

# **Lessons from the Indo-US Collaboration for Engineering Education: Improving Assessment and Performance**

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## **ABSTRACT**

The lead author of this paper was one of almost 600 Indian faculty who participated in the first Faculty Leadership Institute in 2008 in Mysore, India that was organized by the Indo US Collaboration for Engineering Education (IUCEE) and continues to be offered in the summers in Mysore. Participants commit to incorporate and adapt best practices in their courses, provide training seminars to other faculty in Regional Training Centers, report on their experiences, and are encouraged to conduct research with US mentors and publish results. This paper is the third of a series reporting impact from one individual's participation in the IUCEE program, published by the participant from India in collaboration with the US mentor for the State of Gujarat. This paper considers how to improve assessment and student performance. The Indian educational system has two different levels of examinations: one internal, constructed by the faculty member teaching the course; and the other at an external level, done by the government without input from the teacher. The paper describes why some questions sound more difficult to students and how a teacher can be better prepared to make students performance better on them. The IUCEE has trained more than 1000 faculty in two years, and set up 100 regional centers. The faculty that are trained in the Summer Leadership Institute commit to train other faculty in the regional centers to provide a scalable solution to building faculty capability. The model is being considered and adapted by Brazil.

## **1. INTRODUCTION**

Sometimes I hear a comment that a test of some subject is very difficult and our students are unable to solve that test to their satisfaction. To my surprise when I ask them "does the test paper contain some portion out of syllabus?" most of the times the answer is "No" barring some special cases. I always wonder: what is the problem with my exam questions that makes it difficult for the students to attempt.

In May of 2008 I participated in a teaching workshop presented under the auspices of the Indo-US Collaboration for Engineering Education (IUCEE). The workshop effectively transformed the way I teach. In this paper I will show how teaching provided in the workshop gave me an answer to my question.

One of the topics covered in the workshop was designing the syllabus in terms of learning objectives. The learning objectives are specific and directly observable elements that will be taught. The learning objectives for any given subject fall into six hierarchical categories according to Benjamin Bloom, an educational psychologist

at the University of Chicago [1]. This taxonomy is used worldwide to describe the educational objectives of the course, syllabus or test paper or anything similar. Bloom's Taxonomy divides learning objectives into three "domains": Affective, Psychomotor, and Cognitive. Bloom's taxonomy, as stated before, is hierarchical; meaning that learning at the higher levels is dependent on having attained prerequisite knowledge and skills at lower levels. As the focus was on adult technical education, the workshop concentrated on the cognitive domain. The cognitive domain contains two parts; each part containing three different categories. The lower part contains skills of remembering, understanding and applying learned knowledge. The upper part contains analysis, evaluation and creation skills.

When I tried to relate the difficult question papers and something that I have observed, I could find an interesting relation between them. I have collected all question papers of my institute of all subjects. I have found that most of the questions belong to the lower three levels and most of the question papers have no question belongs to upper three layers. I have also seen few "difficult" question papers and found that they are having some content of upper three layers which students had difficulty in answering.

I have glanced through some of these so called difficult test papers and then inquired students and teachers who claim so. To my surprise, I have found a direct relation of this problem with the Bloom's taxonomy. What I have found is, the internal examiner teaches everything based on lower three levels of the Blooms taxonomy, tests them on the same, and expects similar questions in the external exam<sup>1</sup>. If an external examiner asks a question which is unfortunately requiring any one of the top three skills to master, students fumble in answering them and teachers who taught the subject feels uncomfortable. I do not claim hereby that this is the situation always, but few cases which I have observed were like that<sup>2</sup>.

## ***2. Learning Objectives and Bloom's Taxonomy***

One can write learning or Instructional objectives of anything that he is teaching [2]. The problem is to realize the level at which a teacher teaches and the level where he examines the student. Let me try to explain what teaching at lower level and asking question of higher level mean. Suppose the teacher teaches three things to the students

1. What are the characteristics of Ethernet and WiFi (technical IEEE names are 802.3 and 802.11) protocols, student should be able to list down the characteristics of both of them
2. How error is handled in both Ethernet and WiFi networks
3. Apply principles learned for Ethernet and WiFi protocols to WiMax to figure out how error can be handled there.

Now if the external examiner asks questions as follows, then the student will have a problem and claim that they are not taught what is asked in the exam.

1. How WiMax is different than Ethernet or WiFi (Level 5, Evaluation and critical thinking)
2. Design a protocol for a specific situation (Level 6, Creation)
3. Judge in a given case which protocol would work better (level 5, Evaluation and critical thinking)
4. Why WiMax is connection oriented and why WiFi is connection less. (level 4, Analysis)
5. Suggest improvisation of Ethernet error handling mechanism (Level 6, Creation)

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<sup>1</sup> In Indian Education system which is based on University Centric Examination, the external exam paper is set by external examiner and the teacher teaching the subject have little or no control over the test.

<sup>2</sup> A similar case was cited by Felder and Brent as a mistake in teaching where the teacher teaches only first three levels of the material and expect student to "learn to think" to solve problems of higher levels. In time bound exams and without having any practice and serious feedback, such questions always result into poor answers.

## 6. What will happen if there is no data link layer protocol (level 4, Analysis)

In this real case where the question is drawn from the domain of expertise of the specific subject, it is really difficult to answer the higher level question *when the student is not given enough practice at that level*. The three things typically taught to students are memorizing the characteristics of the protocol, listing the error handling techniques of both the protocols and lastly, applying what is learned. The questions asked actually belongs to Bloom level 4,5 and 6, the analysis, evaluation and creation, which requires the student to either analyze and find out answer to a question based on his analysis, compare two different items and evaluate the differences, or create something new. This job requires analytical, critical, and creative thinking process not taught in the class (in our case).

In Richard Felder's opinion, this type of questioning to a student is unfair and unethical if they are not hinted about before and given practice and feedback on such questions. My students, whom I have surveyed, are also of the opinion that examination in such a case is a frustrating and annoying experience [3]. Whose fault it is? How can we improve the situation? One may be tempted to put the blame on an internal teacher who taught that subject. Few of us may think that the external examiner is at fault as he should consider what is taught at every college under consideration and draw the paper accordingly. Some of us may say that the people who are sitting at helm do not know how to draw syllabus and they are at fault. Unfortunately nothing can be gained by blaming any one here. All of us are at fault. Those who design syllabus, those who teach and those who draw papers and additionally those who think teachers are born and not made.

### 3. Study guides

One important thing taught at the workshop, in my opinion, is the answer of how to enable the students to answer the higher level questions. It is known as a study guide. The study guide is collection of learning objectives students must work at to get better marks in the test. An example of study guide is

To do well in the next test the student should be able to do

1. List characteristics of the protocols studied in the class
2. Explain error handling methods used for Ethernet and WiFi protocols
3. Apply the knowledge of error handling for the WiMax case.
4. Compare two or more protocols taught in the class in terms of
  - a. Their bandwidth requirement
  - b. Their memory requirements
  - c. Their robustness, whether they fail in some circumstances
  - d. Their fairness considering different types of users
  - e. ....

I can go on writing but I think now you have a fair idea. The study guide clearly mentions that student must be able to compare two protocols for doing well in the test. If the external examiner now asks the question to compare the protocols, probably more students are there to answer. If the study guide is prepared and distributed among the student community well before the exam, probably the problem becomes less severe. Felder and Brent's suggestion is to give it at least one week before the test. They also suggest arranging the discussion on topics of study guide before the exam. I have started following both the advices and the results are astonishing. Obviously when an examiner give question like generating a new protocol for an application or compare two

protocols, the teacher must be teaching them in the class as well. Also, the teacher must also be able to give students enough practice to do so as these are higher level questions and thus, harder.

#### ***4. Syllabus design, representation and conversion to learning objectives***

The other, rather more important part of the solution, is to represent the syllabus as a set of learning objectives clearly indicating what is expected from students. This requires little more of work from syllabus designers and perhaps educating them for this job. The process of describing what we want from the student in form of learning objective creates a clear interface between the student and a teacher-examiner. All of us dislike when some student approaches us and ask “Is this expected in the exam, is that expected in the exam and so on”. Putting everything in form of set of learning objective is one such way to solve that problem.

One additional solution to that problem is to choose a book which stresses on other than first three levels of blooms taxonomy. I have seen cases where the book describes everything only in terms of first three levels of blooms taxonomy and does not address top three. The teachers who read these books to teach, or the students who read such books to prepare for the exam, have serious problems when any questions based on above three level is asked in the exam. It is not always easy to get a book which is lucid enough for the students to read and also stresses on higher levels, but a teacher can try in that direction <sup>3</sup>. One more solution is to use handouts specially prepared for the students to read with gaps inserted purposefully to make student really learn that material to complete that note. More information can be found about hosts of such advices on Richard Felder’s web site [5]

Additionally, all teachers who teach the same subject should learn about these learning objectives and start using study guides for their internal tests. In my own case I have started preparing and providing study guides to students before the exams and results are really encouraging. [3,4]

#### ***5. Implementation and answers to accusations of this approach***

What we need to do is following.

- (1) Writing learning objectives that address all the knowledge and skills and attitudes the teacher wants to teach in the course;
- (2) Designing instruction that will enable as many students as possible to meet the objectives;
- (3) Sharing the objectives with the students so they understand what they need to learn; and then
- (4) Designing tests that assess mastery of some or all of the objectives, preferably providing study guides well before the exam

Some of us may argue that this is a technique designed to spoon feed the material to the students. In Felder and Brent’s opinion this mentality is inherited from British rule and we must extricate ourselves from it. In my opinion, there is nothing like spoon feeding here. We are not giving students probable questions or not reducing the quality and level of the test, rather it gives us the opportunity to ask difficult (higher level) questions without being criticized for the same! We unknowingly are observing something similar in students who are attempting the exams of 10<sup>th</sup> and 12<sup>th</sup>. Both the board exams previous year test papers are usually given to students to study and attempt as a preparation for the final exam. Good students usually write plenty of such papers to prepare for

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<sup>3</sup> One more solution is to use handouts specially prepared for the students to read with gaps inserted purposefully to make student really learn that material to complete that note. More information can be found about hosts of such advices on Richard Felder’s web site <http://www.ncsu.edu/felder/public/>

the exam rather than reading the same material from the book. It is generally observed that those who attempt papers as a practice get better marks than those who read text books. There can be many other reasons but one of the most important reasons for this is that students who write answers to these papers clearly understand what is expected of them. Which types of questions can be asked or how a specific material is useful in solving a specific problem becomes clear. Learning objective is more specific way of representing what is expected from the student. Representing the syllabus in terms of learning objectives makes the issue more explicit and clear. Here instead of student doing that implicitly, the onus is onto us to do it and then provide it explicitly to our students.

One of the concerns people will have about what I am proposing is that this is a process of making things too easy for the students by telling them everything they need to know on the test--in effect, giving them a sample test in advance. I have two different answers to that accusation. First, I am testing them freely on analytical, critical, and creative thinking questions because I have kept them on my study guides, which otherwise I would never dare to. Second, my study guides are such that if the student do them well, my purpose is served to make them learn what I want them to. Our job as a teacher does not involve evaluation only and passing or failing student but to make them industry ready, and learn the subject. Providing a study guide with such objects serves both of the purposes.

## **6. Solutions**

The Universities in India may take a few years in changing the syllabi in terms of learning objectives, and internal teachers might not have control over the external exam for some more time. Universities are heading towards that direction but the process might take a long time. The only choice left is to educate our teachers. The teachers, in my opinion, should be educated about the Bloom's taxonomy, made aware of different levels, and shown the way of drawing balanced internal papers so students can do better in external examination<sup>4</sup>. Teachers should be told about this predicament; it is very difficult for them to be aware of this problem, let alone learning to solve it, on their own. One interesting comment I remember from Richard Felder is that teaching is the only profession where the candidate is assumed to possess the necessary skills. They are employed and assumed to be ready to teach immediately with no training. No other profession has such tendency. Teachers are not aware of simple things like Bloom levels and need for students requiring enough practice and consistent feedback to master any subject. Teachers are unaware of the need for training students for critical and creative thinking to answer some of the questions they assume student must know how to answer. It is better if the teachers are taught about these important things before they face their first students.

One more point I would like to mention is that if teachers start working on students of the first year and give them creative problems to solve, there is nothing wrong, rather it is an excellent idea. For example, one can give a problem to find networking problems and products which solves them, like file transfer and FTP or remote login and Telnet or Web access and HTTP. One can also ask them to compare on any grounds they deem fit, also can suggest some other area like remote database access and tell them to design an outline of a protocol for such application. According to Felder and Brent the biggest mistake some of us make is that we consider the lower three skills are to be mastered in the undergraduate courses and higher order skills are to be mastered later in post graduate courses. Such skills can and should be nurtured from the beginning. As higher order skills require more practice and feedback, probably the first time we do not get great answers but subsequently both the quantity and quality of good answers increase. In my own experience also I have found similar results. I am fond of giving creative assignments to my students. It takes more time to design such assignments and also requires much more open mind to evaluate them, but it molds students to think the way in an open-minded way. Preparing students to

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<sup>4</sup> I have seen some of my colleague's papers of their internal examinations recently and revealed that they have not asked a single question of the top three levels.



face higher level questions does not only make them attempting the answers of the test but make them better professional with critical and creative thinking abilities.

A last point about learning objectives and accreditation; ABET (Accreditation board of engineering and technology) is an organization that accredits all engineering and engineering technology programs in US. The ABET Engineering Criteria are the conditions that programs must satisfy to be accredited. The Washington accord is an agreement that establishes the equivalence of other countries' engineering programs with ABET accredited programs. India is provisional signatory of the accord currently. The meaning of all the above jargon is that in future it is possible that we may need to go for ABET accreditation (the engineering and technology courses). One important requirement for ABET accreditation is to formalize the syllabus using learning objectives and see that they are addressed properly. So If we start working in that direction now, probably we are better placed when ABET becomes compulsory. So learning about learning objectives makes us future proof as well!

## ***7 Conclusions***

The Indo-US Collaboration for Engineering Education (IUCEE) has developed and is improving a program to build faculty capacity that is scalable and improve the results of engineering programs across all institutions of the Indian higher education system. The great majority of graduates were not employable in their disciplines, so there was a sense of urgency from the part of the government and industry. Since 2008 the Summer Faculty Leadership Institutes has provided more than 20 one-week Train-The-Trainer seminars in general pedagogy and in the content area where 600 professors participate each summer. The professors chosen are faculty with substantial experience and demonstrated dedication. One-hundred Regional Centers distributed across India provides infrastructure for the Indian faculty to train other faculty. The institute provides seminars for administrators on educational management and accreditation. This initiative was funded primarily by two Indian entrepreneurs, one in the United and one in India. The training was designed by teams of US and Indian faculty recognized by their pedagogical expertise, many are authors of leading textbooks used in the discipline. Infosys, ASEE and the U.S. National Academies collaborated to provide expertise and facilities for the development of the institute. Indian Institute participants that comply with the commitment to train other faculty and implement what was learned in their classes to effect a change in their institutions and region are provided with a U.S. mentor to improve their research and publication skills. The IUCEE is video taping and processing all the seminar materials and each year refine the support materials available to the participants.

This is the third paper resulting from one Indian Institute participant's experience and observations from applying, training other faculty and attempting to change the teaching culture at his university. The first paper [3] provided results of applying the new methodologies and techniques learned to the second semester of a two sequence course. The first course in the sequence was taught prior to taking the Institute, the second after. Test results and student perception showed substantial improvement. This is significant since the professor had ten years of experience prior to taking the Institute and was considered a dedicated teacher by his institution. The second paper [4] looked at his experience training other faculty, which showed a need for the Institute to provide more support materials to facilitate the courses. This paper, the third in the series, shows a development of the level of the Indian faculty member within a two year span, shifting his concern from the mechanics of effective teaching within his classroom/seminars to conducting a study in his institution across all exams given in a department to explore why students were not doing well on exams and analyzing the type of questions being missed.

The IUCEE is being considered for application in Brazil, and the process is beginning to determine how it needs to be adapted to be effective in other countries. This US – India – Brazil initiative is being proposed under the umbrella of IFEES, Engineering for the Americas, and iNOVA.

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