**Did it make a difference?**

**Thirty-four and more years at IISc**

**To me? To you?**

**H. S. Mukunda**

**Professor retired from Indian Institute of Science**

**Preface**

This book is about my journey through Indian Institute of Science both as student (Masters and Doctoral for 7 years) and a faculty member (for 34 years) and another fifteen years of aperiodic visit to “my” laboratory CGPL (combustion and Gasification Laboratory) – things I learnt, joy and pain in new research and development, joy of teaching, interaction with distinguished faculty and administrators both within and outside of IISc. It is about more about people who are in the backyard and some very visible, all responsible for the aura of Indian Institute of Science. It is set out in a less-than-rigorous framework based on the adage – don’t take yourself too seriously!

The title is deliberately left open – Did it make a difference – to whom – me?, the laboratory that both absorbed me and released me?, research students I supervised?, students I taught?, to IISc, to others I interacted with ISRO, DRDO and MNRE largely? and many I interacted with on the international scene. Obviously, I have views – considered normally biased in my favor – but have had the benefit of having received critical observations, both direct and indirect.

Living at IISc has shaped my life – through friends from my master’s course who continued on beyond as faculty, teachers who taught courses and allowed learning of what and how to navigate through complex academic milieu.

**An overview of my life**

**Early life**

Born in a town (K. R. Nagar, 40 km from Mysore) in Jan 1944 and living in a village (Gavadagere between K. R. Nagar and Hunsur) till 1948 shifted to Hunsur because of transfers in education department that my father (a teacher in the middle school) was to go through. We lived in Hunsur for nine years including the three years (1954 – 1957) for my high school. I was tutored in English by my father in my middle school career. In the first year of high school, I came across a dilapidated book on geometry by Hall and Stevens. This book may have been used by my elder brother who by that time was already an engineer working in Mumbai. In this book, there were problems of geometry called riders that seem to have enticed me to understand and solve. When I did, I was excited, but there was nobody to share! The world around either in the middle school or high school was academically dry. The town was all about trade and subsistence living and in about seven years of middle and high school when I was understanding the world around hazily, there were perhaps only three lectures at the town hall (or equivalent) - mostly on philosophy, kannada and culture by distinguished visitors. There was a lecture by Sri. Shivamurthy Shastry, the kannada literateur. I remember my father arguing with somebody that the word “culture” was not even defined well, etc. The teaching in the school seemed to be good according to accepted standards that did not have almost anything about how to induce creativity amongst students. Teaching set subjects, learning by memory many things and a small amount for exercising thinking was all the academic environment was about. The fact that I secured 100 out of 100 in Mathematics was socially significant, but I think did not mean much about the skills I had.

The pre-university course (1957-58) was a fast pass through at Sharada vilas college in Mysore and then the engineering college – National Institute of Engineering. For reasons, not known to me, I seemed interested in doing Chemistry as primary subject going through B. Sc and M. Sc as the first alternate. But peer group advice from family and others was in favor of Engineering. The prevailing wind was in favor of Mechanical/Electrical engineering and I chose Mechanical stream, mostly because, electrical engineering had many abstract ideas, but mechanical items were downright visible (!). The teaching in the engineering college like in High school was traditionally good in the same sense. Through the four years where in one of classmates, Mr. Prabhakara Rao and me alternated in getting ranks, the creativity aspect and sharpening the skills needing deeper thinking were always given a go by. I remember many teachers, but the most respected one was Prof. Narasimha Iyengar who came in very well dressed manner and taught Mathematics with measured words; I can recall him standing on the dais even now. Of course, the more (may be the most) popular teacher was Sri. Aprameya who taught us drafting skills, including free hand sketching. Batchelor in Engineering completed in 1963 led me to the aeronautical engineering at Indian Institute of Science…….

**– through IISc (I wrote for a souvenir at IISc in 2007)**

My first encounter with IISc was some time in December 1962, a year before my graduation, at which time I was at Bangalore for laboratory work in Mechanical engineering (my college, National Institute of engineering, Mysore, had not acquired these facilities yet). A friend of mine brought me to the Institute to meet up with his relative in Aeronautical Engineering. I was amazed and pleased to see select group of people working till later part of the day well into the night even though the rest of place was locked up and looked deserted. Having had some bad experience during industrial training in the railway workshop at Mysore, I had “decided”, I would never join an industry demanding fixed timings (!) and would only join a place that allowed freedom to work away as much as needed any time desired. I simply fell in love with the Institute and I intended pursuing M E here almost instinctively. The only place I applied for was Institute with Aeronautical Engineering as the first option (In retrospect, I have often wondered about this foolish bravado for not applying to any other place). It turned out that I got direct admission (admission based on past performance – within the first three ranks in the examinations) without an interview. I have again wondered whether I would have been accepted at all if I have had to face an interview committee. I joined the Institute for M. E. in 1963. Finishing up the masters in 1965 pursued Ph. D with Prof. V. K Jain and Prof S. Dhawan as the supervisors and finished it in 1970. Joining as a lecturer in 1969 in an opportunity that got created due to demand of faculty in newer areas to cope with the new defense sponsored program on *rockets and missiles*, I continued till retirement at the Institute except for a two-year stint at NASA Langley Research Center at Hampton, Virginia in USA (1987-1989) and several brief visits to other countries for conferences or as a part of some delegation. It is true to say that I enjoyed the stay both as a student and as a faculty member. There were many difficult times and mental stress too, but *I recollect no period when freedom to do what I really wanted was curtailed*.

During the time I was pursuing my Ph. D., the department had a fair complement of excellent research students and particularly in fluid flows. Most of them were students of Prof. R Narasimha, Prof. M A Badrinarayan and Prof S. Dhawan. All of them were very active and my most enjoyable moments would be when we got together (Prof. S. M. Deshpande, my class mate in ME course and V. Ramjee, a research student of Prof. MAB) and talked about science, India and its problems and almost anything under the sun very intensely. Amongst the students Dr. T. S. Prahlad and Dr. S. Vasantha went on to become directors of NAL, CSIR and SHAR centre, ISRO respectively. Others became faculty at IISc and as expected, everybody worked through at IISc till retirement.

The area of combustion or reacting flows was very new in the department. The learning of the subject was largely by intense self-reading and discussions with co-students. This self-learning that got imposed on us proved to be of great benefit in the long run since thinking through intricate new issues could be accomplished with much less external input **bringing** **greater confidence of other academics and industries in one-self.** Aeronautics in the sixties and the seventies appeared dismal with no development projects being taken up and a large number of paper exercises on the design of fighters being carried out with the Government or Air force supposedly stating that since HAL had no experience in advanced technology it would be difficult to support such a project. This got repeated several times and the joke was that every head of HAL who happened to be a senior person from air force took such a position to enable him to buy nice equipment from overseas and a better prospect for himself (to become the next air chief). It was clear if we have to be intellectually alive and be relevant (particularly so in Engineering) that I suppose is the aspiration of any academic, we had to think of strategies of achieving this objective. It was also a peculiar period when Ph. D from abroad (that meant usually, USA) was thought superior to Ph. D from India. Also no visionary outlook seemed available from the near surroundings. I remember one event of this period of despondency. I had been working on a set of ideas on a class of propulsion systems called hybrid rockets that appeared very relevant to India as it was a high performing but robust and a very low cost system. To a few friends, I stated somewhat wistfully, can we not do something to such progress in some special area unique to us (but relevant to others as well) that demands that scientists from overseas come and learn here much like it happened in the past at Nalanda and Takshashila. A few colleagues around me looked at me peculiarly and brought me back to reality. As it turned out, of the two major activities that I was instrumental in initiating, the subject of hybrid rockets did not attract the appropriate agency subsequent to ten years of effort resulting in several publications, Ph. D for a student and occasional sporadic interest by several other agencies, but the subject of thermal conversion of solid fuels, particularly biomass has resulted in a situation that was reminiscent of Nalanda. Many distinguished scientists and other professional agencies visited our laboratory and we were instrumental in providing the inputs on the foundations of thermochemical conversion of biomass.

At the court meeting of the institute that happens in the month of March annually, there is a court lunch followed by the meeting. In the year 1981, at such a lunch, I was met by a senior colleague, Prof. Amulya K. N. Reddy who was leading a center for the Application of Science and Technology for Rural Applications (ASTRA) and asked if I could look at a technology called “gasification of solid fuels” by which process it was possible to run diesel engines to generate electricity. His idea was that India had about 3 million diesel engine pump-sets for water lifting and it would be desirable to replace as much diesel as possible by using the gasifiers. His outlook was that this would make a tremendous difference to the oil import and make the rural operations less dependent on diesel with a continuing upward trend in its price. Impressed with these thoughts, I discussed the subject with Dr. U Shrinivasa (who subsequently chose to look at biodiesel seriously at the department of Mechanical engineering) and we started working on the subject with a grant from the Karnataka State Council for Science and Technology (KSCST). By this time, I had a reasonable understanding of the field of combustion, but mostly of liquid and gaseous fuels but very little of solid fuels. I thought through for myself that as an “expert” in combustion if I was posed questions on how biomass would burn and could I estimate the rate of combustion, etc, was I in a position to deal with the issues confidently. I came to a conclusion that it was clearly “No”, *was ashamed of myself* that I knew little on a subject so much more native than what I had looked till then.

The next five years saw serious research and development to understand the earlier work and complement it with the needed work to enable design of combustion systems as well as gasification systems. More arguments were found to say why gasification of solid fuels allows better control on combustion, emissions, and ability to produce the starting “stuff” for chemicals including bio-fuels. Systems for power levels of 5 to 100 kWe were designed, produced using a local support fabrication facility and tried out in the field under a program of the Ministry of non-conventional energy sources. One of the early milestones were reviewed by a committee chaired by Prof. Dhawan after he had retired from IISc, vigorous and as clear cut as he was when he was the director. The next ten years saw an enormous consolidation of the efforts in terms of internationalizing the knowledge base. Three international training programs were conducted. These were attended by scientists from a dozen countries both east and west. Half a dozen students came from overseas to spend months for familiarization, training and research studies. Technologies were transferred to eight licensees in India and two overseas. Engine companies like Cummins have collaborated and have for the first time in the history of gasification in the world agreed to produce and market producer gas based engines for power generation. More than fifty gasification systems with thirty-five of them for electricity generation have been built. Systems of 1 MWe have been built and are operating commercially for more than three years. Every year, nearly a hundred people – a farmer to a CEO of a multi-national company visit the laboratory seeking information, knowledge, cooperative study and some, technology. There is an outstanding team of academics and researchers currently active in the field at the combustion, gasification and propulsion laboratory in the department dealing with basic research and development, solving field related problems, providing advice on new concepts of bio-residue use in electricity generation process for a rural community or an industry and of course, creating project profiles on techno-economically meaningful basis. The management is structured to operate under a society called “Advanced Bio-residue Energy Technology Society” (ABETS) whose board chairman is the director of the Institute. Research and Development are continuing with vigor even in 2007. An effort in the last three years has led to modern gasification based cook stoves and combustion devices. Fans that are built for computers (and so of low cost) are used in carefully thought-out fluid dynamically driven designs to burn solid fuels in an efficient and environmentally benign manner. These technologies have been transferred to a multinational (BP, India) who are intending to commercially exploit it to service a huge rural market in India and other developing countries. Protecting the technology requires patenting in India and select countries (where it is perceived that the technology uptake may take place) to enable reduction in investments for maintaining the patents. The area of IPR is itself a large subject that cannot be put away as being outside the normal research and development work. There is no escape from understanding the nuances and taking protective actions in a changing world.

This pathway from a simple academic interested in publishing papers as many significant ones as possible to one who enjoys dealing with a variety of responsibilities has been thrilling to say the least. Finally, it is a pleasure to express my gratitude to the institution that provided the space and time to seek fulfillment of a wide spectrum of aspirations.

**What did I think of others at IISc and elsewhere?**

When I think warmly about IISc, because there were many people aspiring to do things in science that would bring them fame and awards in what they have accomplished. There was a distinct peer pressure. Those in science departments had settled down to a minimum routine – use high class fine equipment – GCMS to atomic field spectroscopy and all other in between to examine molecules – inorganic, organic and bio-organic to determine the structure and synthesize new ones with the aim of connecting up macro-properties to micro features. There were also theoreticians in the physics department looking at basic features of condensed matter physics. There was a centre names Centre for Theoretical Studies (CTS) where faculty could do almost anything they desired without having to supervise students towards a degree. Prof. E. C. G Sudarshan, the well know physicist was drawn in by Prof. Dhawan to head this centre and bring in fresh wave of ideas. This was because the physics department then had been involved in experimental spectroscopic research and the faculty had become impenetrable for new ideas! Doubtlessly ECG Sudarshan provided an aura for the centre and when he spoke on Physics to wider audiences at the Institute, it was a great pleasure to listen to him, for he spoke even on classical physics with a different vantage point that it was always a pleasure to listen to him. He would also engage in discussions in matters including spirituality, a subject on which several of us were drawn in – Prof. Deshpande, Dr. Nagendra (who went on to establish VYVYAS, a centre at Jigani) and myself.

There were two streams in Masters course – aerodynamics/fluid mechanics and structures. This meant that the projects that would take would be in this stream. Otherwise all classes would be the same. All of us 25 students were expected to learn all things (!). There seems to have been undercurrent of wanting “good” students to join structures. We were well aware of this. Myself and S. M. Deshpande seemed to have matching enthusiasm and inspiration that we uncovered in the first few days of our joining IISc and opted to join Aerodynamics stream. Mr. Prabhakara Rao from NIE also joined the course and he continued to be a classmate. Most of our teachers were quite distinguished.

By the time we joined, Prof. Satish Dhawan had already become director and was not teaching courses (sadly, for us). A curious thing took place when we got the time tables for the first semester. It was written inside the box SD indicating the instructor for the course. We got excited that director is going to teach the course. We uncovered that the excitement was short lived since it turned out that it referred to Prof. Somayajulu Durvasula who taught us structural vibrations. One of the most popular teachers was Prof. C. V. Joga Rao who was somewhat universally admired by all students. I was in disagreement with this admiration since I found that he lecturing was quite dull on the technical aspects. He taught from his notes that did not seem to have changed from quite some time. Also connectivity with reality seemed quite low even in this course as also in most courses. This was partly because there were no projects of significance on aeronautical development and demand for true understanding was not in great demand! There were also many moments of challenge in understanding things but the passage through the course was not as fulfilling as I thought it would be. Prof. Roddam Narasimha taught us basic fluid flows and asymptotic techniques. The course on asymptotic techniques, a subject that was undergoing development was very valuable. Prof. A. K. Rao who appeared very bright and sharp in conversations did not take any formal course. Prof. M. A. Badrinarayanan taught turbulent flows and the teaching was as chaotic as turbulence. He would not hesitate creating confusion, even though when quizzed he could not be swayed from a deeper correct point!

While at the end of my undergraduate education, I did not know what I did not know, at the end of Mater’s course, I came to know largely what all I did not know and it was not small – not information, that I knew reasonably well, but the fundamentals! To fill the black holes in my understanding, it took over ten years and of course, in some way it continuing even today. I have never felt far from being a student, even now. Over a period, I have learnt a reasonable amount– because I learnt “by surely knowing a little of whatever stuff that be, I can derive a whole lot of other things”. I also like Sherlock Holmes’s answer to what he knows and what he does not. He stated (my words): I do not know about stars and all the rest, but I know how to distinguish between a hundred and forty different cigarettes from the ash that I can smell – because this is what I need to know. It is not what you do not know because it is always an infinity. But what you know for sure is very important even if it is small. I can do several things attributed to Richard Feynman – like obtaining approximate values of square roots, cube roots or other arbitrary roots of numbers either in my mind mostly or the back of an envelope and I feel challenged to examine difficult integrals, differential equations using approximate methods – inspired by Richard Hamming in his book on numerical analysis and Bender and Orzag in their Advanced mathematical methods for scientists and engineers. On these aspects that I developed interest over a period of time and there was no local inspiration or role model (meaning at IISc). I also have liked the adage by Richard Feynman, you can say you know when the same problem posed under different garbs can be traced back to the original problem of which you know (the solution as well). On this aspect I did work hard by reading several pieces of researches relevant or weakly so to gain “surrounding knowledge”. In fact, I concluded that the difference between the speech of a man of knowledge and any other person is that the man of knowledge is speaking only a fraction of the stuff he is aware of on the specific topic being discussed and that part itself is significant whereas most other people may be speaking beyond or just about their level of understanding and you can virtually see through them.

**Did I get to where I wanted to be?**

It is not that only the well know physicists or Nobel laureates have the privilege of expressing thoughts on questions of the above kind occurring in one’s mind?

These questions occur to the lesser mortals as well and if there is deep commitment to one’s own ideals and self-expectations, one needs to respond to these introspective queries.

**What all did I learn from Carlos Castaneda’s writings on Don Juan?**

If there is one set of writings that has held sway on me even beyond Upanishads, Bhagavad Gita and other literature of this class, it is the writings by Carlos Castaneda.

Pages 227 – 252 of Tales of Power in the chapter: The strategy of a Sorcerer contain a presentation of how Don Juan trained Carlos Castaneda over ten years – a very remarkable summary that provides deep understanding of the subtleties of spiritual progress (it may be inferred that this is the quintessential matter of nearly six books).

On p. 227, he states: A teacher never seeks apprentices and no one can solicit teachings. In a way, this is crucial point. Quite often, in our tradition, you keep encountering discussion and suggestions that a person interested in spirituality should seek a Guru. What Don Juan states is that neither can the teacher (Or a Guru) seek a student (or shishya), nor can a student seek a teacher. He then outlines how the connect between him and Carlos took place indicating that an “omen” showed the possibility and he just pursued it.

The above broad conclusion is reinforced by the following observation

Page 241,

“...When we think we decide, all we are doing is acknowledging that something beyond our understanding has set up the frame of our co-called decision, and all we do is to acquiesce.” Is it not the same as fate controlling the lives of people and the idea of free will is an illusion?

All the so called efforts towards spirituality are simply to aim to aligning oneself with the will of the beyond or the “intent of infinity”. It is simply the dominance of ignorance that permits arrogance

 **Is science below spirituality? Is spirituality beyond science?**

Spirituality is a subject concerned with deeper universal questions of one-self and life beyond the limits of religion that is tradition and rule bound. Science is concerned with questions of observable world in all the deepest possible sense and obviously far outside of religion. Science is practiced by people of all religious faiths and the conclusions they come to based on theory and experiments applies to people of all races and far more, all the species in the universe. The theory (or experiment) prescribes the limits of applicability over the species-space-time domain always wanting to look for generality in applicability. Since spirituality is concerned with matters within one’s mind, it is often stated that where science ends, spirituality begins. This is playing with words and in reality whether you think of “science” or “spirituality” you have to use your mind. When examining nature outside of one-self common to all people in many ways, the contemplation is of the external world, in fact, the issues of the external world are modelled in the mind and examined. And this examination needs deep contemplation to resolve paradoxes and conflicts that nature presents. Many a time, this degree of contemplation can be no different from resolving internal human complexities of ideas: to aspire or not to aspire, be ambitious or be contented, imposed unhappiness and joy all of which are the stated concerns of spirituality supposedly outside of science. Whenever such observations are made, it appears that the meaning of “science” is misunderstood. Science when interpreted as a systematic approach to studying questions seeking validity of resolutions at as many stages as possible appears applicable to the study of external factors as much as internal. And mind usually treated as a single amorphous entity is now broken into simpler activities inside the brain and resulting perceptions. Each of these activities is examined through various new non-invasive tools.

What I find realistic is ”spirituality through science” a paradigm that may appear scandalous to many. The reason is that after all, all thoughts or actions related to spirituality can only occur in the brain (or the mind) and there is always some logic that drives the actions. It is the logical process which is at work in science.

**General Science related Talks**

**2003**

**Aero-space Engineering department**

 **– Snapshots from the past, Snippets of a future**

**Abstract**

This talk aims to depict (largely in the speaker’s perception) the external and internal factors that have influenced the way the department of Aerospace Engineering Department has evolved over the last five decades. The principal projects and personalities of missile, space, and aeronautics with a roller coaster ride up to the seventies and a more distinct pathway in the eighties and the nineties will be described. The reasons for the lack of character in aeronautics in this period, alternate management strategies for the creation of ADA, the success of SLV-3, the change of leadership and mindset in defense missile development, islanding of a few key defense institutions leading to a low organizational self-esteem that is still an issue, flight failures of PSLV-3 and a national review committee, form a sample of the nature of external factors. The rockets and missile program at the department in the seventies, involvement of several faculty of the department in the review processes in space technology first and defense developments later, filling in the lows of space and defense by looking at other societal issues by active minds to better use their talents form the sample of factors – internal to the department.

Most developments till now are to keep abreast of the developed world to within about two decades. Currently, wisdom is shown in attempting to build a hypersonic vehicle for military applications and this would lead to significant advancement. Making space accessible at the lowest cost possible is another important national agenda, an unconquered vision of the twentieth century whose elements are being pursued, perhaps, without adequate focus on the right issues.

Great pace of technological progress in miniaturization of electronic systems and their deployment in aeronautics, space and missile systems, integration of software and hardware for specific duties, robotic systems, small vehicle development (like unmanned aerial vehicles), fashioning after nature – birds and insects to act for snooping form a sample of a class of new developments to be assimilated.

The period 1970 – 2000 has been characterized by the faculty and in part, students being a part of the developmental process. This has honed the teaching skills of the faculty and made students generally much better. Consequently, the department has produced several directors of laboratories and project directors. For this trend to continue it is vital that there be a vibrant relationship between a substantive part of the department and the development agencies while continuing to be on the forefront of research.

**2009**

**Science at IISc – Good, great, Outstanding, …?**

**An inner dialogue**

Having lived in and with an institution for forty years (including six years of student life), one is apt to develop attitudes that may amount to self-praise or being overly critical. Notwithstanding these, one has opportunity to examine the institution from outside too, when you have visitors who make observations, or when you need to make careful observations during your visit to other institutions both in and outside the country.

Clearly, as far as I am aware, within India, IISc stands out as an extremely worthwhile place to stay and work either in basic or engineering sciences, for, you brush shoulders with a number of colleagues from various disciplines who can think deeply and who can provoke you to think deeply as well. Also it has always been headed by distinguished men whose engagement with science is unquestionable and successive governments have been respectful of this status. Does this entitle IISc to claim camaraderie with the best institutions in the World? Some faculty in authority (and some others as well) wish to assert this. And some who were in authority state that much is desired before achieving this. Either way, the subject needs examination by all and action on behalf of the men in authority. Has such an act not happened in the past or is it happening at the present are the questions for this dialogue. I have titled this as “an inner dialogue”, for most of what is said here has been brought up for informal conversations with several distinguished men of science at IISc, but left behind for me to engage in a more assiduous way.

Over years, several debates on teaching vs. research, research in engineering departments vs. science departments, meaning and role of consultancy in faculty output, and commercialization of intellectual property rights have taken place more informally in select groups rather than as specifically flagged items for full scale discussion. Many of these have had inputs more personalized than institutionally focused.

Teaching has traditionally been the main forte of engineering departments; it is only in the nineties that science departments also introduced course requirements for research and this needed classroom teaching by science faculty. Many men of importance have generally regarded teaching as an unavoidable chore rather than a valuable professional activity; there used to be statements of slighting the teaching activity, some publicly in meetings and certainly more in private discussions. Hence teaching quality has remained at an average or poor level ~~f~~or over decades with perhaps cursory attention paid to repair or upgrade. By international standards, this will place IISc not in any great favor. Arguments are made that what is important is research. The connecting link between good teaching and students who could be fired up to do some interesting research has been glossed over. The fact that good teaching is still practiced perhaps in pockets is inspite-of rather than due to a supportive action towards teaching. This does not mean excellence in teaching has not been honored. Yes, they have been. But the atmosphere of the Institute does not breathe even partly of excellence in teaching.

There have been significant differences in attitudes on research between the science and engineering faculties. What is practiced in science departments is understood to be research indeed. What is done in the name of research in engineering departments meets with the expectation of research only in parts. As such, there is an undercurrent of feeling that research in engineering departments does not measure up to that in science departments. Engineering departments also do not make their case of good science very strongly – there is no “lobby” in this regard. The lobby for goodness of science in science departments is far too well “understood” to be even doubted. But the claim to superior science in science departments is faced with answering the typical question: how many Nobel Laureates does institute have? Why is it that in the last fifty years, IISc has not been able to produce even one Nobel Laureate? It is not that the lack of a Nobel tag makes the quality of science poor, but it puts burden on making complex looking and long-winded arguments about the quality of our science. One often invokes the conclusions of the survey done on the standing of scientific institutions all over the world based on some select criteria that states that IISc is 18th amongst the institutions in the world and some others that may say IISc is No. 1 in the Asia Pacific region, etc, etc. These do not always carry the same weight as would be the case of having a “Nobel Laureate”. One message is clear: Gaining position within the institution by looking down upon engineering research is not the best thing to do, for, one might be attempting to throw stones living in a glass house. As such, it is perhaps appropriate to ask a more relevant question; Can institutions not aim to do “Nobel” quality science – in science or engineering departments? Stated differently, should faculty not debate questions about what class of problems in each area to address? Some problems are pedantic, the origin of which will lie in some path breaking work elsewhere, pursuit of which will assure publications, will receive pat on the back by the more distinguished or those scientists established overseas, perhaps more of western origin. There are many reasons for this. Such an act assures quicker recognition, a possible sabbatical, a visiting position for a few months or at the least, an invited lecture. If one does path breaking work here that disposes of a concept, disproves a hypothesis originated overseas, it is far more difficult to be recognized at least initially; it is an uphill task. One would need to keep attending meetings in several parts of the world and argue with each group about the sanity of one’s own approach vis-à-vis the existing thinking.

There is an important distinguishing feature about working in science and engineering departments. In science departments the majority of the work can address questions that are universal and with marginal connectivity to “nation”. Perhaps the choice of the problem could be such as to be of national interest as well. In engineering, a significant part of one’s work has to be of national interest, for otherwise the connectivity with the real world becomes weak, if not lost. In institutions in developed nations, the meaning and relevance of the work for the nation are not different from that for the rest of the world and hence one does not need to debate. In developing countries, one needs to do work in engineering departments that would help build up the research and development efforts somewhat directly. Problems that arise in defense and space departments need resolution in a local environment since overseas technology regimes impose “sanctions” as in the recent past preventing access to developments. Sometimes this is regretted. But this act is perhaps very welcome – it helps indigenous build up of science and technology tools with self-reliance becoming an accepted strategy. The national need and relevance of faculty and scientists thinking about advanced subjects becomes established beyond the attitude of “poor engineering science”.

This is not always true of all fields in engineering. There are some fields like telecommunications, biotechnology in pharmaceuticals that have been entered into by multi-nationals who can afford to and actually bring together excellent scientists to do meaningful frontier research and the question of academics making significant contributions becomes a more difficult aspect – the field becomes locally very competitive and it is not easy to choose outstanding areas to make contributions.

There was an interesting event during the regime of Prof. Padmanaban as the director. Sometime during 1976 – 77, some large scale funding was supposed to come to the Institute specifically to ECE/CEDT aimed at creating a school, it was said. The Director held a discussion meeting on the issues associated with this. During the discussions, the primary aim seemed to fluctuate between providing teaching services at high personal remuneration and as yet unidentified research. For the perceptive, it was clear research agenda was low and perhaps, their investment was aimed at using the Institute for low cost teaching or better termed as HRD by paying remuneration high by IISc standards and manageable by industrial standards. I had occasion to voice thoughts I have brought out in the earlier paragraph, but was thought having a negative thinking on the subject. Not wanting to be contained like this, I drafted a long letter on the philosophies of how research at IISc gets influenced by factors outside India including the thoughts above and sent it away to the Director. I know that it reached the divisional chairmen’s office and saw its end, I guess!

In either case, the demands on an academic in engineering science are two-fold – scientific contributions of significance at an international level, and technological or scientific supportive contributions at national level. It is possible that these have overlap, but more usually they are distinctive. This is the double demand of excellence that is not usually expected of an academic in science department. Excellence in international science is adequate. There have been new scenarios of even the academic in science department being concerned with spending a part of the time in capitalizing on the basic research. It appears as though this has to be done against the current trend tolerating non-approving looks from colleagues who matter. Thus though the area of consultancy and technology transfer are allowed to happen without any stumbling blocks, there is no active scouting of research work that has the possibility of being commercialized and connecting such work with industrial houses. In this age, industrial houses buy up advanced technologies from overseas and use them for commercial purposes. Sometimes there are hiccups in the process and opportunities for new work on modeling and offering solutions in a native approach. To be aware of new technology dimensions and capitalize on the new possibilities, it is useful to be in communication with industrial houses at equal par. Such a situation can be generated if enough respect can be created for the academic research – showing the relevance of the thinking to industry. Such a thinking does not seem to have permeated into the academic community till now.

It is important to return to the choice of research/technology problems for pursuit in academic arena. The event of IISc reaching a hundred years nearly coincides with the hundred years, of eventful growth in science and technology, the fruits of which are being savored by the current civilization. Scientific pursuits have answered many questions and areas that were green some time ago remain no longer so. To maintain uniqueness in research ideas requires far greater effort, for somebody somewhere has thought of a similar idea and has already published the work or is on the point of doing it. The only way out of this appears to be exchange of thoughts with faculty presenting their areas of work justifying the uniqueness. In an environment where a technical criticism from a colleague is usually interpreted as personal criticism, it is necessary to create structure of discussions in which things can be learnt on what one should be attempting to do and what one should definitely avoid. If such debates do not occur, creation of excellence becomes an accident and not a part of design. Surely, it is not possible to promise for oneself a Nobel prize winning work; but excellent work at the frontier is possible. Students should talk about it at the café, at the hostels amongst themselves and others as to how some piece of work going on in a certain laboratory is truly outstanding – in soft whispers to loud debates; the atmosphere will become charged with expectations. Creating such an environment is the demand on the leadership at the Institute. The concept outlined above is called co-creation in management jargon.

A very recent view of businesses across world articulated by Prof. C. K Prahalad\*, a management guru now in the USA talks of co-creation as the order of the day for new business model. Co-creation implies involving the consumer in the creation of product of value. What has been articulated here – debates of the choice of problems for study, in a participative mode rather than being left to natural events shaping the career of individuals is somewhat similar. In one case, what is “sold” is a product or a service. In another case, it is scientific work of value.

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\*see a recent interview at “It’s now the era of Micro-Innovators”, Business today, May 02. 2008

**2015**

**Great Science and Technology in India –**

**at IISc and higher educational institutes?**

**- further analysis and possible solution**

After Mr. Narayanamurthy’s strongly worded speech at the convocation address at IISc on July 15, 2015, many articles by distinguished scientists have appeared – Prof. G. Padmanaban in Hindustan times on August 11, 2015, Prof. C. N. R Rao, in Current Science, 11 August 2015, Dr. R. A. Mashelkar in Current Science, 25 September 2015, Vijay Chandru, a former professor of IISc in Hindu, August 03, 2015, and several others in various other magazines.

I wish to dwell on the core theme in the light of what has been stated by these distinguished scientists, indicate a missing element in each of these observations, draw upon the a recent history involving success in building excellence out of an existing dilapidated system and outline a strategy to grow, even if slowly, from the current situation to excellence in multiple dimensions.

The tone of most of the writings I have read is somewhat defensive and on occasion using offense as a tool for defense, partly related to Mr. Narayanamurthy drawing parallels from MIT (USA) without adequate and deeper reflection of the accomplishments and the role played by academia including IISc in India. The positive point of his address is the start-up of strong debates contributed by many distinguished people.

Prof. Padmanaban who spent his life time of active work at IISc and as a director for four years has made two critical points. He states “…*Are we doing cutting-edge research? Not really. It is very good research, but not the breakthrough kind. Even senior scientists do not want to leave the comfort zone to risk an untrodden path. It’s still ‘publish or perish’ that decides the future of scientists”*  and “…*The problem with the IISc is its laid-back environment*” The question that arises is if can we do something concrete about these two aspects.

Prof. C. N. R Rao has in fact suggested that if a few billion dollars were provided for, he could help create a world class university. Even if this were possible in say, five to ten years from now, what about IISc with its long history and the dozen other science and technological institutes of higher learning of history not as long, but substantial and those established in recent times; should these be written off? I think there is an alternate pathway I want to describe that should bring up all institutions. Great work happens because there is a very large pool of good scientists doing good work, large pool of scientists doing very good work and a smaller number doing extraordinary work in a pyramidal manner – Greatness does not appear in isolation albeit with a very low probability.

Dr. R. A Mashelkar invoked lack of “irreverence” as a possible reason for lack of high quality research. While this may well be so, if we have not seen better evolution towards irreverence over this period and no hopeful situation coming along, how long can the country wait for the right people to arrive – is there no sure approach to obtaining results instead of unsure expectations?

Prof. Vijay Chandru has brought insight from the systems in the truly successful situation in the USA explaining what may be lacking here and expresses hope of creating a structure through NITI Aayog. No matter what structure is suggested, creation of new knowledge of worth to the society around and the World at large is an act that should happen within the institution and discussions on the way forward must happen within. Inputs can come from outside but that is no argument for the lack of intense discussions within.

The example that I would bring to the attention of the scientific community is of Dr. Abdul Kalam on what he did at DRDL, Hyderabad - aspects that have not figured in any of the recent articles on him by many distinguished people. I was familiar with most of the scientists and directors from that time – quite often engaging them in conversations on why ISRO appeared performing better that DRDL in rocket engine based vehicle related developments. There was a clear despondency in DRDL with most active scientists having no self-faith, feeling that nothing significant would happen in their organization. Dr. Kalām’s entry to DRDL as its director in 1982 after successful SLV launch was of course greeted with enthusiasm, but the lack of trust between product developers and users, namely, defense services was considered a stumbling block, yet. That he created an integrated guided missile development program (IGMDP) with five different classes of missiles along with user community on board and sanctioned by the Government was in itself extraordinary achievement. Then onwards, he devoted all his time – on a 24 x 7 basis to these projects, brought to fruition the most important ones. With Dr. Gen. Sundaram as the project director, Prithvi, the semi-tactical surface-to- air missile saw its successful flight and further tests leading to interest in deployment by the army in about six years. The joy this development gave to the organization was stupendous. We must remember that the change occurred in just six years! What is crucial to appreciate is the role played by Dr. Kalam. He would engage with individual scientists at several levels and technicians in workshops at DRDL with a zeal and commitment that was simply not seen in the organization till that time. He could drive his colleagues to intense work and also show compassion at moments of personal misfortunes in ways that all those associated with him felt clearly that they were working with him and not simply for him - implying working for the country. He brought greater fame to DRDO through the realization of the strategic vehicle, AGNI over years both at DRDL and later as SA to RM. The third vehicle -surface to air tactical missile, AKASH was fruitfully completed to the satisfaction of the user community more recently and based on this, DRDL has received orders for 30000 systems – an extraordinary achievement by any standards.

During the period when he was the director, he made no fundamental changes to the organization. He gave the organization what was needed most – a leadership with organizational interest the uppermost with little visible personal gains demonstrating to people at every level that they also mattered and mattered to the organization (I have christened this quality elsewhere through a dimensionless number – called Gandhi number – a number that the is the ratio of what any individual does for outside of oneself to what is done for oneself. Many past distinguished people belong to this category; amongst people I have known, Prof. Satish Dhawan and Dr. Kalām would qualify for a very high Gandhi number).

What would be inferences for the question on hand, namely, performing excellent science and technology in academic institutions? The analogy that I am drawing from the above illustration of Dr. Kalām is illustrative. In the case of DRDL or ISRO, the goals are clear – develop a system with specifications. It is not so for an academic. The goal is excellence in science wherever it takes. In such a journey, it is possible, one goes a long way along unknown paths and is struggling to move ahead – as it will be so for excellent scientists, but there is another extreme that is more common – being lost in justifiably significant, but in truth insignificant work being pursued for decades. If effort is made to let deeper reflection on the latter aspects, some who are “lost” can indeed be “retrieved”. I know of many who are looking deeply inside for direction, but do not get any for long times for a variety of reasons and think that it is below their self-esteem to seek clarity from colleagues. Most importantly, excepting promotions that affect their immediate stature, there is little institutional demand for performing excellently. I am discounting long or short speeches at faculty meetings when the directors make remarks demanding excellence. It is simply not clear to anybody whether such a demand is more than statutory. This is the reason for what Prof. Padmanaban described as “lay back attitude”.

What then is the solution? Two things that directors should do – (a) Interact directly with individual faculty members on a one-to-one basis for an hour or two each year exploring the broad contours of individual research - motivation for research or development, what the peers that the faculty members interacts think of this class of work, does the faculty member have difficulty in getting things published, are there any serious bottlenecks in the conduct of work within the campus and offer suggestions, when possible, to get to higher levels in the exploration of the field and all that encompasses academic world. The fact that the chief executive is directly interested in his/her work becomes the strong motivating factor for individual pursuit to excellence, (b) Hold meetings of small groups of academics pursuing similar subjects in a more relaxed environment along with divisional chairmen and chairmen of connected departments (senior academics overseeing progress of work and promotions) to discuss cooperative work enhancing the total accomplishments, (c) Often use the presence of and distinguished academic visitors to hold similar group meetings and encourage a vibrant discussion and only make mental notes. The last technique was what Dr. Kalām used to calibrate various people including “experts” and academics, gently prodding people to perform better or accomplish more. The directors of institutions should deal with these subjects beyond administration a role that seems to occupy most for most time. It brings about close connectivity between the director or the head of institution with the faculty; it helps own up the faculty and the faculty owning up their head as academics, apart from a boss clearing papers and dealing with promotions.

It is realized by many directors after a while that there is some deadwood within their academic family. It is important that serious attempt be made to identify, nudge such people to get out of such situations. It is far more serious these days when full professors have an academic life of 25 years or so and can cause havoc if they are non-functional and spread an impression that the kind of life they are living is also worth living. Such problems cannot be resolved unless dealt with directly by the chief executive speaking quietly, gently, but surely to the individual faculty.

Further, the point made by Prof. Padmanaban on the impression that “publish or perish” attitude being dominant is sometimes denied by some directors. However, from what I have known, there is a visible broad tendency to disown developmental and technological accomplishments even if they are truly science based; and even if this is untrue, it is certainly true to say that this is the public impression. It is therefore extremely important to speak about work of significance to the nation in various relevant forums allowing the possibility for rejuvenation of broad based academic values.

Over years, there has been decay in the functionality of segments related to contact with the industrial world. Prof. M. N. Srinivasan of Mechanical engineering department who took care of the Centre for Scientific and Industrial Consultancy laid early foundations for a dynamic and interactive place with Prof. Dhawan responsible for starting this center. Slowly over twenty years with some ups and downs it became a reactive center rather than a proactive one. Prof. C. N. R. Rao started the SID (initially society for instrumentation and development and later society for innovation and development) wanting a strong proactive center for industrial interactions. For some time in early nineties, several discussion meetings between various faculty groups were held to understand the new relevant science and technology activities across the Institute. I am unaware if such meetings have taken place in the last decade. Essentially this institutional arrangement has also degraded into project processing center in a reactive mode. Serious efforts must be made to keep the dialogue with industry alive on a periodic basis both semi-formally and formally. It is also equally true to say that interaction of academia with DRDO and ISRO is going down over time. I reflected on this at a research council meeting at DRDL, Hyderabad some time ago and suggested that they invite younger faculty to be brought in for briefing and awareness meetings. Conscious efforts must be made institutionally to keep the links with reality alive. There is no escape from reality checks for any academic work particularly in engineering science.

Lastly, Narayanamurthy made a point that MIT, USA provided him with a booklet indicating list of technologies that they offered the nation during his visit. Even at IISc, in 1996-97 when the then prime minister, Mr. Deve Gowda visited IISc, five technologies were presented to the nation by Prof. G. Padmanaban, director then. These events have neither been followed up or preserved over a time essentially due to the fundamental lack of respect for these by those distinguished men in the tower (where offices of director and other functionaries at IISc are located with somewhat similar ones in most institutions) and continued attempts to dismantle institutional segments of significance for this kind of outreach.

In summary, there is much room for raising the quality of work and projecting them to the world with academic authenticity. There is responsibility for the heads of institutions in knowing the broad contours of academic work of individual faculty members –whether it is for the cause of international science or national development and providing needed encouragement, also that they care for their colleagues with a smile or gentle nod of recognition more often. In stating the last words, I remember Dr. Kalām rather vividly.