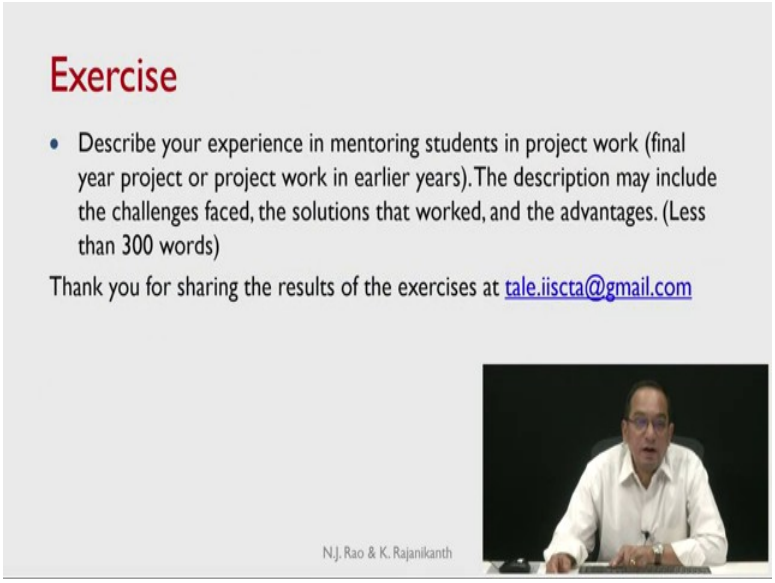

Exercise: Please describe your experience in mentoring students in the project work. Most of you must be having experience in mentoring the final year project. But if some of you have already implemented some mini projects in the earlier years, and if you do have an experience in mentoring project work in earlier years that would be actually more welcome. If you have a choice between final year project and earlier project, we request you to consider earlier project.

Your experience in mentoring students: Please describe that. The description may include the challenges faced, the solutions that worked, the advantages, your own unique situational factors - please describe. If it can be in less than 300 words, great; but please do not take that as an absolute limit. If you wish to share your experience in greater detail, explaining the situational factors, you are welcome to exceed 300 words also. That way we can share this collective experience because there is something that is seen as very important and we need to collectively learn from this - the project-based approach on a wider scale. The present century seems to demand such novel approaches to student learning.

Thank you for sharing the results of the exercise at tale.iiscta@gmail.com

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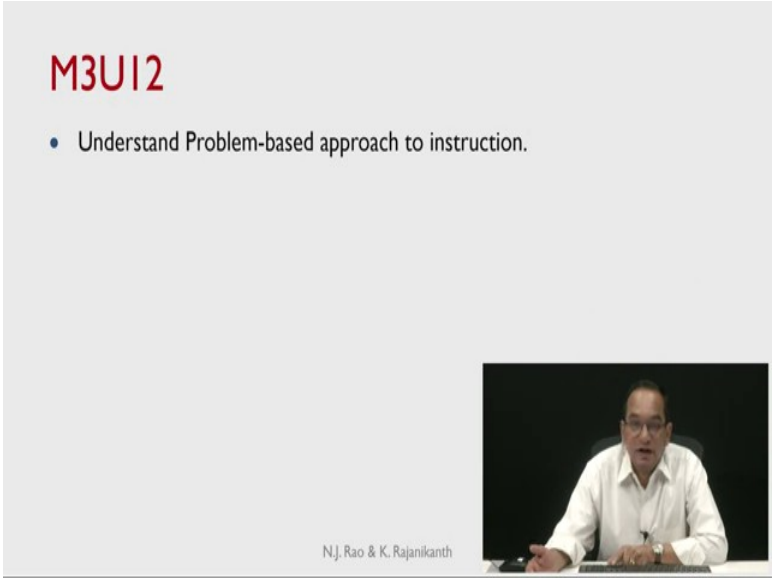

In the next unit, we will look at another important approach to the instruction which is problem based one. Though the prevalence of problem based approach in engineering education seems to be somewhat less compared to project-based approach - still that approach is also very important and it is gaining in its adoption in engineering programs. So, we look at the problem based approach to instruction in the next unit. Until then, we will wait; hoping to meet you again.

Thank you.