Knowledge Center as a Grass root Initiative for Making Engineering Education in India Meaningful

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***Abstract*— The mushroom growth of engineering institutes in India on one hand and the growing disinterest of youth in engineering careers on the other hand has brought into sharp focus the issue of quality of engineering education in the country. In this paper we discuss how the present engineering education is falling short of country's expectations and how the knowledge center initiative recently taken in our institute can compensate for the lacunae of this education system. The initiative aims to convey how knowledge of engineering and science can be interesting, useful and enlightening promising benefits of joy, jobs, wealth and wisdom to learners. A case study of our application of this initiative to the knowledge domain of light is presented. Our encouraging results motivate us to propose it as a grass root initiative that can make engineering education in India meaningful with the addition of perspectives of knowledge, skill and wisdom to the prevailing education system.**

***Index Terms*— knowledge center, engineering education, accreditation, Employability, skill, wisdom, knowledge society, outcome based education, engineering ethics, industry-institute interaction**

I. Introduction

From about 44 engineering institutes at the time of independence with a total intake of 3200 students to over 3000 institutes at present with the corresponding intake of over 16 lakh students [1], there has been a steep quantitative growth of engineering education in India. However, recent reports about the unemployability of majority of the engineering graduates and the rapidly declining interest of youth in engineering education have brought into sharp focus the issue of quality of engineering education in India. Though this scenario has been well studied and the challenges faced by Indian engineering education have been documented by several experts [2-7], there is a dearth of grass root initiatives in this regard. This is particularly more significant from the view of India's aspirations towards a knowledge society [8, 9]. Recently we have taken Knowledge Center Initiative (KCI) in our institute that addresses this issue [10, 11]. In this paper we discuss our recent research under this initiative.

II. Engineering Education Falling Short of Expectations

Recently several studies, reports and eminent persons of India have expressed serious concerns about how engineering education in India is falling much short of the desired expectations of the country in general and industry in particular [2-7, 12, 13]. If we retrospect the scenario of engineering education in last two decades, we find it to be going through a vicious circle. If we compare the gross enrollment ratio (GER) for higher education in India, which was estimated to be 22.5 % for 2013-14, we find it lower compared to that for the developed nations of the world (more than 40 %). [14]. Thus granting permissions to a large number of self financed institutes can be understood as a response to the need for increase in GER. But the number proliferated in an unprecedented and uncontrolled way in the last two decades as can be seen from Table I. In just five years, from 2006 to 2011, the number increased more than two-fold.

TABLE I. Number of Engineering Colleges and Students Intake [1, 15]

Year	No of colleges	Student intake
2006-07	1511	659717
2007-08	1668	701214
2008-09	2388	753910
2009-10	2972	1093380
2010-11	3222	1219347
2011-12	3286	1386083
2012-13	3369	1565722
2013-14	3384	1634596
2014-15	3392	1702827
2015-16	3345	1630790
2016-17	3289	1553809

For a variety of reasons [2-7], the majority of these institutes could not meet the quality demands of engineering education. The foremost among them are weak accreditation procedures and poor monitoring of quality norms by regulatory bodies, shortage of qualified faculty, poor teaching learning processes that fail to create student's interests, poor industry-institute linkages and running of second shifts by some renowned colleges in an ineffective way. The poor quality of education resulted in turning out engineering graduates lacking in

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requisite knowledge and skills for employment in industries. According to the National Employability Report (2015-16) by Aspiring Minds [16] over 80 % of the engineering graduates in the country are unemployable. In case of mechanical, electronics / electrical and civil engineering, a mere 7.49 % are employable. The mismatch of education with the world of work also resulted in many engineering graduates ending up doing jobs that has no link with their study towards graduation.

As industries started rejecting the products of engineering education in such a large number the faith of stakeholders in engineering education started eroding and the preference of engineering as a career option started going down. As a result the number of vacant seats in engineering colleges has been steeply rising since last few years. For example, in Andhra Pradesh the number of vacant states increased from 40,273 in 2010 to 76,310 in 2011 and further to 1,00,392 in 2012. In 2012, six colleges in Andhra Pradesh didn't have a single student and 24 colleges had less than 10 [5]. Almost all states have been facing the same problem since last few years. In 2015, 50 per cent engineering seats were vacant across the country [17].

Thus the envisaged expansion didn't work in a proper manner but it rather boomeranged. An interesting observation is that the institutes, which bypassed the accreditation standards and eluded the quality check of the government (though accreditation is mandatory, very few engineering institutes in India are actually accredited [7]), ultimately got trapped in quality checks of the stakeholders and society.

This also gave rise to two more vicious circles. With large opportunities of admission to engineering institutes many of the colleges admitted students with very poor performance at the qualifying examinations for their sustenance. In order to push these students ahead through their engineering courses lot of compromises have been made on the academic front. It is not surprising that industries often overlook the marks earned by students in colleges as it has been a widely shared experience by industry that these marks are unrelated to their knowledge and skill based competences. Thus, even though some colleges just pull on with the poor intake they accept, the inability of these students is exposed at the time of placement, leading to further cumulative reduction in industry's faith and corresponding rise in unemployability. Secondly due to large number of vacant seats many colleges face financial crisis and make compromises on standards of faculty, infrastructure and laboratory equipment. This further reduces the quality and hence the stakeholder's faith in engineering education.

However, this is not to point out that the envisaged expansion was wrong. There are only 1,290 engineering students per million population in India, whereas it is 2570 in USA, 2356 in UK, 3791 in Japan, 3149 in China, and 11227 for Russian federation and S and T personnel per thousand population in India is 3.5 as against 8.1 in China, 45.9 in South Korea 45.9, 55 in U.S.A., 76 in Germany and Israel and 110 in Japan [2, 3]. Thus the expansion is very much needed for country's global competence. Secondly the issue of quality is also addressed in a fruitful way to some extent by the first-tier and second-tier engineering institutes. The premiere institutes like IITs and BITS, Pilani are widely considered to offer the highest-quality engineering education. However, they are like 'islands of excellence' as they represent just about 1 percent of the total engineering graduates turned out every year in India. The rest major lot has to wallow in mediocrity.

One of the major reasons cited for the current grim scenario is the failure on the part of the regulatory bodies in maintaining standards through effective monitoring. However, recently AICTE has sought to stem the decline in the quality of engineering education by reducing 40 % of the intake over next few years [18]. For the first time in last several years AICTE has closed down about 386 engineering institutes and 3539 courses in the last five years [1]. Such welcome measures will go a long way in achieving a planned and quality controlled expansion of engineering education in India. As the major participation in engineering education is from private management, which accounted for about 94 percent of engineering institutions in 2011 [3], a significant contribution in facing the present challenge is also expected to come from them. Recently we have taken a Knowledge Center Initiative (KCI) in our institute that aims to compensate for the lacunae that ails our present education structure. The encouraging results of this initiative motivate us to propose it as a grass root initiative for making engineering education in India meaningful.

III. KNOWLEDGE CENTER INITIATIVE

As explained in our earlier papers [8, 10, 11] the KCI aimed at facilitating learners with a cafeteria approach to uncover and discover what they cover as a part of the university syllabi, which will ensure their enjoyment, employment, empowerment and enlightenment. This aim demanded departure from the routine education pattern and brought to fore several new ideas and interesting results. The research into this initiative laid bare several gaps of the present system and also brought to fore effective solutions to fill them. It opened doors for knowledge and creativity that the system almost prohibited. In Table II we summarize these lacunae and their solutions with our initiative. The cumulative output of our research work under this initiative is available on our website [19].

TABLE II. LACUNAE IN THE PRESENT SYSTEM AND THEIR KCI SOLUTIONS

Existing gap in the present system	How the KCI fills it
The knowledge of science and engineering has been brought forth by scientists and technocrats through assiduous and painstaking work. The stories and anecdotes that depict these endeavours are inspiring but are often neglected as they cannot be made a part of the examination oriented system.	Knowledge through stories is a regular feature of our initiative. The stories cover a wide spectrum of a rich variety of flavours of scientific discoveries and engineering accomplishments. Few examples are stories that convey how failures have been overcome, how doing helps learning and how accuracy of planning and consistency of implementation is important in such pursuits.

Knowledge has been expanding at a rate more than ever before and a syllabus oriented approach cannot keep pace with what is currently happening or envisaged for future.	Students are regularly exposed to current knowledge under our initiative. For example, the recent detection of gravitational waves [20] aroused lot of interest as it proved the prediction which Einstein made hundred years back.
Many of the knowledge concepts and skills can be acquired only by doing. But students are not free to learn in this most effective way. There is an experimental component but it is never used optimally. As all students are expected to get similar results the scope for individual creativity is severely constrained. The marks based approach often results in students missing the valuable experience of learning by doing.	The KCI has been enriching our experience of how the goals of internalization of knowledge and skills are achievable only by involving oneself completely in that learning goal, i.e., by doing. The doable projects done under KCI are very different than the experiments covered in the laboratory. As there are no marks a learner gets the credit only upon completion of the intended project and demonstration of the skill acquired. As there are no fixed results there is hardly any scope for manipulation.
Quotations by great men are like pearls in the ocean of knowledge and wisdom and have always been a source of inspiration for learners. However, they are only of an ornamental value in the existing system.	A regular feature, 'Quotations – Pearls in the Ocean of Knowledge and Wisdom' has been recently started in which various quotations by famous scientists, engineers and visionaries are elaborated to convey their import to the students.
Subtleties of knowledge are often neglected because more elusive the knowledge more difficult it is to mould in a mediocre examination pattern. This is reflected in the vast difference in the examination standards of mediocre and premier institutes.	As a part of the 'Curiosity Corner' activity of our initiative students are encouraged to ask questions and pursue them to explore the underlying concepts to a depth that will satisfy their curiosity, leading to the ability to read between the lines and to the development of insights.

The methodology of our initiative is explained in our earlier paper [11]. Following this methodology we directed our efforts towards the knowledge domain of light in 2015, which was declared as the International Year of Light by the United Nations. Pursuits by students and faculty under the KCI culminated in impressive outputs that were showcased in the knowledge and wisdom corridors that were developed for this purpose. These outputs are briefly presented below in the form of a case study.

IV. Case Study - Application of KCI to the Knowledge Domain of Light

The knowledge domain of light is close to the life of almost everyone and has a rich interface of applications with theory at levels extending from school to advanced research. This domain was explored beyond the limited aim of marks in order to achieve the objectives of KCI mentioned earlier.

The output of our work included 3 articles, in the form of stories, published / to be published in 'Science Reporter' [19, 21] and a series of 10 stories published in the local daily, 'Hitavada' [19, 22]. The titles of the stories are included in Table III. A knowledge exhibition was curated that displayed about 72 A3 size posters and 28 A4 size posters that conveyed how knowledge of light promises joy, jobs, wealth and wisdom of learners. The exhibition was visited by a large number of visitors and fetched accolades from media [23]. The initiative had earlier fetched an encouraging response from several eminent persons (included under 'response' in our website [19]). In Table IV a summary of the exhibition is presented.

TABLE III. Published stories based on knowledge of light

Stories published / to be published in Science Reporter			
1. Decoding the Enigma Called Light, published in May 2015 as a cover story **2.** Wonder Pipes for Digital India - Optical Fibres, published in February 2016 3. Seeing the World of Eye, to be published			
Stories published in the Hitavada			
Title	**Date**	**Title**	**Date**
1. Story of light	22/9/2015	6. Learning light lightly	3/11/2015
2. Light through the lens of history	29/9/2015	7. Light plus light is not always light	10/11/2015
3. Decoding the mystery of light	6/10/2015	8. Lighting the world of eye	24/11/2015
4. Tapping the treasure of radiation	20/10/2015	9. Light for employment and empowerment	1/12/2015
5. Knowing where light comes from	27/10/2015	10. Story of light for enjoyment and enlightenment	8/12/2015

TABLE IV. Posters displayed in the exhibition on light

- Logos and photographs of celebrations of International Year of Light in different parts of the world
- Curious questions asked by physicists and theories advanced by them about nature of light
- Quotations about light by scientists and other great personalities
- Careers and professions based on light
- Books on light authored by scientists
- Nobel prizes awarded on discoveries and inventions related to light
- Phenomena of light in nature such as sunrise, sunset, blue sky, white clouds, mirage, sparkle of a diamond, emission of light by the firefly and beautiful colours of bird feathers, soap bubbles, clouds and rainbow and their explanations as refinement of everyday thinking
- Light as a part of the electromagnetic spectrum, hazards of electromagnetic radiation
- Knowledge world of eye, LASIK eye surgery
- Applications based on the knowledge of light such as light sources and lighting technologies (CFLs, LEDs, lasers etc), glare reduction by polaroid sunglasses, geometric optic technologies, quantum optic technologies, interferometers, scanning electron microscope, photodevices, imaging

technologies, holography and LIDAR applications

- History of Lasers and its key role in US economy, how lasers empower our world by enabling business, creating jobs and improving lives, how lasers are used in Manufacturing, Medicine, Biotechnology, Telecom and Information Technology, and how basic research in laser science continues to drive innovation [24]
- History of optical fibers, story of discovery, improvements in the fiber optic systems, protection, installation and splicing of optical fibers, fiber optic sensors, aims of digital India

V. KCI AS A GRASS ROOT INITIATIVE FOR INDIA

In our last paper we discussed how our initiative can institutionalize knowledge reforms in an engineering institute. Our recent experiences with this initiative have further substantiated our belief due to its consonance with India's aspiration towards reemergence as a knowledge society [8] and also with the prevalent ideas addressing quality concerns of education such as accreditation, Outcome Based Education (OBE), engineering ethics and industry-institute interaction (Table V). This belief motivates us to suggest KCI as a grass root initiative that can favourably impact engineering education in India.

The KCI started with physics and has been broadening to other engineering subjects on one hand and deepening to more roots of physics on the other hand. Thus our earlier physics knowledge center has been opening scope for development of optics knowledge center and further for that of laser knowledge center. A knowledge hierarchy in place may prove to be a more appropriate strategy towards our aspiration instead of the existing educational hierarchy that puts apart just 1 % bright learners from the rest and thus fails to take advantage of our rich youth demographic dividend. It is not possible to take all aspiring students to IITs but it is possible to take the IIT like ambience to every aspiring student. KCI captures this spirit and can be an effective step in developing 'excellence out of mediocrity'. As a grass root initiative it promises to be a new learning paradigm for the overhaul of engineering education in India.

TABLE V. CONSONANCE OF KCI WITH THE PREVALENT IDEAS ADDRESSING QUALITY CONCERNS

Accreditation and Outcome Based Education

Accreditation is the process by which the quality of engineering education can be evaluated by an external body. On 13th June 2014, India became the permanent signatory member of the Washington Accord – an international accreditation agreement, created in 1989, for engineering degrees based on OBE methods. With this accord, the National board of accreditation (NBA), the accreditating body of India, has started accrediting engineering programs in India that follow OBE methods [25].

The accreditation procedures are usually based on the attainment of the program objectives/outcomes (POs) and course outcomes (COs) [26]. These COs and POs are mostly defined in terms of knowledge gained and skills acquired, which are a primary focus of our initiative. The student centric focus of OBE is also well served with KCI as teachers become facilitators in our initiative and the diversities of the natural propensities and competences of learners are given due importance in the learning process. For example, in our earlier paper we discussed how initiatives in teaching learning process that address the goal of assisting both bright and weak students (listed under Sec. 2.2.1 of the NBA document) are closely served with our initiative [11]. Thus the focus on outcomes is very well achieved with KCI as compared to the existing education structure, which is based only on the marks scored in examinations thus smothering individuality and compelling everyone to try to reach the same goal in the same time despite widely varying natural competences of knowledge and skills. As marks are treated as 'official parameters' of learning outcome measurements, the goals of knowledge and skill are often converted into goals of marks that are greatly vulnerable to dilution at various stages.

Industry Academia Interaction

The mismatch between the skills that education impart and the skills required by the workplace has been discussed by several workers [27-29] who have stressed for more effective industry academia interaction. Education concerns more with conceptualization and validation at the laboratory level whereas industry concerns with translation of the laboratory validated concept into economically viable commercial propositions. Jalote [28] has stressed the need for suitable platforms for achieving this kind of interaction. The knowledge paper on skill development in India [29] has put the "learner" first and elaborated upon how the "demographic dividend" can be used for the success of skill development mission of India, which has set a target to skill 500 million people by 2022. At present only 10% of the total workforce in the country receives some kind of skill training as compared to 96 % in Korea, 80 % in Japan and 75 % in Germany.

Knowledge centers promises to be an appropriate platform for skill based reorientation of education as the open-ended approach of KCI helps in bringing to fore connections between classroom and industry. The theory and problems covered as a part of the syllabus often misrepresent the situations that engineers encounter in their field. Under KCI students are encouraged to interact with the experts and get exposed to the field situations to enable a more complete and relevant learning through hands-on experience and building entrepreneurship skills.

Engineering Ethics

Wisdom and ethics are important aspects of engineering education but they too slip out of the rigidity of present education like knowledge and skills. According to Nichols *et al.* [30], "For engineers, engineering ethics is not a topic separate from engineering, it is part of the essence of engineering --- ." Various features of our initiative and the methodology we follow are not constrained by the limitations of a marks based system and thus facilitate natural development of passion and commitment towards pursuing knowledge and lifelong learning. Inculcation of modesty and wisdom, which are important aspects of engineering ethics are in built in our methodology. Our recent relevant contributions in this regard are a report, "Mahatma Gandhi – Pioneer of the science of nonviolence" published in a US magazine [31] and a paper on how Gandhian model of education can be materialized through KCI, presented at the national conference on the new education policy and Nai Talim [32].

VI. CONCLUSION

In this paper we discussed our KCI that can arrest the deterioration of engineering education and provide effective solutions to the challenges it is facing currently. Traditionally the Government was responsible for higher education. But today the solutions from the Government will not suffice as the private participation has increased enormously. We have sought effective solutions to these challenges through our KCI by adding the perspective of knowledge, skill and wisdom to the existing system and reached a conclusion that it has the potential to be a proactive grass root initiative for the overhaul of engineering education in India. The initiative has been throwing open many new motivations which are currently being pursued.

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