Educating Engineering Educators to Nurture 21st Century Indian Engineers

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Abstract

An educational institution is defined by its faculty; student intake and infrastructure are largely dependent on the faculty. Any educational system, therefore, has to focus on educating the faculty on an ongoing basis. While ample research has been reported on the requirements of the 21st century engineers, its deployment is not satisfactory, especially in the Indian engineering education system. This has to be addressed as India is endowed with impressive demographic dividend, as compared to many developed economies and is poised to become a major workforce supplier in the coming decades. Being of Indian origin with international experience, we have designed, developed and delivered a two-day workshop for educating the educators in the emerging Indian economy. The objectives of the workshop were a) to introduce the participants to the changing needs of engineering education, and b) to illustrate an approach that we have developed over the past decade to address the needs. In this paper, we present the design and implementation of the workshop.

The context of the workshop is set by Richard Riley’s beautifully articulated statement: “we are currently preparing students for jobs that don’t exist using technologies that haven’t been invented in order to solve problems we don’t even know are problems yet”. While we cannot list technologies and problems; we can envision some basic themes around which the future may revolve. To enable a focused discussion of topics, we imagine a future in which individuals are empowered to participate in the global value network where geographically distributed people (including engineers) collaboratively develop, build, and test solutions to complex socio-techno-eco problems in wired and interconnected world. We posit that to be successful in the future, our engineering students need to be empowered to develop white-space competencies and learn to realize sustainable engineering systems.

The workshop was designed to be highly interactive. We used a model course developed over the past 15 years, which embodies threshold concepts such as the ‘question for the semester’ (Q4S), self-evaluation and learning communities, relying on developing competencies to fulfill the learning objectives, etc. The model course embedded all the concepts espoused in the workshop. The approach was based on the principles from mass customization and competency-based learning rather than one-size-fits-all content delivery. The workshop started with identifying competencies and meta-competencies required for the 21st century Indian engineers. Methods for identifying white-space competencies, dilemmas and managing them were discussed. The participants discussed many issues such as developing the Q4S for educating the 21st century Indian engineer and concluded with the course that they would like to develop with the concepts learnt in the workshop. The participant pool consisted of 32 Indian educators from different parts of the country. The workshop received positive feedback and the participants went back with a resolve to deploy the knowledge that they acquired at least in a course. The paper includes the design, implementation, and key learning of the authors from the workshop.
1 Frame of Reference: Educating 21st Century Indian Engineers

1.1 Indian Engineering Education System – Current Status and Needs

The Indian engineering education system is one of the largest and most relevant global systems where around 3400 colleges turn out over a million engineers every year. The country has emerged as a major player in the global arena and has produced engineers who have contributed significantly to the economic and technological development at international levels. These contributions have been made not only in the information technology sector – as is largely perceived – but also in various engineering disciplines and in hi-tech research and development in automotive, telecommunication, healthcare, solid-state electronics, communications and embedded systems sectors.

The Indian engineering education system has tremendous potential and national value. Cognizing this, the government and the business community are showing a strong commitment to improving the system. It is complemented by an equally strong interest from the youth and their parents. The interest and support has been creating a virtuous spiral resulting in the stronger system. The spiral can grow up much rapidly. There has been increasing globalization of suppliers, workforce and customers all around the world. India, due to her rich demographic dividend and the promising education system, is seen as an important contributor to the intellectual capital of the world. The requisite steps must be taken to fulfill the potential.

As of now, the education system appears to have some inadequacies to fulfill those requirements. There is a lack of academic rigor and focus on fundamentals. It is also seen as more theoretical and lacking stronger connections with the world of applications. It requires students to complete 180-200 credits as compared to other systems requiring 120-130 credits. The heavy curriculum takes its toll on developing a deeper approach and encourages a cursory or examination oriented approach. More important, it suffers due to the paucity of qualified faculty. Currently, the shortfall is estimated to be 40%. In addition, if we count qualified and motivated faculty, the number may be far higher. While the All India Council of Technical Education (AICTE) standard norms require faculty members to have a Ph.D. qualification; only some members fulfill that condition. The quality of those research scholars also may not be up to the mark. We strongly believe that completing Ph.D. itself is not a sufficient condition for an engineering teacher. A good research scholar can be a good researcher, but he may not be a good teacher. Neither regulatory bodies nor the engineering colleges’ leadership requires teachers having any exposure to theory and practices of education domain. This impacts performance of faculty and overall college education, and perhaps results in mushrooming of private tuition classes that have short term focus and examination orientation. It is estimated that the overall private tuition market’s annual turnover is double than the budget for education in the ongoing five year plan. All this is resulting in stooping down of the estimated employability of graduate engineers to only 25%.

Meantime the global demands from engineering graduates are changing. The expectations from 21st century engineers are moving beyond outcomes and attributes to the traits, motives and self-concept. The Indian engineering education system, therefore, has to not only work on the backlog but also catch up with the global trends and that too very fast. It can achieve this by focusing on development of the most critical aspect of the education system, namely, faculty.
1.2 Rapid Changes in the Job Market

Rapid globalization has led to many unprecedented changes in the world in which our students and graduates will practice. According to Friedman\(^5\), “Globalization has collapsed time and distance and raised the notion that someone anywhere on earth can do your job, more cheaply”. In his book, Friedman\(^5\) gives a number of examples of jobs that are being outsourced from developed countries such as the United States to emerging economies such as India and China. The new jobs created in India through outsourcing created a significant demand for personnel with a unique set of skills, such as the ability to collaborate in global settings, ability to work in geographically distributed teams, and ability to work with individuals from different nationalities in different time-zones. Nearly a decade has passed since Friedman wrote his book “The world is flat”. Within the past decade, the labor costs in India have steadily increased\(^6\). According to Chandramouli\(^7\), the increase in salaries was between 12-27% during FY2012. Such changes are expected to further result in changes in the kinds of skills required by the Indian workforce over the next decade or so.

Realizing how much the business environment has changed over the past two decades, it is apparent there is a need to change the way Indian engineers are educated. Drastic changes in the educational system cannot be made without faculty members who understand and appreciate the need for such changes. Hence, our goal was to create a workshop where Indian educators were invited to participate. Within the workshop, our objectives were to: a) introduce the participants to the changing needs of engineering education, and b) illustrate an approach that we have developed over the past decade to address the needs.

The workshop was widely publicized. We received the required 50 nominations in a few weeks’ time. Out of them 74% were from the host institute (College of Engineering, Pune) and 26% from other institutions across India. Finally, 32 participants could attend the workshop with 69% from the host and 31% from other institutes. The faculty members were from various departments and had broad experience.

1.3 Competencies Required for the 21st Century Indian Engineer

With increasing globalization and 21st century trends such as the commoditization of technology, individuals are required to refresh and adapt their skills and technical competencies continuously and keep their knowledge current. We have identified the following five categories of meta-competencies necessary for a 21st century engineer to support innovation\(^8\).

1. Managing Information: This includes ability to gather, interpret, validate and use information, have an ability to understand quantitative and qualitative information, and to discard useless information.

2. Managing Thinking: This consists of ability to identify and manage dilemmas associated with the realization of complex, sustainable, socio-techno-eco systems, ability to think across disciplines, holistic thinking, ability to think conceptually, ability to speculate and to identify research topics worthy of investigation, ability to perform divergent and convergent thinking,
ability to engage in critical discussion, be able to identify and explore opportunities for
developing breakthrough products, systems or services, and ability to think strategically
through theory and methods.

3. **Managing Collaboration**: This includes the ability to manage the collaboration process in
local and global settings, ability to create new knowledge collaboratively in a diverse team,
competence to negotiate, and to work in diverse teams

4. **Managing Learning**: Ability to identify the competencies and meta-competencies you need
to develop to be successful at creating value in a culturally diverse, distributed engineering
world, ability to self-instruct and self-monitor learning, ability to interact with multiple
modes of learning.

5. **Managing Attitude**: ability to self-motivate, ability to cope with chaos, ability to identify and
acknowledge mistakes and un-productive paths, and ability to assess and manage risk taking.

We use these meta-competencies as a basis for revitalizing the education of next generation
engineers. In this paper, we present an overview of a recently conducted workshop at the College
of Engineering, Pune. The design of the workshop, the overall objectives, and the core elements
of the strategy are presented in Section 2. The details of the workshop, including talks and
activities are presented in Section 3. Finally, lessons learnt and closing thoughts are presented in
Section 4.

2 Designing a Workshop for Educating Faculty to Educate the 21st Century Indian
Engineer

The changing environment and the diverse learning needs of individuals require a change in the
existing paradigm of engineering education towards a more flexible, learner-centric paradigm
that, among other things, instills in individuals the habit of being self-directed life-long learners.
The overall objective in this workshop was to introduce the participants to the changing needs of
engineering education, and to illustrate an approach that we have developed over the past decade
to address the needs. The workshop was targeted towards engineering educators who are
interested in exploring new models of education to better prepare their students for the changing
environment. It was conducted in May 2013.

2.1 Core elements of the approach

Our educational approach for personalized mass customization of engineering education suitable
for globally dispersed learning settings 9. The approach is anchored in the following foundational
constructs:

- constructive alignment,
- Bloom’s taxonomy,
- learning organizations, and
- a combination of collaborative, cooperative and collective learning.
As a part of constructive alignment, an instructor aligns the planned learning activities and assessment tasks with the learning outcomes. Bloom’s taxonomy is a model in which learning is partitioned into six domains of knowledge of varying levels of complexity. The taxonomy is used to scaffold different learning activities. The learning organization construct is adopted to transform a traditional passive learning environment into an active person-centric learning environment. Collaborative learning enhances the knowledge of a group by encouraging diverse individuals to learn from each other \(^{10-12}\). The foundational principle in this approach is to focus on competency-based learning rather than one-size-fits-all content delivery. The instructors’ role shifts from lecturers to orchestrators of learning and the role of the students shifts to active learners. Through this approach, we are able to shift the emphasis from lower cognitive levels of learning on to the upper levels.

In the workshop, we discussed how the approach can be used to create learning communities, embedding flexibility in courses, leveraging diversity, making students aware of the learning process, and enabling students to make decisions where all information may not be available.

### 2.2 Questions for the Workshop

The workshop was structured around the following six questions for the workshop (QW1-QW6).

<table>
<thead>
<tr>
<th>QW1</th>
<th>What are the key foundational white space competencies that “tool maker” engineers must have to be able to create value in a wired and interconnected, democratized and diverse world?</th>
</tr>
</thead>
<tbody>
<tr>
<td>QW2</td>
<td>What are the key foundational technical competencies that “tool user” engineers must have to be able to create value in a wired and interconnected, democratized and diverse world?</td>
</tr>
<tr>
<td>QW3</td>
<td>What competencies do you wish to develop to be successful at addressing dilemmas associated with the realization of complex, sustainable, socio-techno-eco system in the wired, interconnected and culturally diverse world of 2030?</td>
</tr>
<tr>
<td>QW4</td>
<td>What are your learning objectives for the course and how do they relate to the competencies?</td>
</tr>
<tr>
<td>QW5</td>
<td>How can personalized learning objectives and competencies be achieved in classroom settings?</td>
</tr>
<tr>
<td>QW6</td>
<td>How can we systematically identify and manage dilemmas associated with the realization of complex systems?</td>
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The first two questions are geared towards identifying the white space competencies necessary for engineers operating in the 21\(^{st}\) century. The first two questions address the competencies from a very broad perspective of the wired and interconnected world. The third question is focused on a specific aspect of the wired and interconnected world. The focus is on the realization of complex socio-techno-eco systems. The fourth question deals with the process of identifying the learning objectives and competencies that individual participants in a learning activity wish to achieve. The fifth question focuses on a strategy for achieving the personal learning objectives and competency goals. Finally, the sixth question focuses on steps for
identifying and managing dilemmas that arise in the realization of complex systems. These questions are addressed through a series of talks by the workshop organizers and a number of activities to actively engage the participants and to enable them to generate their own ideas within the context of their own classrooms. An overview of the workshop is presented in Table 1. The details of the talks and the activities are presented in the following section.

### Table 1 – Overview of the two-day workshop

| Day 1 | Introductions and workshop overview  
| Talk 1: Educating Engineers for the 21st Century Wired, Interconnected and Democratized World  
| Group discussion and report to all participants: On transforming education. How do we facilitate students learn how to learn AND help them speculate about the future?  
| Talk 2: Competencies and Learning Objectives  
| Team activity: Critically evaluate three competency / learning objective proposed constructs  
| Talk 3: Identifying “Tool maker” and “Tool User” Competencies  
| Activity: Three Little Pigs game |
| Day 2 | Talk 4: Threshold concepts and sample course structure  
| Group discussion: How can the question for the semester be augmented for the educating the 21st century Indian engineer?  
| Talk 5: Identifying and Managing Dilemmas  
| Group Discussion: In the context of the augmented question for the semester formulated in the previous discussion, identify the education-specific dilemmas, and discuss methods for managing them  
| Talk 6: Self-grading and Closing the Loop  
| Group discussion: Having completed the workshop, how would you structure your existing courses differently? |

3 **Workshop Details: Talks and Related Exercises**

3.1 **Talk 1: Educating Engineers for the 21st Century Wired, Interconnected and Democratized World**

The objective in the Talk 1 was to frame the workshop and to take the participants out of their comfort zone of the current educational system. The talk was focused on addressing QW1 and QW2. The meanings of various keywords used in the workshop were discussed. During the talk, the workshop organizers established the context as follows:

**Context:** We imagine a future in which individuals are empowered to participate in the *global value network* where geographically distributed people (including engineers) collaboratively develop, build, and test solutions to *complex socio-techno-eco problems*. Such a globalized world poses great new challenges in addressing complex socio-techno-eco problems. Some examples of these challenges include

- increasing need for dilemma management,
- increasing need to pay attention to environmental, socio-cultural drivers in engineering a
solution,
• significant uncertainty, and
• increased product and process complexity.

In this context, the participants were encouraged to think about the competencies required for an engineer to be successful. The following examples of the white-space competencies were provided to guide the thought process:

- **Framing the problem:** ability to *continue learning through reflection* and the associated creation and articulation of knowledge; ability to *speculate and to identify* research topics / white spaces worthy of investigation.
- **Domain of application:** ability to *account for sustainability* considerations in formulating, partitioning, and executing multidisciplinary, systems-design problems that are characterized by the open innovation construct.
- **Negotiating a solution:** ability to *identify and manage dilemmas* associated with the realization of complex, sustainable, socio-techno-eco systems; ability to *identify the competencies* an engineer needs to develop to be successful at creating value in a culturally diverse, distributed engineering world.

Approaches for addressing these competencies were discussed in the following talks. At the end of the first talk, a question-answer and discussion session was held.

### 3.2 Talk 2: Competencies and Learning Objectives

The second talk was on identifying competencies and learning objectives. QW3 and QW4 were addressed in this talk. In the globalized environment discussed above, one of the main tasks of an educator is to prepare engineers who are capable of identifying and solving problems that do not yet exist with tools and methods that have not yet been invented. Hence, there is a need to educate students to “learn how to learn” and to empower them to take charge of their own education. From the students’ perspective, this translates to identifying and obtaining the competencies needed to become a valuable asset for a dynamic career. Hence, the first step is to let the students identify their personal goals for the semester. The objective in this talk was to provide the participants an understanding of how learning objectives and competencies can be defined, how to establish relationships between them, and how to prioritize them.

Competence is the ability to perform a specific task, action or function successfully. Incompetence is its opposite. Competencies are the result of integrative learning experiences in which skills, abilities, and knowledge interact to form bundles that have currency in relation to the task for which they are assembled. A learning objective is defined as the generic skill you wish to attain so that you are competent in performing the task. Learning objectives are defined in terms of the six learning domains defined in the Bloom’s taxonomy (knowledge, comprehension, application, analysis, synthesis, and evaluation). We use Bloom’s taxonomy because, based on our experience, engineering students find natural and easy to grasp. Bloom identified six levels within the cognitive domain, from the simple recall or recognition of facts,
as the lowest level, through increasingly more complex and abstract mental levels, to the highest order, which is classified as evaluation. As alluded to before, these six levels are: (1) knowledge, (2) comprehension, (3) application, (4) analysis, (5) synthesis, and (6) evaluation. Learning objectives are related to the competencies. An example of the learning objectives and competencies anchored in Bloom’s taxonomy is provided in Figure 1.

At the end of the second talk a team activity on identifying learning objectives and competencies was carried out. The participants were asked to form groups of 4-5. They were provided a list of sample competencies and learning objectives. They were asked to critically evaluate three competency / learning objectives, and list what is missing, and how each competency/learning objective can be improved. The participants were asked to identify the one your group will use as a template for further development, and justify their choice. Each group was asked for recommendations on improvements to be made.

3.3 Talk 3: Identifying “Tool maker” and “Tool User” Competencies

The focus in this talk and associated activity was to address QW2: “What are the key foundational technical competencies that “tool user” engineers must have to be able to create value in a wired and interconnected, democratized and diverse world?” Tool-user competencies are the competencies that are appropriate for solving simple and complicated engineering problems anchored in a single or multiple related disciplines. On the other hand, “tool maker” competencies are meta-level competencies such as the ability to learn how to learn and the ability to speculate.
To help the participants understand the meaning of tool-user competencies, the workshop organizers designed a hands-on group activity of building a model home. The task was to build a model home using the material provided, that had certain desirable characteristics such as being as high as possible to take in the spectacular views, functional from a space utilization standpoint, and strong enough to withstand high winds. The materials provided to each team were eight sheets of paper, three strips of sticky tape (20 in. total), two scissors, two scales, two pencils, two erasers, and a box of coloring pens. The teams were advised to follow the following key steps central to all design processes:

1. Plan – know what you are trying to achieve in the design. What are the design requirements?
2. Design – map out information about the design with sketches or computer drawings. What does the design look like and how does it behave?
3. Assemble – build a working prototype of the design. How is the design manufactured?
4. Test – check to see if the design behaves as expected. Does the design meet all design requirements?

At the end of the activity the participants were asked the following question: “In light of the preceding experience what “tool user” competencies will you add to the competency / learning objective construct that you have chosen? Justify.”

This activity helped the participants identify the competencies necessary for successful realization of products with diverse conflicting requirements. This activity concluded the first day of the workshop.

3.4 Talk 4: Threshold concepts and sample course structure

The second day of the workshop was focused on strategies for addressing the competencies and learning objectives identified on the first day. The specific focus of Talk 4 was on addressing QW5: “How can personalized learning objectives and competencies be achieved in classroom settings?” Over the years, Mistree et al. 15,16 have developed an approach, and implemented it in graduate and undergraduate courses, to help students attain competencies and meta-competencies discussed in the previous sections. The approach involves a fundamentally different way in which design-related courses are orchestrated. The approach is based on a number of threshold concepts, including:

- Bloom’s Taxonomy
- Kolb’s experiential learning
- Learning organization
- Observe, Reflect and Articulate (ORA) construct
- Sustainability pyramid
- Methods for identifying and managing dilemmas
- Self-grading

The overall architecture of the courses based on this approach is presented in Figure 2. In the courses, the students are first asked to speculate about the world of design and manufacturing of the year 2030, based on current literature and developments, before learning about the engineering design process as we know it. By speculating about the world of 2030 they get a new
perspective on the potential requirements of future engineering design processes. Thus, the students create new knowledge beyond what they could learn from any given text book.

The students in the course are required to take stock of their current competencies and compare what they already have to the competencies a successful designer may need in future. Thereby, students are empowered to take charge of their own learning by articulating their individual associated learning objectives within the broader context of this course. A single question is provided to the students to be answered throughout the semester. This Question for the Semester (Q4S) is essentially a take-home exam and that they even have the right to tweak this question in response to their personal learning objectives. The question for the semester is used to align the efforts of all the students while providing enough flexibility to the students to explore the topics that are particularly interesting to them. That way, they are encouraged to start shaping their own learning.

The approach is based on the threshold concept of individual learning in a group setting through the formation of a learning community. The blueprint for this is the model of the Learning Organization (LO) as introduced by Senge. According to Senge, a Learning Organization is “an organization that facilitates the learning of all its members and consciously transforms itself and its context”. A learning organization exhibits five main characteristics: (1) systems thinking, (2) personal mastery, (3) mental models, (4) a shared vision, and (5) team learning. We have adapted Senge’s leaning organization model to educational settings. Systems-thinking is achieved by posing a high-level question (Q4S) for the students to be addressed by scaffolded activities and assignments throughout the semester. Personal mastery is achieved by defining and striving to achieve personal learning goals that are tied to the development of competencies and meta-competencies. The students are continuously challenged to understand and assess their mental models. Team learning and shared vision are achieved through the process of collectively completing the assignments and answering the Q4S.
One of the important aspects of the approach is the identification and management of dilemmas. The following talk was dedicated to dilemma management. At the end of Talk 4, the participants were provided sample questions for the semester and asked how the question for the semester be augmented for the educating the 21st century Indian engineer. The participants worked in teams to answer this question.

3.5 Talk 5: Identifying and Managing Dilemmas

The question for the workshop addressed in this talk was QW6: “How can we systematically identify and manage dilemmas associated with the realization of complex systems?” The competitiveness of the next generation of engineers will no longer be defined solely by their knowledge and technical skills but also by their abilities to identify white spaces and then proffer solutions that manage dilemmas associated with complex socio-techno-eco systems. A dilemma is a problem offering at least two solutions or possibilities, of which none is practically acceptable. Current engineers are trained to solve problems that are well defined. Typically, the problems are defined by someone else, generally by someone at a higher level in the organizational hierarchy (e.g., manager). Within the current educational paradigm, engineers are equipped with tools to solve such well-defined problems using foundational engineering knowledge and tools.

In contrast to problem solving, we believe that the next generation of engineers need an entirely different paradigm, namely, dilemma management for engineering complex socio-techno-eco systems. Dilemma management broadens the purview of a problem, where an engineer begins to see a set of “events” rather leading to the problem being worked on. For example, the engineer may discover that the problem ceases to exist if an upstream event is managed, thereby completely eliminating the problem itself. Such activities enable the creation of new knowledge, and development of competencies to operate in a flattened world across multi-disciplinary and multi-cultural backgrounds. Management of dilemmas is the key to delivering transformations in complex socio-techno-eco systems. Our premise is that systems engineering is a means to resolve dilemmas between economic, social and environmental goals. Additionally, a university is a place to learn how to manage dilemmas between competing goals.

Management of dilemmas must start by dilemma identification. In this talk, the workshop organizers discussed a method for identifying dilemmas, documented by Bertus et al. The authors describe the method for a Feed-In-Tarriff (FIT) policy design scenario, as follows:

1. Identify the stakeholders. Develop a requirements list consisting of wishes and demand for each category of identified stakeholders.
2. Develop a requirements list for the policy makers.
3. Research and list the different characteristics of FIT policies, reduce the list to a manageable size for analysis.
4. Analyze the relationships between policy characteristics and policymakers’ requirements.
5. Analyze the response of stakeholders to different FIT policies.
6. Analyze the effects of stakeholders’ decisions on policymakers’ requirements.
7. Based on the analysis in steps 4, 5 and 6 identify dilemmas among three dimensions of sustainability pyramid, shown in Figure 3.
Similarly, an approach for systematically managing dilemmas was discussed in the workshop. The details of the approach are presented by Ahmad et al. Following Talk 5, the participants were asked to identify the education-specific dilemmas associated with implementing new educational approach for the 21st century. The activity was performed in the groups formed on Day 1.

3.6 Talk 6: Self-grading and Closing the Loop

Talk 6 was focused on QW5: “How can personalized learning objectives and competencies be achieved in classroom settings?”. In this talk the workshop organizers discussed the importance of self-evaluation as an essential part of learning how to learn. In the approach discussed by the organizers, students are called on to close the loop with regard to what each has learned – to what extent have they achieved the competencies and the associated learning objectives proposed at the start of the learning activity. The students are asked to address the following in their self-evaluation:

- Summarize your contributions under the following headings:
  - Themes / ideas proposed by you and adopted by the group.
  - Themes / ideas proposed by others that were adopted by the group.
- Please convey how you progressed in attaining your competencies and learning objectives throughout the semester.
- Reflect on your performance in this class throughout the semester.
  - Contribution to the collective Question for the Semester. Justify.
  - Degree to which you attained your competencies and learning objectives and why.
  - Degree to which you learned what you would do differently and why.
- Overall grade you award yourself for this submission.
In the approach developed by the workshop coordinators, the students are required to revisit all their activities and deliverables, and to reflect on the extent to which they have managed to climb the Bloom’s taxonomy, and to what degree have they learnt how to learn. In addition to revisiting the learning objectives and competencies, the students are called on to reflect on their learning process, the quality of their contributions to the various assignments, the value gained with respect to attaining their individual learning objectives and competencies as well as the value added to the overall learning organization. Finally, based upon this self-reflection, the students are asked to propose a grading scheme for evaluating their own work as well as that of their peers. This includes developing a comprehensive assessment rubric showing the categories of work to be assessed along with justifications for the various degrees of achievement, as well as the articulation of the specific grades they believe they have earned. This grading approach was shared with the workshop participants as a part of the overall learning process.

3.7 Wrap-up and Feedback

At the end of the workshop, we collected feedback at the end of workshop by asking them to list:

1. The three most important things (in order) that they liked about this workshop
2. The three most important things (in order) that can be improved
3. The interventions that they would recommend in the area of engineering education?

We received 20 responses. In response to the first item, most of the participants said that they enjoyed the interactive, active-learning style of the workshop. Most of them felt that the workshop should have been for longer duration (about 5-6 days). In terms of the content, the topics that they liked the most are: the global context of education, competency-based learning, dilemma management, and the sustainability pyramid.

In response to the second item, some participants reported that all the concepts were not clear enough due to the breadth of issues covered and the short timeframe. Some participants wanted to cover topics such as Bloom’s taxonomy, emerging trends and more local scenarios in greater depth. Finally, in response to the question about interventions they would recommend, many participants listed the needs for competency-based education to complement the current educational system. Many participants highlighted the need to include more active learning techniques within the engineering curricula. One participant identified the need to build a community of educators who are interested in implementing ideas from the workshop. Some of the quotes from the participants are:

- “At least one competency based course to be included in the curriculum” and “Combination of learning and competency-based approach”
- “Bridging white space competencies in curriculum design and evaluation”
- “Regular meetings of interested faculty to share their experience while implementing the learnings of the workshop.”
4 Closing thoughts

An edifice of an educational organization rests on three pillars – faculty, student and infrastructure. Of the three, faculty is both an active and a stable pillar. It largely decides quality of the other two pillars. Even though it is obvious, the faculty members, especially in Indian engineering education system, did not attract attention commensurate to its criticality from leadership as well as industry. Increasingly, Indian education system has been playing a significant role in serving the global demand of engineering talent. As we go forward, it is going to increase its contribution and requires global attention right at this stage. Therefore it is imperative that all the stakeholders converge on this vital faculty pillar of the critical education system and more carefully nurture it.

In this paper, an effort towards educating the educators of 21st century Indian engineers is presented. The effort is based on foundational threshold concepts and approaches developed over the past two decades. The approaches are centered on competency-based principles of learning, mass customization of learning experiences, and collective learning based through learning organizations. The workshop was structured as a two-day event with the first day focused on identifying the issues and necessary competencies, and the second day focused on developing courseware to address the competencies. Various group activities were carried out to reinforce the concepts. During the next offering of the workshop, the feedback received from the participants will be accounted for. Specifically, the duration of the workshop will be increased to provide sufficient time for discussion and more group activities around specific courses within the Indian engineering education curriculum.

5 References