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Knowledge Center Initiative for Contributing to Catalyze the Transformation of Engineering Education in India

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Abstract : The processes of imparting and acquiring knowledge, skills and wisdom through educational institutes are key contributors in the cause of national development. However, if we examine the scenario of engineering education in India from this perspective, we find that it has been departing from these primary goals in recent years due to the rigid confinements of marks and degrees. Recently we have taken a knowledge center initiative in our institute that facilitates learning in an open and flexible way using a cafeteria approach that ensures enjoyment, employment, empowerment and enlightenment of learners. In this paper we discuss the impact and growth of this initiative in contributing to transforming education in our institute through development of new and innovative processes of imparting and acquiring knowledge, skills and wisdom that go much beyond the narrow boundaries of marks and degrees. We further discuss how this initiative can also contribute effectively to catalyze the transformation of engineering education in India.

Keywords : engineering education; knowledge center initiative; knowledge spiral; learning motivations, learning by doing, curiosity based learning, experiential learning

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1. Introduction

Education plays a key role in the development of any nation because the educational processes of imparting and acquiring knowledge, skills and wisdom are the key ingredients in building the knowledge foundation of any country. This is aptly clear from the history of developed countries, which could build a strong knowledge foundation and harness it concomitantly to achieve a rapid technological growth and a sound economy. For example, Denison attributed 94 percent of the growth of the US economy from 1929 to 1982 to factors relating to knowledge generation and dissemination [1]. In a paper, "Knowledge for Development" by Jacobs and Asokan [2], the authors argue that knowledge has emerged as one of the most important development resources that can dramatically accelerate India's development. This is because the characteristics of knowledge differ greatly from those of material and financial resources. Knowledge is not lost when it is given away. Rather it expands when shared.

Engineering education is mainly concerned with disseminating knowledge that is created through research and applied in industries. Developmental goals thus demand strengthening the links of engineering education with research, industry and culture. However, if we look at the present scenario in India from this perspective we find that these links have been largely obscured and education has got confined to the rigid boundaries of marks and degrees thus leading to education becoming a goal in itself, bereft of challenges pertaining to creation and application of knowledge.

Recently we have taken a knowledge center initiative (KCI) in our institute [3-6] that aims to convey how knowledge can be made interesting, useful and enlightening to promise the benefits of joy, jobs, wealth and wisdom to learners. In this paper we discuss how this initiative has been growing in its role of transforming education in our institute and how it can also contribute effectively to catalyze the transformation of engineering education in India. We first discuss the prevailing deterioration of engineering education in India (Section 2). Then we discuss how our attempt to arrest this deterioration by bringing forth new and innovative processes of imparting and acquiring knowledge, skills and wisdom became the motivation and basis of KCI (Section 3). In section 4 we discuss the impact and growth of KCI. In conclusion we discuss the immense potential of this initiative in catalyzing the transformation of engineering education in India (Section 5).

2. Current Scenario of Engineering and Engineering Education in India

That India has been aware of the power of engineering and science in the shaping of a nation is evident from our spectacular achievements in the fields of space exploration, information technology, agriculture, healthcare and nuclear technology. We are the second largest group of scientists and engineers and one of the largest producers of engineers in the world and are among the very few countries which have developed indigenous nuclear technology and ballistic missiles. Our spectacular achievements include, among others, being the first Asian nation and only the fourth in the world to reach Mars orbit, only the second nation after USA in the field of supercomputing after the development of PARAM (the superconducting machine) and only the second country outside Europe to join the European Molecular Biology Organization [7]. Though these achievements accord us a status of a strongly developing nation, we are far behind in the race towards a developed nation as can be seen from the Table I.

Table 1: India in Comparison with Developed Countries

Parameter ↓ Country →	USA	UK	Japan	Germany	India	Reference
Gross enrolment ratio, Tertiary, 201 3	89%	57 %	62 %	61 %	24 %	[8]
Expenditure on res earch and development (% of GDP) (year in brackets)	2.742 (2013)	1.701 (2014)	3.584 (2014)	2.869 (2014)	0.85 (2015)	[9]
Researchers in R & D per million people [(2015); for USA the data is for 2014]	4232	4471	5231	4431	216	[10]
% share of scientific publications 2005	38.5	8.6	10.3	9.5	2.6	[11]
% share of scientific citations 2005	62.7	12.0	9.9	11.5	1.1	[11]
% share of GDP 2005	20.10	3.00	6.40	4.13	5.95	[11]
GDP in $ trillion, 2012	15.68	2.44	5.96	3.40	1.84	[12]
Number of Patent applications filed 2013	287,831	14,972	271,731	47,353	10,669	[13]

Science and engineering are fields of curiosity and creativity, of questioning and exploring and of discoveries and inventions. Knowledge, skills and wisdom are thus the fundamental requirements for contributing to developments in these fields. However, several eminent persons including the prime ministers and the presidents of the country have expressed grave concerns about the existing education scenario in the country and the need for its overhaul to meet the challenges before India's aspiration of a knowledge society [3-6, 14, 15]. We have discussed this scenario in detail in our earlier papers [3-6]. However, it is included here briefly for the sake of completeness.

India's higher education system is the third largest in the world, after China and the United States [11] and engineering education constitutes a major component of this system. Today we have more number of engineering institutes in the country than the number of engineering students at the time of independence. The number of institutes has increased from 44 to 3224 (about 73 times) and the intake capacity has gone up from 3200 to 1336832 (about 418 times) [16]. However, this expansion left much to be desired because of the growing unemployability of engineering graduates and rapidly declining interest of youth in engineering education. According to the recent statistics over 80 % of the engineering graduates in the country are unemployable, about 50 per cent engineering seats across the country have been remaining vacant [6] and science has dislodged engineering as a preference for UG education [17].

Our system of engineering education hasn't undergone any major changes since it was first introduced. However, in the initial years of its introduction, it served its intended purpose well resulting in a satisfactory balance between students admitted, students graduated and students employed. As the number started increasing, examination oriented practices started getting more preference and popularity over the knowledge oriented ones. The meaning of education started getting constricted to preparing students for answering questions based on syllabi and asked in exams. This shrunk the vast domain of engineering education to the limited aims of taking examinations and awarding degrees resulting in the distortion and deterioration of learning processes. The products of these structures thus started getting conditioned to be taught rather than to learn thus turning out only literates and graduates instead of engineers in the true sense of the term.

In India, admissions to engineering courses are done through competitive exams for which students can appear after completing 12 years of their education in the 10 + 2 pattern. Only about 1 % of the total number of students who appear for these exams get selected for admission to premiere institutes like IITs, IISERs, NITs and BITS Pilani and the remaining majority enter colleges affiliated to the universities. There is a vast difference between the quality of education imparted in premiere institutes and that in the affiliated colleges.

The exam structures of premiere institutes have been mostly reformed and moulded in knowledge based ways so that these institutes are KCs by default. However, this is not so in the majority of colleges affiliated to the universities. These institutes are governed in a way that is similar to different boards governing the schools and junior colleges, which have been criticized for their marks based orientation that emphasizes rote learning and for issues like grade inflation and "artificial spiking of marks" [18]. Thus about 1 % students get access to quality education that is knowledge based whereas others continue with similar marks based structures.

As the education system started getting deteriorated it also started showing its negative consequences for the Indian society. Many fake colleges and universities sprang up in the country that awarded marks and degrees to students with the sole objective of minting money. Educational corruption in India is considered as one of the major contributors to domestic black money [19]. Though there are

Table 2:Knowledge Center versus Present Education Center

Knowledge Center	Education Center
The goal of learning is to get joy, job, wealth and wisdom.	The goal of learning is to get marks, grades and degrees.
Guides / Experts facilitate learning, uncover and discover syllabi and prepare learners for career and life goals.	Teachers teach topics, cover syllabi and prepare students for the goals of clearing examinations.
Learning is by reading between the lines and developing insights and evaluation is through applications of what is learnt in one's career and life. This creates mindsets of students in favour of assimilation and application of knowledge.	Learning is by reading and remembering the lines (of the answers) and evaluation is through how many of them are reproduced in exams. This creates mindsets of students in favour of memorization.
Experience and internalization of knowledge is achieved through informal learning processes in which attention is more important than physical attendance.	Exposure to knowledge is achieved through formal lectures and physical attendance in classes is given utmost importance.
A cafeteria approach is followed and individual propensity and competence decides the learning goals and the time to attain them. Thus a 'fixed syllabus' is replaced by an open and flexible knowledge spiral [5] which can be climbed to different extents by different individuals as per their needs and inclinations. Thus different learners follow different learning curves. This leads to encouragement to excellence as well as inclusion.	A 'one size fits all' approach is followed compelling everyone to set the same learning goals and reach them in the same time despite widely varying natural propensities and competencies. Thus all students are required to follow the same learning curve (or rather a straight path). This smothers individuality and very often leads to attitudes of vanity among students scoring higher marks and of depression among those scoring low marks.

mechanisms such as accreditation bodies in place for ensuring quality of higher education, they have not yielded quite encouraging results so far [14, 20].

Thus a closer look at the education scenario reveals that the marks based educational hierarchies that exist in India are unable to utilize properly the favourable demography of our youth [more than 50% of our population being below the age of 25 [21]]. Only a few premiere institutes cannot fulfill the knowledge aspirations of a large country like ours. Moreover, the contributions from such institutes to these aspirations have not been significant due to the acute problem of brain drain. Marks can be a barrier for access to quality education but there can be no barriers to curiosity, knowledge and creativity. If we can move from the present artificial educational hierarchies towards natural knowledge hierarchies through initiatives such as KCI we can serve India's aspiration better as brought out in the following.

3. Motivation and Basis of KCI

KCI was launched in our institute about three years back solely as a new learning initiative under which we could experiment with our ideas of free, open and flexible learning. These experiments in turn enriched our own learning experiences that helped in giving shape to the initiative. Experiments that yielded deliverables became the basis for the sustenance of KCI, whereas those that didn't yield any became our useful learning experiences. These experiences helped us to come out clear about how KCs differ from the present education centers. Table 2 lists these differences.

In a short span of time KCI started showing germs of expansion in many directions and came to be perceived as a breath of fresh air that promised to break the monotony of the rigid examination oriented atmosphere of an educational institute. It enabled us to look beyond the boundaries imposed by our current education structures and opened new vistas to several interesting motivations of imparting and acquiring knowledge, skills and wisdom that our education system almost prohibits or leaves unaddressed. Table 3 lists the main motivations that helped to us to build and fortify the basis of KCI.

Table 3 : Motivations that Helped to Develop the Basis of KCI

Curiosity Based Learning : Learning can be enhanced if it is pursued out of natural curiosity as there is lot of science and engineering around us which cannot be moulded in the syllabus oriented format comprising of terms, laws, formulae, definitions, descriptions and derivations but can be learnt out of wondering about them and exploring the underlying caus es. Such learning makes one appreciate how knowledge can be exciting, wonderful and novel. History of science tells us that wonders led to many discoveries, which, in turn, led to more wonders. Curiosity leads to knowledge but what is more interesting is that knowledge leads to more curiosity!
Learning by Doing : Learning by doing involves learning through experience (experiential learning) and is a proven way for internalizing knowledge and developing entrepreneurshipskills. In the existing structure laboratories provide opportunities for such learning. However, again due to the examination orientation, all students are expected (and even compelled sometimes) to get similar results after performing experiments and the scope for individual learning and creativity is severely curtailed.
Learning in a Seamless and Holistic Way : Education compartmentalizes knowledge into disciplines with thick boundaries, whereas knowledge inputs from many disciplines merge seamlessly an d holistically in nature as well as in the world of work. There is a deep interconnectedness among various knowledge domains and researches based on the interflow of ideas among them have led to the synergistic development of several interdisciplinary, mutidisciplinary and cross disciplinary branches of science and engineering. Motivation of learning in a seamless and holistic way thus promises to reduce the divorce of present education from reality.
Learning About the Advancing Frontiers : Knowledge has been expanding at unprecedented rates and a syllabus oriented approach cannot keep pace with what is currently happening or envisaged for near future. Learning about the advancing frontiers of science and engineering helps learners update and appreciate the current happenings in these domains and broaden the horizons of their knowledge.

Learning through Stories, Jokes, Pictures and Quotes : Learning can be made more joyful and interesting through these varied features. Stories of the eureka moments of scientists and engineers convey the excitements in research and stories that relate their assiduous and painstaking struggles in reaching these moments convey the underlying challenges. Jokes can convey knowledge in lighter vein and pictures, due to their vividness, can clarify something that is difficult to put across in words. Quotations by great visionaries bring out the essence of their knowledge and wisdom and can provide constant illumination to enquiring and inspired mindslike pearls in the ocean of knowledge and wisdom
Learning through Excerpts from Books : Many of the authoritativebooks include excerpts that greatly enhance the understanding of the ideas being described. However, such novel and rigorous knowledge scarcely reach students because it cannot be moulded in the exam format. Thus the syllabus, which can be covered through exam oriented books, can be uncovered and discovered through such knowledge oriented books.

The motivations included in Table 3 necessitated institutionalising new methods and mechanisms of learning and using new learning resources that are different than the ones that are currently in use for studying syllabi and passing examinations. Earlier KCI was perceived as an 'extra mile initiative' introduced as a compensatory mechanism to overcome the lacunae of the present system [5]. Thus the activities under KCI were scheduled outside the working hours of the institute. But as the fundamental role of the initiative started becoming more and more convincing KC slots were accommodated in the regular time table for facilitating learning as per the objectives of KCI.

Though knowledge is essentially unstructured, these slots helped us to put in place a simple, broad structure and a mechanism to allow the initiative to grow. A simple methodology that evolved out of these initial steps is to arouse the motivation of students to learn under KCI and facilitate and mentor their learning. The learning pursuit may lead to an output in some form like a poster, article, paper, presentation, dissertation or demonstration but the main emphasis is not on the output but on the process of learning. The detailed methodology and a case study based on its application are discussed in our earlier paper [5].

Requirement of learning resources suitable for KCI provided motivation to faculty members to uncover and discover the syllabi they taught to collect and develop learning material of this type. We found that the motivations listed in table 3 could be served better by developing serial posters on these various themes and displaying them periodically. This led to exhibitions of such posters (A3 size) becoming a regular feature and a learning platform of our initiative. A case study of exhibition on light is presented earlier by us [6]. Knowledge oriented books and various periodicals dealing with science and engineering at UG level also became our learning resources.

Thus we could accommodate KCI in our institute within the available resources. The activities of the initiative could be conducted with small additional funds in the range of Rs 10000 to Rs 15,000 every year. With the well defined motivations and basis of KCI in place, we discuss, in the next section, how KCI could make an impact on students, faculty and the overall ambience of our institute that grew with each passing year.

4. Impact and Growth of KCI

KCI has taken impressive strides since its inception three years back [4]. Starting with physics department (2015-16), it first spread to the other departments of the first year (2016-17) and recently the initiative has been extended to all the departments and all the years of various engineering programs (2017-18). The impact has been twofold. As it was felt that KCI need not be restricted to physics alone but should be for all science and engineering subjects, PIET KC started taking shape and Physics KC continued by limiting its scope to knowledge of physics. Thus as PIET KC grew it also motivated development of other departmental KCs to address their domain specific knowledge. Today we have a PIET KC, which addresses the objectives of KCI in a comprehensive and holistic way and which comprises of 13 departmental KCs.

The growth in the impact of KCI became

discernable with increase in the number of students and faculty members exposed to the initiative and the infrastructure used for its purpose. This led to the concomitant growth in the number of students registering their learning motivations under KCI, number of articles / papers published under KCI and the number of posters available in KC. These data are presented in Table 4. Cumulative data are presented for number of posters and papers / articles because these are retained cumulatively in KC as learning resources for students.

Table 4: Data showing the Growth in the Impact of KCI

	2015-16 and before (2012 onwards)	2016-17	2017-18
Number of students registering their learning motivations out of the total number of students	48/284	51/300	275/1111
Cumulative number of articles/papers published [3-7, 22-38]	23*	29	32
Cumulative number of posters in KC	72	129	229

* includes 10 articles published in the local daily, 'Hitavada' on the eve of International Year of Light – 2015, available on our website [39]

As can be seen from this table, the number of students registering their learning motivations increased steeply in the current session mainly due to the fact that majority of the students were exposed to the initiative. In the earlier 2 sessions the initiative was restricted to first year students. However, in all the three sessions the numbers are smaller (less than a quarter fraction of the total number of students). It can be attributed to the factors that KC activities are not mandatory and KCI reform, like any other reform to be effective, is being pushed slowly. Secondly many of the students who find the existing syllabi and exams too difficult to cope up with cannot look beyond them. But even for these students KCI had been useful through its activity called 'knowledge clinic' under which students are counselled through personal interaction on how requisite knowledge for scoring in exams can be acquired.

Apart from this measurable impact, KCI also made a subtle but significant impact in several ways. It attracted large number of visitors, captured media attention [40] and improved the academic ambience of the institute. A picture story, 'a scholar and a boatman' [41], painted on a 30 ft × 10 ft wall of KC entrance, has been driving home the importance of

Table 5: Few Instances of the Subtle Influences of KCI

Posters displayed in the exhibition on light that discussed the phenomenon of interference of light in thin films and occurrence of different colours due to this phenomenon aroused the motivation of some students to learn about the beautiful colours of feathers of birds.
Several posters on Einstein (his research, struggle and quotes) and the book on Atomic Physics by J B Rajam [42] developed curiosity among some students about how the equation $E = mc^2$ can be derived.
The cover story of crystals in science reporter [33] motivated some students to know more about the simple crystal structures around us and also about the complicated ones such as penicillin and cholesterol.
Among those resources which have been evoking a lot of interest among learners are a book, 'Why the sky is blue' by C V Raman (lecture delivered on 22 Dec. 1968) [43] and a paper by Lawrence Bragg [44] (students study Bragg's law in their first year syllabus).
Resources like the articles written by college students [45 - 49] have been attracting and inspiring learners. These articles convey clearly what motivated the young authors to study and write (for example, Mahima Verma, who had just passed her XII exam, contributed an article on how Maxillary Sinus Cancer can be prevented after she lost her mother to this cancer [46]) and thus impact the peer learners.

acquiring knowledge and skills that are useful for one's life and thus conveying the relevance and utility of KCI. In Table 5 we discuss few more instances of the subtle influences of KCI.

These influences helped in maintaining our emphasis on the processes rather than the outputs of learning. Thus we focussed more on outcomes like kindling interests of students in knowledge oriented resources and enhancing the diversities of their learning motivations. As an example of the first outcome, the posters displaying excerpts taken from reference books stimulated students' interests and motivated them to read these books further (which they would have seldom read in normal course). Table 6 includes a few examples of such excerpts and the further reading that they motivated. Under the second outcome KCI could bring forth and handle a vast spectrum of the natural interests and inclinations of young minds that ranged from how a laser beam can read a CD to how spirituality can affect human mind, from how artificial diamonds can be produced to how vocabulary can be built, from how light is modelled differently by different scientists to how to learn about advanced topics in computer science like machine learning and deep learning. The learning curves of students also helped them in setting clear goals about their career and life. A few responses from the beneficiary students are uploaded on our site [39].

The major motivation for faculty under KCI is to uncover and discover the syllabi they cover in usual classes. Table 7 includes our updated work in this regard on 5 out of 8 units of our physics syllabi [52]. We are encouraged by the unlimited scope opened up by this motivation. For example, there are around 30-40 subjects in every engineering program, which pave way for lot of further work under this motivation. Even if we explore a particular unit once and contribute an article/paper based on it, new scope emerges when we revisit the unit. This is borne out by our work on unit on crystals [33, 37] and lasers [38, 22]. Secondly showcasing useful knowledge from varied sources for kindling interests of students is virtually a limitless process.

Table 6: Excerpts Stimulating Students' Interests

Excerpt	Reference, Page No.	Stimulation for Further Reading
"Scientists know the art of engineering the atoms."	[26], 311	Study of structure – property correlations in materials and use of this knowledge in development of materials with desired properties
"What is electrically impossible is electronically possible in a transistor"	[26], 417	Understanding transistor action and appreciating why transistor was such a novel discovery
"More we know more we come to know that there is much more to know."	[26], 242	The journey from physics of atoms to the physics of nuclei
"Reality, whether matter or radiation, is made up of a subtle and almost indefinable fusion of two antagonistic but complementary factors, the continuous wave and the discontinuous particle; it is a discontinuous continuity or a continuous discontinuity and hence not a simple but complex unity!"	[42], 494	Developing insight into wave –particle dualism of matter and radiation
"We are the children of stars."	[50], 1108	Stellar explosions; how elements in our bodies are manufactured in the interiors of stars
"Physics is not something that has to be done in a physics building."	[51], preface	Appreciating how physics is a philosophy of nature

Table 7: Our Updated work under 'Uncovering and Discovering the Syllabi'

Syllabus	Uncovering and Discovering the Syllabus
Unit III, BE I Sem. (Crystal Structure): SC, BCC and FCC unit cell characteristics, Miller indices, Inter-planar distance, Bragg's law of X-ray diffraction, Voids	Crystals around us in nature and technology: minerals, rocks, snowflakes, gems, metals and salts; Complicated structures such as cholesterol, penicillin and vitamin B12; Protein crystallography; Crystal polarimetry; Crystal engineering; Cambridge Structural Database; Nobel Laureates in X-ray Crystallography [33, 37]
Unit IV, BE I Sem. (Semiconductor Physics): Band-theory of solids, Fermi-Dirac distribution Function, Intrinsic and Extrinsic semiconductors, PN-junction diode, Tunnel diode, Zener diode, LED, Transistor, Hall effect	Understanding how semiconductors, which were considered useless 100 years back turned into the most useful materials; Band formation in different semiconductors, band gap engineering; semiconductor devices and junction devices; Physics involved in the discovery and development of transistor; Chip Revolution [34]
Unit I, BE II Sem (Laser): Coherence of a light wave, three Quantum Transitions, Metastable states, Pumping schemes, Principle of laser, Laser characteristics, Components of a laser, Principle & working of He-Ne, Ruby and Semiconductor lasers, Applications	How the invention of laser is looked upon as a solution looking for problems; Measuring distance between moon and earth using a laser beam; Applications such as Laser printer, CD, bar codes, cloth cutting, drilling, welding, marking, alloying, wire stripping, machining and polishing; Applications in fiber optic communication; Applications as a surgical and diagnostic tool [38, 22]
Unit IV, II Sem. BE (Wave Optics): Interference in thin films, Wedge shape thin film, Newton's rings; Anti-reflection coating; Advanced applications	Decoding an enigma called light; Applications of Interferometric techniques to determine various material properties and to test surface finish of devices; Design and development of thin films for desired applications [32]
Unit IV, II Sem. BE (Optical Fiber): Total internal reflection, structure and classification of fibers, Modes of propagation, Acceptance angle, Numerical aperture, Attenuation and dispersion, Light sources and Detectors, Applications as sensors and detectors	History of Optical Fibers; Design and development of fibers with low attenuation, low dispersion and high data transmission capacity; Application of fiber optic sensors for measurement of parameters such as pollutants, blood pressure and positions of earthquake faults; Fiber optic smart structures [30]

Table 8. Stable Themes of KCI

1. Learning through stories 2. Amazing Powers of Knowledge 3. Discovering the Joy of Knowledge – Eureka Moments of Scientists 4. Learning through Jokes 5. Curiosity Corner – Knowledge Around You 6. Learning through Pictures / Sketches / Diagrams 7. Learning by Doing 8. Knowledge for Career Edge – Learning through Applications	9. Seamless and Holistic Knowledge, 10. Wonderful and Exciting Knowledge 11. Learning through Quotations – Pearls in the Ocean of Knowledge and Wisdom 12. Advancing Frontiers of Knowledge 13. Novel knowledge 14. Uncovering and discovering syllabi 15. Education reforms for knowledge based India

In developing posters for exhibitions held under KCI, some of the themes which addressed the objectives of KCI very closely could be repeated through several examples. These themes have now become the stable themes of KC and are serialized. Some other themes, which are incidental, are displayed with their appropriate individual titles. Table 8 lists various stable themes evolved so far and Table 9 lists how a theme is serialised using an example of the theme, 'Learning through stories'. Table 10 lists the incidental themes of exhibitions held so far along with titles of few of the posters exhibited. Recently when Stephan Hawking, the famous physicist, passed away on 14/3/18 [53], KC paid a tribute to him through a poster on his famous quote, "The greatest enemy of knowledge is not ignorance, it is the illusion of knowledge".

Table 9: Titles of Posters Developed under the Theme, 'Learning Through Stories'

1. Plenty of Room at the Bottom - Story of Nanotechnology
2. Story of Alfred Nobel - "The Merchant of Death"!
3. Story of Semiconductors – How Useless Turned Useful
4. Student who disproved his teacher – Story of Discovery of Optical fiber by Narinder Kapaney
5. A Scientist who Failed 999 times - Struggle Story of Edison
6. Struggle Story of the Discovery of Blue LED
7. From a Clerk to the Greatest Scientist - Struggle Story of Albert Einstein
8. Struggle Story of Goddard - One of the Founding Fathers of Modern Rocketry

Table 10: Incidental Themes of Exhibitions and Few titles of the Exhibited Posters

Theme	Titles of posters
International Year of Light – 2015	Light in nature, Iridescent clouds, Light effects, Careers and Professions on light, Nobel Prizes on Light, Learning light, Light applications, Lasers in Science and Industry
Science, Engineering and Education from a Gandhian Perspective (2017-18)	Gandhi as a Scientist, Gandhi's Research Laboratories, Gandhi's Innovative Experiments, Gandhian Engineering, Gandhi on Basic Education, Gandhian Environmentalism, Scientists, Engineers and Educationists Influenced by Gandhi, Gandhi and the Nobel Peace Prize, Einstein on Gandhi, Khadi Science, Quantum Mechanics and Nonviolence, Scientific Inaccuracies of the Theory of Violence, Nonviolence and Swarm Theory, Self -Organization in the Cosmos, Microbial Universe and Nonviolence, Spirit and Science in the Vedanta
Another exhibition is currently being displayed with the theme, 'Wonderful World of Science, Technology and Engineering'. In addition to posters on stable themes, it also includes posters for all the 13 de partments that explain the rationale, evolution and current development of that knowledge domain and posters on the new themes like 'Science and Engineering for Nation', 'Science and Engineering in Society and Nature' and 'Scientists, Technologists and Engineers as Entrepreneurs'.	

5. KCI for Catalyzing the Transformation of Engineering Education in India

Undergraduate education is the phase of transformation in the life of an engineering student. In this phase a student needs to be educated to leave behind the routine and secure habits and known challenges of early education (known syllabi and familiar exams) and to be prepared to face the real world of new and unknown challenges of career and life. It is a phase in which students need to be gradually brought out of the life of exams and prepared to face the exam of life. KCI offers us an opportunity to contribute to this transformation by honing the innate propensities of a learner and chiselling a researcher, an author, an entrepreneur or any other resonating professional out of him / her; KCI can make the learner an engineer before he/she becomes an engineering graduate!

KCI has been providing us an encouraging experience of how autonomy of learning and excelling can be achieved even in the rigid atmosphere of an affiliated institute like ours. Owing to its fundamental role, the initiative has also been helping us to fulfill the expectations of 'Outcome Based Education' on one hand [6] and on the other hand it has been providing significant inputs to almost all major cells of the institute like placement, higher learning, industry-institute interaction and entrepreneurship development contributing to the overall growth of the institute. The growth in the impact of KCI in our institute has encouraged us to extend it to other institutes in and around Nagpur. Recently we developed an extension proposal in this regard [39] that envisages serving the knowledge needs of curious and creative youth of this region.

There are many other initiatives that address the issue of improving engineering education in India such as implementing pedagogic approaches like project based learning, active Learning and open-ended quiz strategy [54-56] and initiatives like 'From lab to land', 'Technological Universities', 'Gurukuls or Centers of Excellence' 'Research Parks', 'Entrepreneurship Development Centers' and 'Business Incubators' [14, 15, 57, 58]. Recently AICTE has also institutionalized a slew of reforms in this direction. It will be closing down as many as 200 subpar engineering colleges, reducing engineering seats by 80,000 and enhancing the percentage of NBA accreditated engineering colleges to 50% [59].

However, KC can be developed in consonance with any of these initiatives in any institute (or even as an independent initiative) as a grass root and comprehensive initiative. Moreover, it also does not require unaffordable funds or resources as it only attempts to bring the focus of knowledge, skills and wisdom back in our system and can be accommodated in the system with existing or little additional funds and resources.

The Science, Technology and Innovation Policy-2013 of India [60] aspires to position India among the world's top five scientific powers. However, time and again it has been proved that development is a process, which cannot be controlled and ensured by government alone but requires participation of the whole population. KCI promises to improve this participation by ensuring knowledge dissemination that is strongly linked with knowledge creation and knowledge application. In this paper, we discussed how our current engineering education system falls much short of these expectations and how the approach of taking it beyond the limited goals of marks and degrees through KCI can provide a surer recipe for 'education for development'.

Thus it can be concluded that KCIs have immense potential in filling several gaps that exist in the present engineering education system and hence in contributing to catalyze the transformation of engineering Education in India. Multitude of such KCs promise to unleash the unlimited creativity out of our limited resources so that new fields, new industries and new employments are generated continuously to cater to the vast spectrum of interests and needs of our favourable young demography.

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