**TALE-2 Course Design and Instruction of Engineering Courses**

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**Lecture – 30**
**Problem Based Approach to Instruction**

Greetings. Welcome to Module 3 Unit 12 - Problem Based Approach to instruction.

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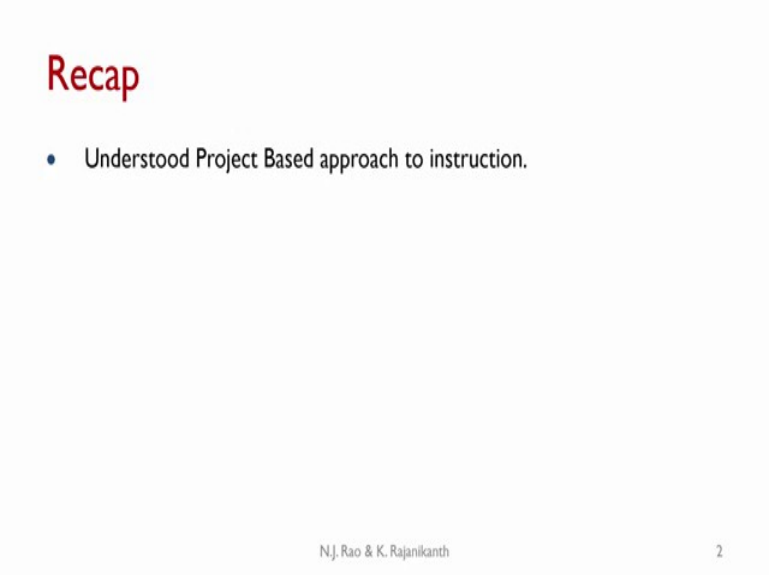


In the earlier module, we understood project based approach to instruction, an approach that results in or an approach that facilitates project based learning by students.

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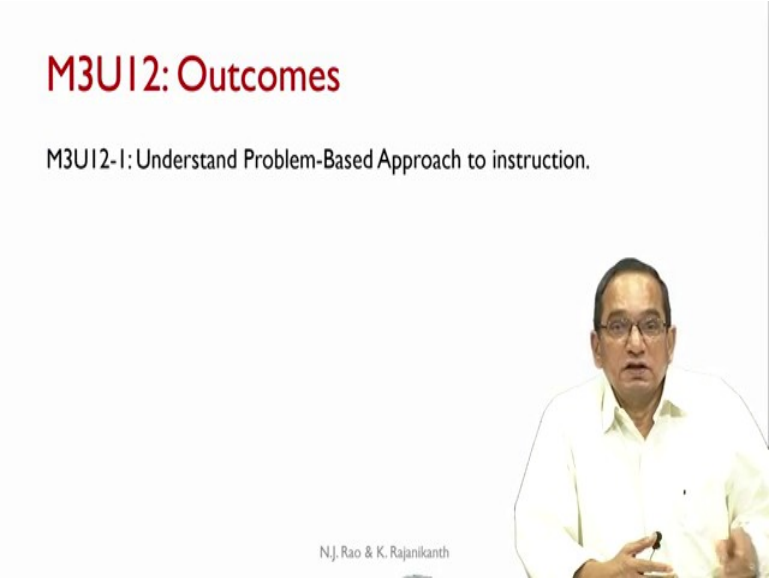


In this unit, we will understand problem based approach to instruction, another popular approach in engineering education.

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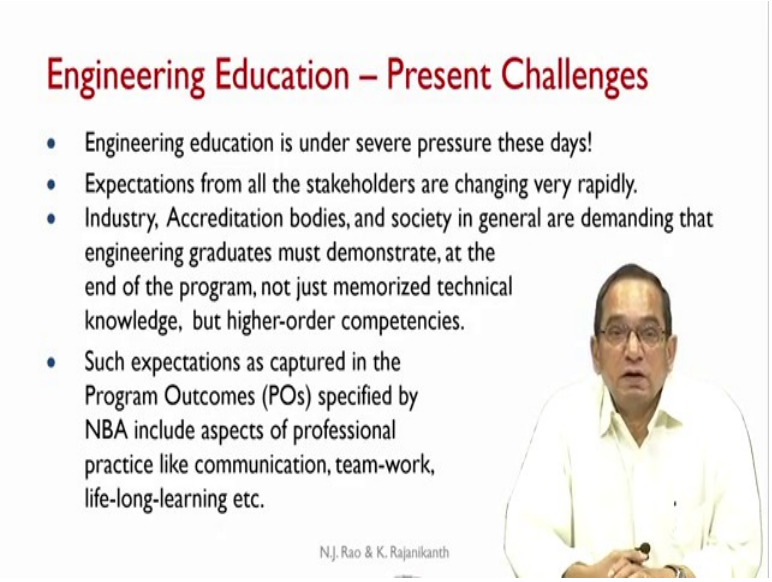


If you look at the background for the emergence of these approaches - project based approach, problem based approach, experience approach - we see that the context is that the engineering education is under severe pressure these days. The expectations from all the stakeholders are changing very rapidly.

Industry, accreditation bodies and society in general are demanding that engineering graduates must demonstrate, at the end of the program, not just memorized technical knowledge, but higher order competencies. These expectations are becoming more and more strident from all the stakeholders. These expectations as captured in the program outcomes specified by the National Board of Accreditation include aspects of professional practice like communication, teamwork, lifelong learning etc.

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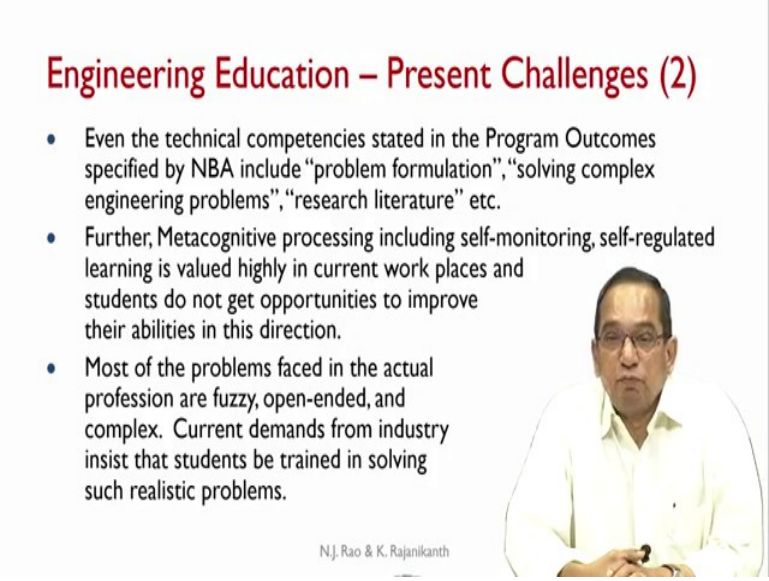


All these outcomes also are becoming very significant. Even if you look at it only from the technical competency aspect, even there, the program outcomes specified by NBA include problem formulation, solving complex engineering problems, research literature etc. In addition, Metacognitive processing including self monitoring, self regulated learning is valued highly in current workplaces and students do not get opportunities to improve their abilities in this direction.

Most of the problems faced in the actual profession are fuzzy, open ended and complex. Current demand from industry insist that students be trained in solving such realistic problems and solving such realistic problems would include the skill to formulate the problem in engineering terms where the problem is fuzzy.

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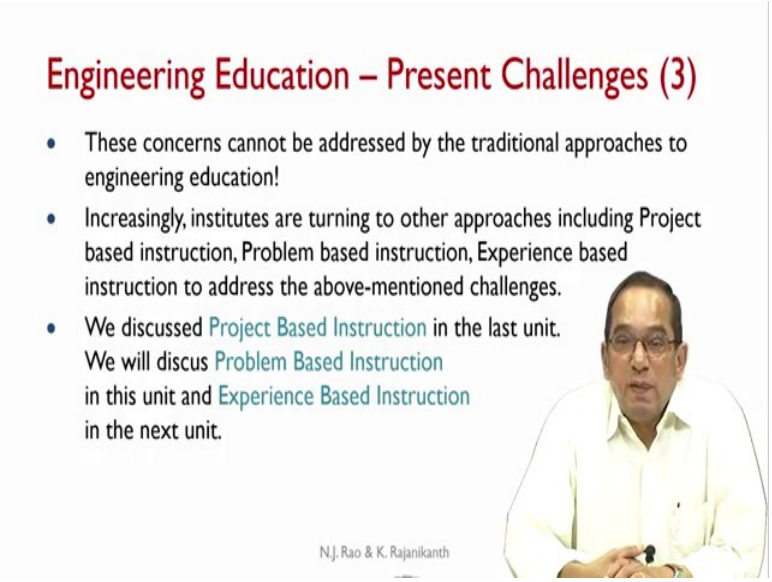


These concerns cannot be addressed by the traditional approaches to engineering education. Increasingly, institutes are turning to other approaches including project based instruction, problem based instruction, and experience based instruction to address the above mentioned challenges. We discussed project based instruction in the last unit and we will look at problem based instruction in this unit; and experience based instruction - we will look at it in the next unit.

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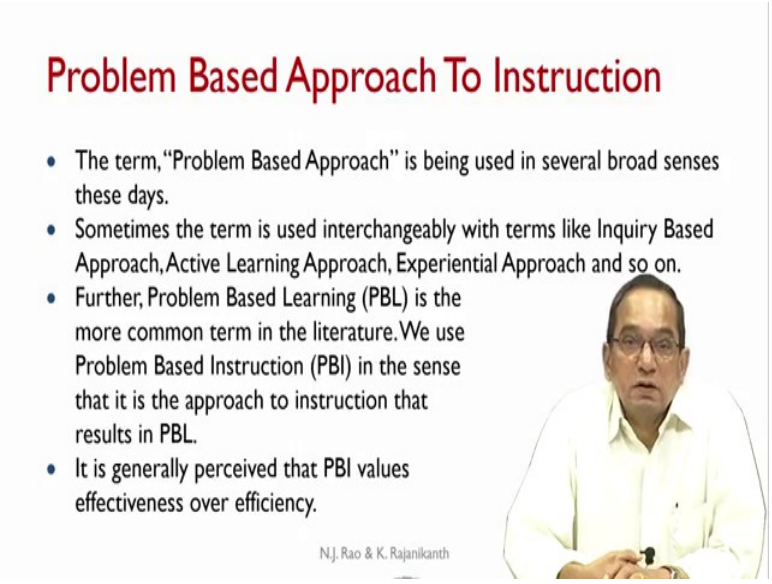

The term ‘problem based approach’ is being used in several broad senses these days. In fact, with project based approach also we saw a similar situation - several different implementations get the same name. Here also several different approaches, several different specific implementations, are tagged as problem based approach. Sometimes the term is used interchangeably with terms like enquiry based approach, active learning approach, experiential approach and so on.

Further, problem based learning is the most common term in the literature. We use problem based instruction in the sense that it is the approach to instruction that results in problem based learning by the students. This is the same idea that we used with project based instruction also i.e., an approach to instruction which facilities or results in project based learning by the students. And in PBI, we mean an approach to instruction that facilitates or results in problem based learning by students.

It is generally perceived that PBL - Problem Based Learning as well as PBI - Problem Based approach to Instruction, value effectiveness over efficiency. We will see that the PBI is somewhat inefficient to implement in the engineering contexts in India. In fact, even across several institutes around the world, they find that PBI implementation may not be that efficient, but the focus here is on effectiveness. They hope that the PBI would lead to better learning by the students.

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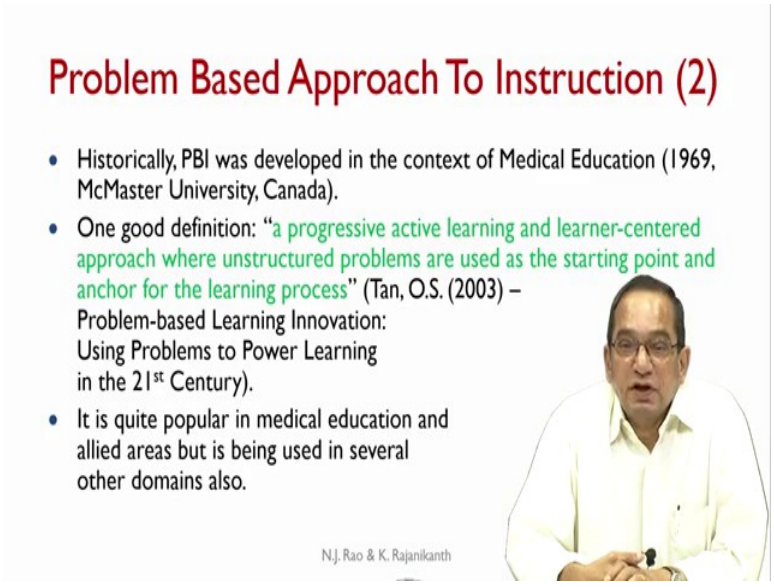

Historically, PBI was developed in the context of medical education. Way back in 1969 at McMaster University Canada and in initial days the adoption of PBI was more in the areas related to medical profession like nursing etc. There are several definitions for problem based approach to instruction, but one good current definition is that "a progressive active learning and learner centered approach where unstructured problems are used as the starting point and anchor for the learning process."

One of the keywords is that, we start with unstructured problems. And it is learner centered and it is also active learning. "Problem based learning innovation: Using problems to power learning in the 21st century" - that is the article where this particular reference is given. There are other equally valid definitions. But in all these, the emphasis would be on active learning, learner centered approach and most importantly unstructured problem with which the investigations begin.

(As I mentioned) it is quite popular in medical education and allied areas and it has been used quite extensively in those areas. But it is being used/tried in several other domains also including engineering, arts, humanity, business management, law; in several other programs.

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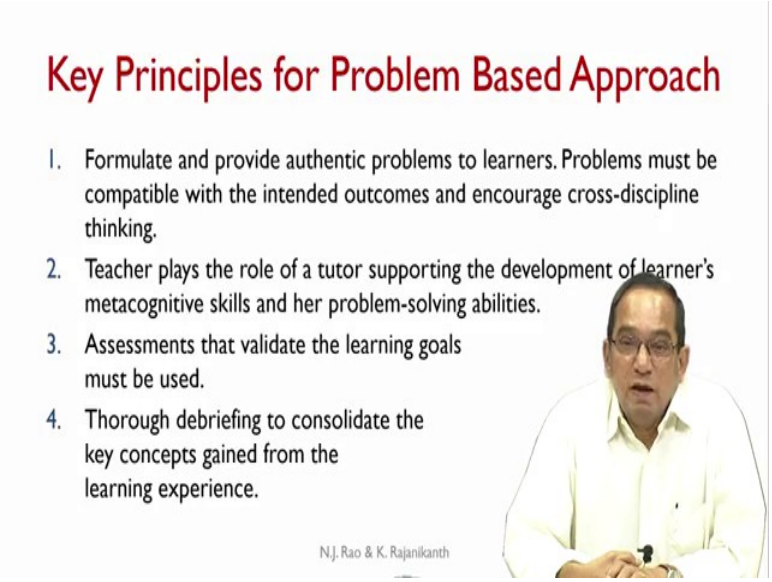


Key principles for problem based approach: Whatever be the specific domain in which we were trying to implement the problem based approach, whether it is medical or business administration, business management or engineering, these are very broad

universal key principles for problem based approach. Depending upon specific situation there could be certain variations; we will have a look at some of these variations in the later part.

But the universal key principles for problem based approach are these: Formulate and provide authentic problems to learners. The keyword here is 'authentic problems' and problems must be compatible with the intended outcomes and encourage cross discipline thinking. Instead of being confined to narrow silos they must encourage cross discipline thinking. The second key principle is 'teacher plays the role of a tutor supporting the development of learner's metacognitive skills and her problem solving abilities.'(We will elaborate on all these principles shortly.)

The third principle is that assessments that validate the learning goals must be used and the fourth principle is thorough debriefing to consolidate the key concepts gained from the learning experience.

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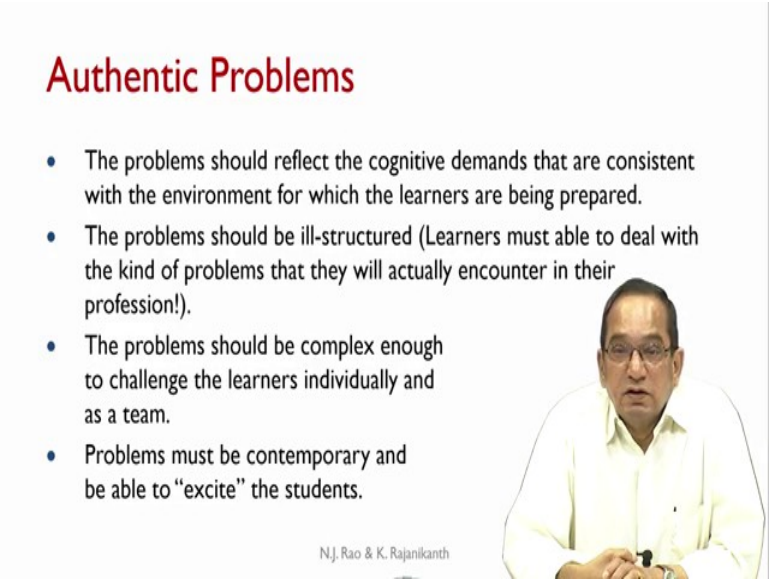


Authentic problems: The problems should reflect the cognitive demands that are consistent with the environment for which the learners are being prepared. In other words the problems should look very similar to the kind of problems that we expect the learners to face when they actually enter their profession.

This is not to say that the problem should be identical, but the cognitive nature should be quite similar. That is why we call them as authentic problems. The problems, their cognitive nature is quite similar to the cognitive nature of the actual problems that these people will face, when they enter their profession. The problem should be ill structured. Learners must be able to deal with the kind of problems that they will actually encounter in their profession and we know that in real life almost all the problems are ill instructed to begin with. Learners must be trained to deal with ill structured problems.

The problem should be complex enough to challenge the learners individually and as a team. At the same time, if the problems become so difficult that learners lose their motivation, then it will become counterproductive. (We will discuss that aspect also.) But it is important that the problem should be complex enough to challenge the learners. Problems must be contemporary and be able to excite the students. That is another important feature of the PBI.

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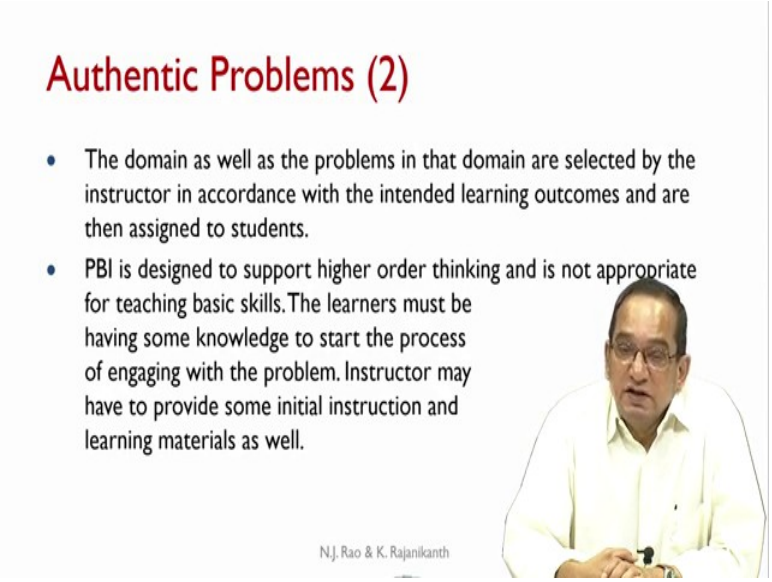


The domain as well as the problems in the domain are selected by the instructor in accordance with the intended learning outcomes and are then typically assigned to the students. That means, at the level of choosing the problems, the control rests with the instructor. The domains as well as the problems in the domain are selected by the instructor. PBI is designed to support higher order thinking and is not appropriate for teaching very basic skills; which means that, before the students start with problems

demanding higher order abilities, the basic skills that are required must have been taught earlier, if necessary using more direct approach to instruction.

PBI is designed to support higher order thinking. The learners must be having some knowledge to start the process of engaging with the problem. Instructor may have to provide some initial instruction using other approaches including direct approach to instruction and the teacher has to provide the learning materials as well to kick start the process.

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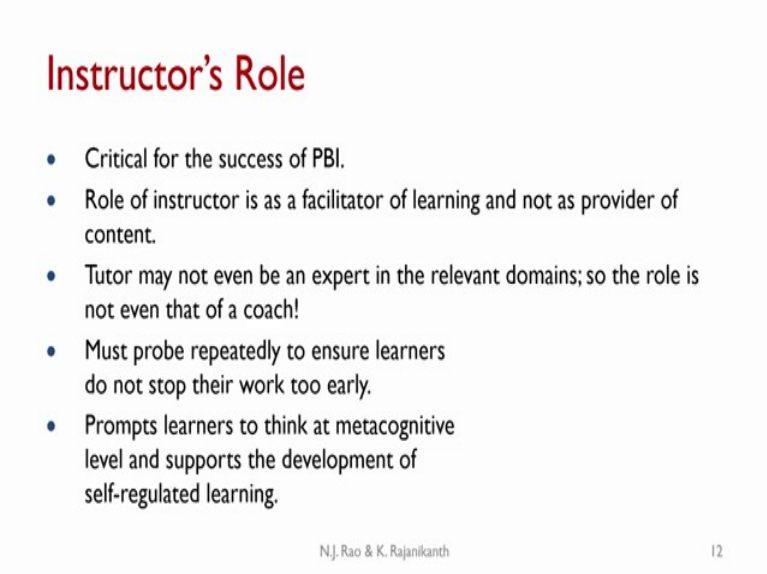


Instructor's role is very critical for the success of PBI as with project based instruction also. Role of instructor is as a facilitator of learning and not as provider of content. In fact, in the PBI, the general philosophy is that tutor may not even be an expert in the relevant domain! But teacher should facilitate the activities of the students. So, the tutor may not be even an expert in the domain; the role is not even that of a coach; it is primarily the role of more of a tutor.

(Tutor) Must probe repeatedly to ensure learners do not stop their work too early; question the conclusions reached by the students; the assumptions made, being made by the learners; the references being used by the learners. All these must be questioned by the tutor repeatedly, again and again. Is this assumption correct/ valid? Can this conclusion be supported by the evidence that you have gathered? These kinds of probes

will ensure that the students engage with the problem using deep skills rather than shallow arguments.

(Tutor) Prompts learners to think at metacognitive level and supports the development of self-regulated learning. These are also the skills which get promoted with PBI. Learners must be able to monitor their own progress, regulate their own learning activities and must be able to analyze, criticize their own assumptions.

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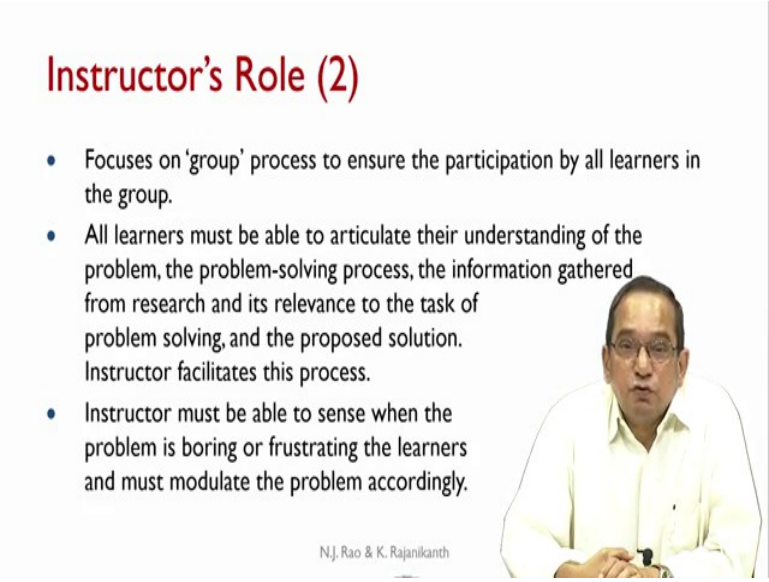


Instructor must also focus on the process of group itself. There are several activities which are done as a group, but the concept of a group itself maybe not that comfortable for the learners. The idea of a group that must be facilitated by the instructor focuses on the group process to ensure participation by all learners in that group.

All learners must be able to articulate their understanding of the problem, the problem solving process, the information gathered from research and its relevance to the task of problem solving and the proposed solution. The important point is that all the learners in the group must acquire these skills, because these are all part of the skills that the learners are supposed to acquire through the PBI.

The articulation of the understanding: The relevance of the information gathered, the process by which information gathered - all these things must be articulated by every member of the group. It is not like there is a spokesman for the group and only that

person expresses all these conclusions. Every participant, every member of the group must articulate these views and instructor must facilitate this process.

Also instructor must be able to sense when the problem is boring or frustrating the learners. If the problem is so complicated, so complex and the required information is really not available that easily to the learners; it is possible that at some stage, the learners get turned off. They become bored or they become frustrated and they start losing the passion required to engage with the problem.

Instructor must be able to sense this mood of the learners and if there is a likelihood that it is going to set in like this, then the instructor must modulate the problem accordingly - may be provide certain parts of the information directly to the learners or slightly tone down the fuzziness of the problem or the complexity of the problem. This is somewhat tricky, but it is required to ensure that PBI becomes successful.

Otherwise the students really might get turned off, lose interest and then the whole process would be a failure. So, instructor must be able to monitor closely and sense when the problem is frustrating the group. This requires very close monitoring of the whole process by the instructor.

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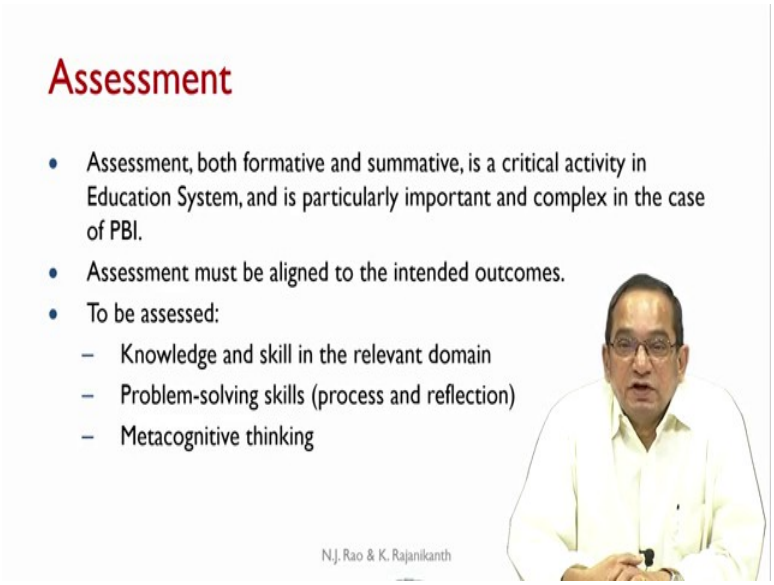


Assessment: we have mentioned any number of times that assessment, both formative and summative, is a critical activity in the education system. But in PBI it is particularly

important and complex. Assessment must be aligned to the intended outcomes and we must assess knowledge and skill in the relevant domain as well as problem solving skills.

The process through which the team is going through; the reflection that individual students engaged in; metacognitive thinking - these are all the aspects which need to be assessed and this is definitely a complex process.

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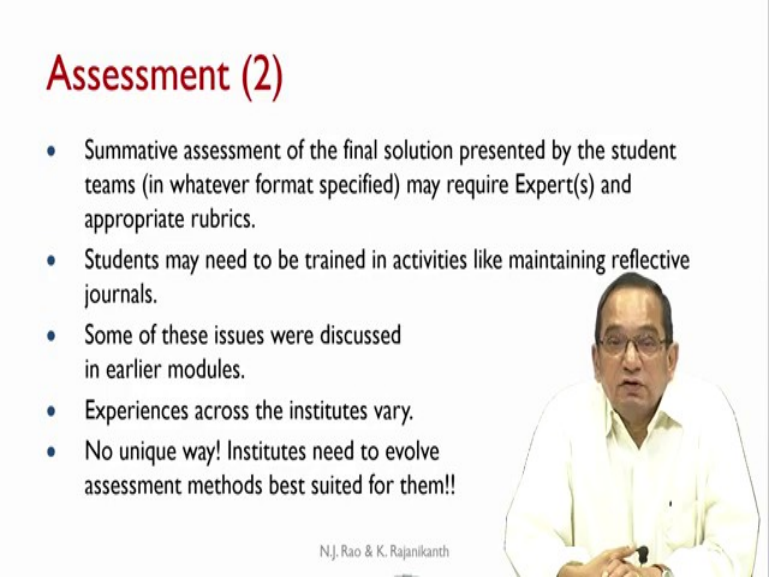


Summative assessment of the final solution presented by the student teams: Because the instructor may not be really a domain expert or because the solution proposed by the student team requires certain expert opinion to judge whether it is a valid solution or not - this may require expert or teams of experts and obviously, we need appropriate rubrics. Sometimes externals may have to be invited to sit in and evaluate the solution proposed by the students.

Students may need to be trained in activities like maintaining reflective journals. The metacognitive processing of the students can be accessed through reflective journals maintained by the students. As they are going through the process of solving the problem, the thinking that individual students are having, the logic that they are employing, the way they are supporting their axioms - all these things, every learner must record in a written journal. And sometimes, the students may not be familiar with the process of maintaining such journals.

Before the teams commence the process of solving the problem, instructors may have to provide some training to them on maintaining reflective journals and some of these issues were discussed in the earlier modules also. Even with project based approach to instruction, we saw that reflective journals maintenance may have to be intimated to the students and sometimes students may have to be trained in the art of maintaining such journals. Experiences across the institutes do vary with respect to these kinds of assessment practices; no unique way. Institutes need to evolve assessment methods best suited for them; what works for them. They have to decide over a period of time.

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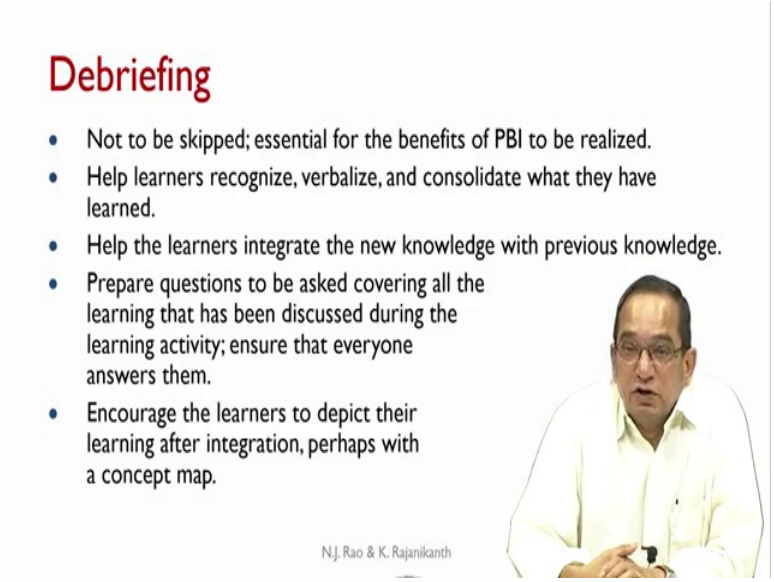


Another very important activity which often is ignored by the faculty who are implementing the PBI for the first time is “debriefing”. Because, most of the times, in engineering education we are not really very familiar with this debriefing process; sometimes it does get ignored if the institutes do not have adequate experience with PBI.

All the practitioners of the PBI approach in their experience and in their reports have stressed on the point that, the debriefing is not to be skipped; it is essential for the benefits of PBI to be realized. The claim is that this helps learners recognize, verbalize and consolidate what they have learned. Helps the learners integrate the new knowledge with the previous knowledge. Here, if we recall, this is also one of the Merrill’s first principles of learning - that the new knowledge acquired must be integrated with the previous knowledge.

For the debriefing purposes, instructors must prepare questions to be asked covering all the learning that has been discussed during the learning activity. Note that while the learning activity is happening, the instructor is in close touch with the teams. Instructor is monitoring actually what is happening, making notes on what is happening. Using these observations and notes, instructors prepare questions to be asked during the debriefing session and they ensure that everyone in the team answer these questions. Encourage the learners to depict their learning after integration perhaps even with the concept map.

The idea is that during the debriefing, we help the students to integrate the new knowledge with the previous knowledge and that is where the gains from PBI get consolidated. So, this is a very important step.

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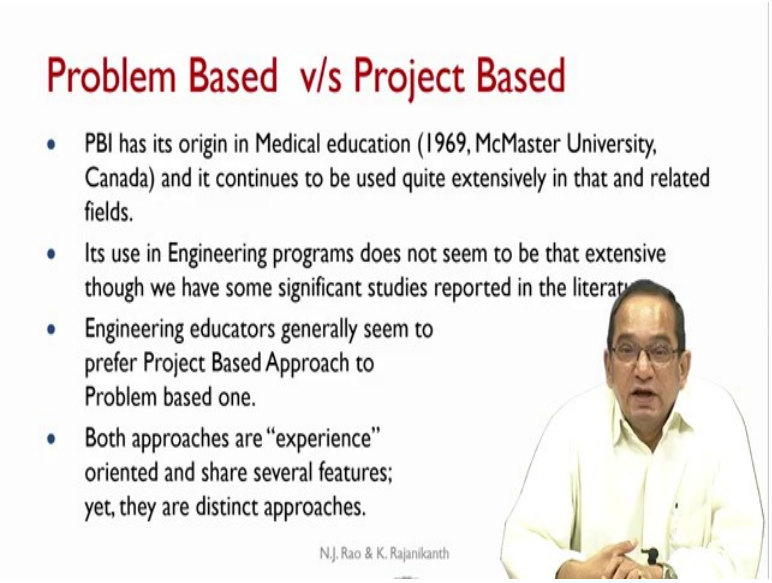


If you look at what we have discussed so for, we see certain number of similarities with the project based approach to instruction which we discussed in the previous unit. It is true that both these approaches share certain common methodologies, but at the same time they are distinct also. There are points on which there is some agreement; there are points where they are substantially different. While in medical education, problem based approach has become very popular, has it become equally popular and successful in engineering education (wherever they have implemented)?

Certain case studies are available in literature where the institutes have implemented problem based approaches as well as project based approaches and these case studies are

available in the literature. If you look at them, we see that PBI has its origin in medical education and it continues to be used quite extensively in that and related fields. Its use in engineering programs does not seem to be that extensive though we do have some significant studies reported in the literature.

But it does not seem to have permeated engineering education to the extent that it has permeated medical education and business administration or business management education. Even in that domain (Business Management), PBI is being used quite extensively. Comparatively in engineering programs, PBI in its true spirit, does not seem to have become that popular. There are certain other approaches which go by the name of PBI, but strictly speaking PBI in its true sense does not seem to have become that popular in engineering programs.

Engineering educators generally seem to prefer project based approach to problem based one. This is not to say that in project based approach the students are not solving the problem, but the focus is slightly different. Both the approaches are experience oriented and hence share several features, but they are distinct approaches.

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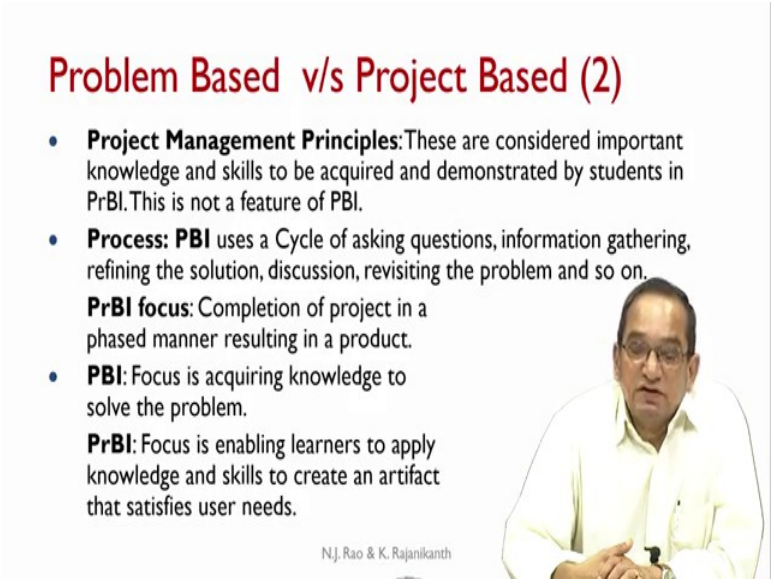


If you look at some of the points in which they differ substantially (but, there are other issues on which they differ, but these are the issues where the differences are substantial) - they do influence the outcomes that result from these approaches.

First, very important one is: “project management principles”. These are considered important knowledge and skills to be acquired and demonstrated by students in project based instruction. Students must understand how to setup the project monitoring systems, how to setup the milestones, how to prepare the project scheduling - these are all the kind of a skills which go under the broad category of project management and this also one of the POs specified by the NBA. And this constitutes an important part in project based approach to instruction. But this is not a key feature of problem based approach to instruction because it does not look at the whole activity as a project; it is more like knowledge seeking. The project management principles is not a key feature of problem based approach while it is a key feature of project based approach.

Then if you look at the process - the problem based approach to instruction uses cycle of asking question, information gathering, refining the solution, discussion, revisiting the problem and so on. That means, in principle, the process can be implemented in a classroom. We can have a round table around which the students sit and they discuss the information that they have gathered. Then they see to what extent it is relevant to the problem; then they see whether based on this information they can come out with the solution; whether they can defend the solution. If there are gaps in the solution, what further information is required? They make notes of all these things; they go back and start collecting more information and then they start asking more questions. It is a cycle of asking questions, information gathering, refining the solution, further discussion, revisiting the problem and so on.

On the other hand the project based instruction focus is different. The focus is completion of a project in a phased manner resulting in a product. That means, the progress must move through specific phases; requirement must be completed; design must be completed; the necessary materials must be gathered; a prototype must be built. Of course, it depends upon the kind of project that one is working on. But whatever be the nature of the project, the focus is on the completion of that project.

It must result in an artifact or in a software package or in a solution in agreed upon format. So, the focus is on completion of project where as in PBI the focus is on acquiring knowledge to solve the problem. The project based approach is enabling learners to apply knowledge and skills to create an artifact that satisfies user’s needs. So,

we can see that though there are certain similarities in students engaging in self learning etc, there are substantial differences.

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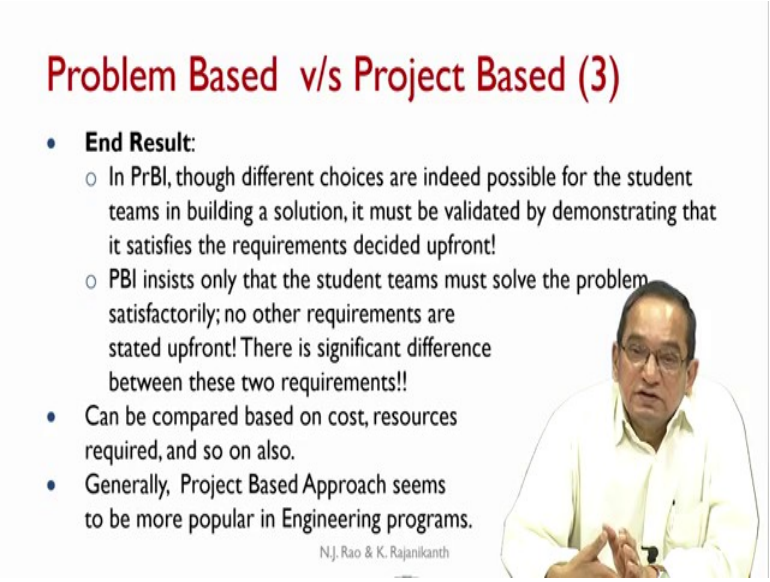


The End Result: In problem based approach to the instruction, we can have different choices; are indeed possible for students' teams in building a solution. It must be validated by demonstrating that it satisfies the requirements decided upfront. In the case of project based approach the proof is finally, the artifact that is produced must satisfy the requirements decided upfront. Where as in the problem based approach to instruction - it only insists that the students teams must solve the problem satisfactorily. No other requirements are stated upfront.

There is a significant difference between these two requirements. In project based approach, upfront we are having certain user requirements and at the end, the artifact must satisfy those requirements. That is not so in problem based instruction. It can be compared based on cost, resources required and so on. But in general, the project based approach seems to be more popular in engineering programs because the activities that the student engage in during the project based approach to instruction seem to be more closely aligned to the kind of activities that professional engineers actually engage in.

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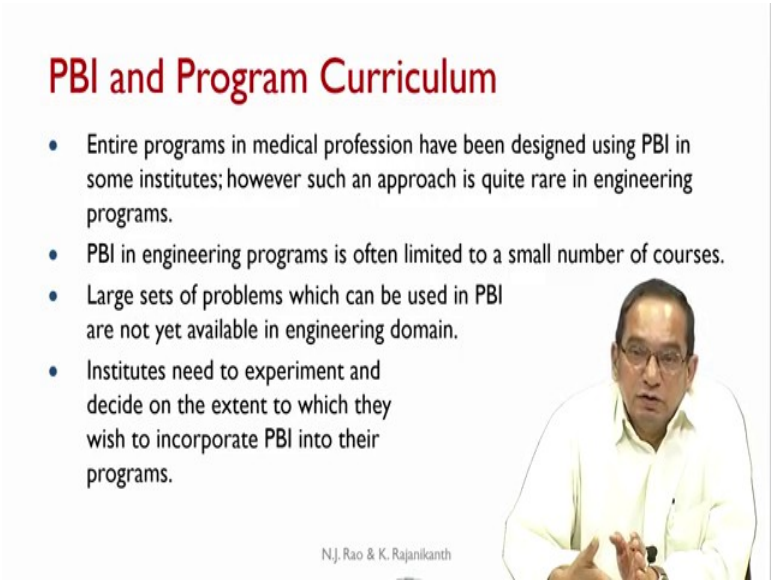


If you look at the incorporation of problem based instruction into the program curriculum, the same kind of problems that we encountered while incorporating the project based instruction into the curriculum, will appear here also. Entire programs in medical profession have been designed using PBI in some institutes. However, such an approach is quite rare in engineering program. PBI in engineering programs is often limited to a small number of courses. Large sets of problems which can be used in PBI are not yet available in engineering domain while such large sets are available in the medical domain.

Institutes needs to experiment and decide on the extent to which they wish to incorporate PBI into their programs. All the case studies reported in the literature regarding the use of PBI in engineering education only talk of using this approach in a very, very limited fashion; probably to help one or two courses in a semester; most often only in two or three semesters. It is not incorporated as extensively as in the case of medical education into the curriculum; may be 2 to 4 semesters; replacement for only 1to 2 courses!

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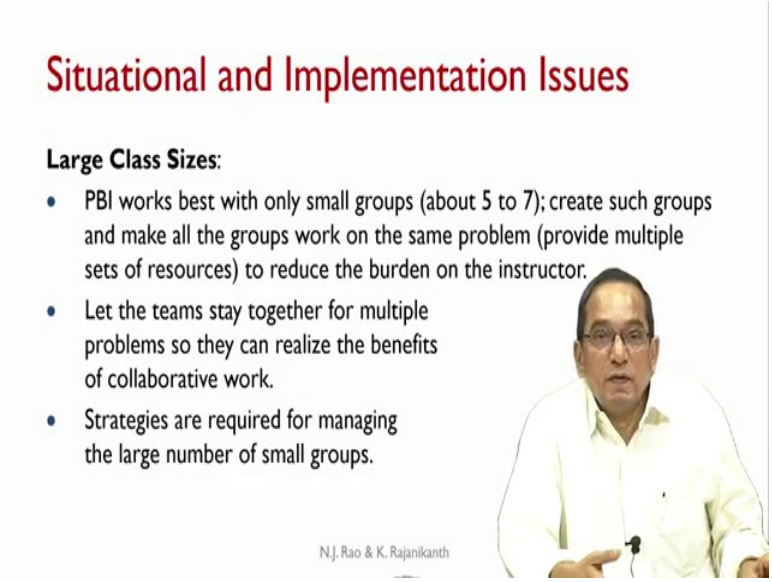


As mentioned earlier, there are several situational and implementation issues. While the broad universal principles hold good everywhere, there are variations based on the specific situations. One of the biggest challenges would be the large class size. PBI works best only with small groups about 5 to 7 because they need to interact very closely with each other and they need to discuss and they need to refine the solutions. A very small team size is optimal for PBI approach. And "create such groups and make all these groups work on the same problem" can be one of the solutions, i.e., is you create small groups, but give the same problem to all the groups. We can provide multiple sets of resources. This will reduce the burden on the instructor; otherwise creating that many problems; monitoring them; providing resources; may prove to be very difficult.

Let the teams stay together for multiple problems so that they can realize the benefits of collaborative work. That means, for extended periods, let the same teams work together on different problems. Do not reform the groups. And strategies are required for managing large number of small groups.

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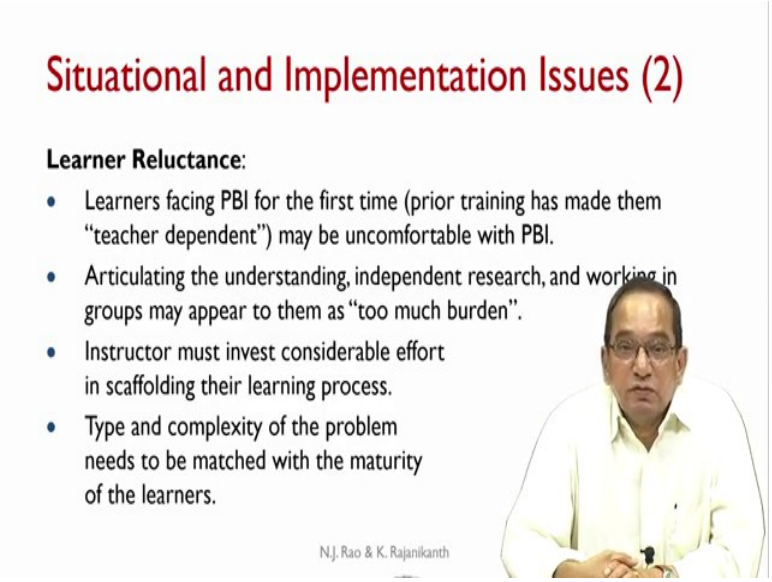


Then there can be learner reluctance: Learners facing PBI for the first time maybe uncomfortable with PBI; particularly if the earlier experience has made the students quite comfortable with teacher dependent mode of learning where everything is controlled by the teacher. Teacher decides and essentially provides all the information; students more or less can play passive roles and be done with it. There is no responsibility on the part of the students. If they are accustomed to this style of the learning they may always look up to the teacher to provide everything to them. Some kind of spoon feeding, but the approach which is problem based approach requires considerable effort from the student side. So, initially they may be reluctant.

Articulating the understanding, independent research, and working in groups may appear to them as too much burden. Instructors also must invest considerable effort in scaffolding their learning process if the students are not yet familiar with this approach.

Type and complexity of the problem needs to be matched with maturity of the learners. This is also very important. If the problem is too easy then the students would really not have any motivation to put in effort. If the problem is too complex then the learners may lose interest and they may become, in a kind of disappointed mode, and may turn away from the problem.

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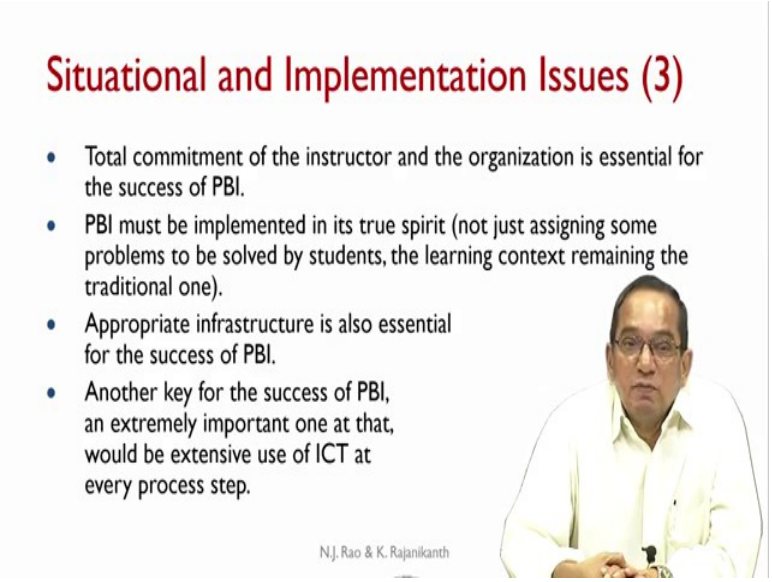


Total commitment of the instructor and the organization is essential for the success of PBI. Obviously PBI must be implemented in its true spirit; not just assigning some problems to be solved by the students; the learning context remaining the traditional. In the sense that everything else is same; just we give certain assignments and ask them to do - that does not become a problem based approach. Appropriate infrastructure is also essential for the success of PBI. There must be places where they can sit together as a group, discuss and the instructor must be able to monitor; they can make notes.

Another key for the success of PBI - an extremely important one at that, would be extensive use of information and communication tools at every process step. Particularly, the recording of the reflective journals, recording the minutes of the discussion and sharing their research findings - if all this could be done using appropriate ICT tools, the implementation process would be considerably simplified and keeping the records for later review also would be considerably simplified.

Institutes must adopt ICT on a very large scale if the approach of problem based instruction is to be successful. Of course, even without this approach, the use of ICT has become very essential. So, this would be a worthwhile investment for any institute. But, for the success of PBI, extensive use of ICT would be very, very helpful.

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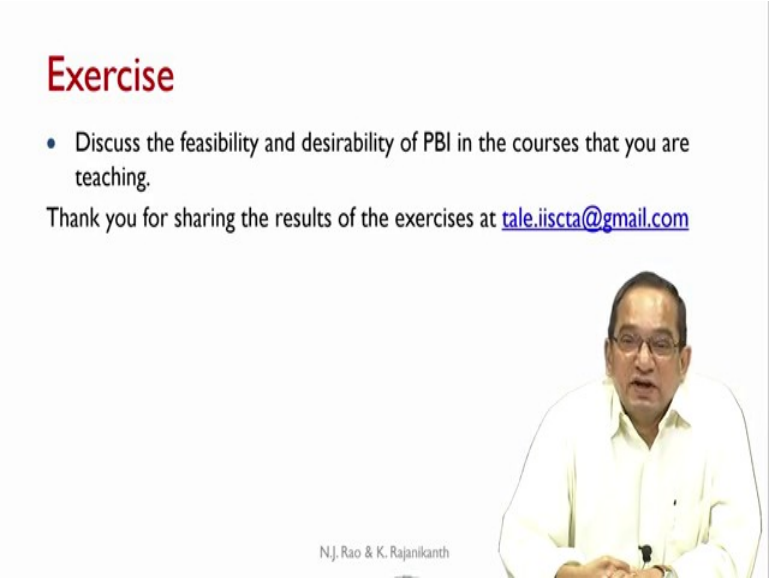


Exercise: Discuss the feasibility and desirability of PBI in the courses that you are teaching.

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

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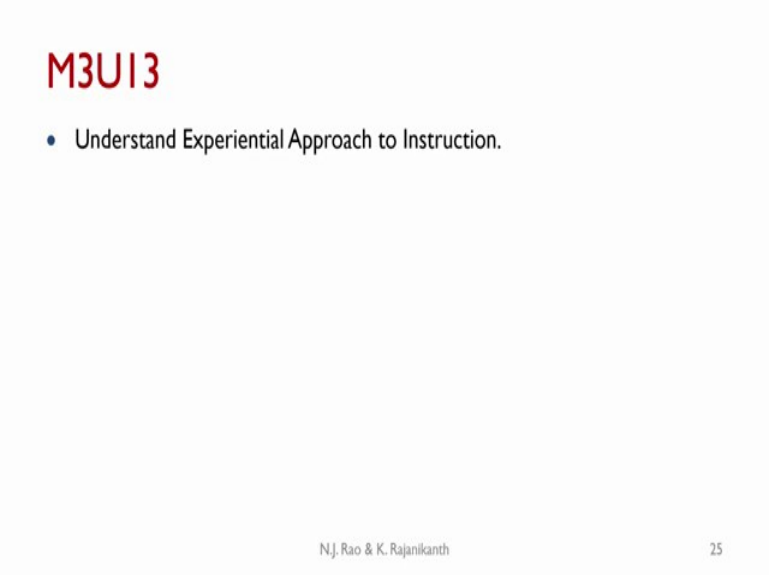


In the next unit, we will look at the experiential approach to instruction. Project based approach to instruction, problem based approach to instruction, experiential approach to instruction are the three major changes that are coming in to engineering education to address the challenges that are appearing in the engineering education. We looked at the

project based approach and then problem based approach. In the next unit, we will look at the experiential approach to instruction.

Thank you; until then bye.