## More Quality Ph.Ds

Research is an activity based on intellectual investigation and has the purpose of discovering, interpreting, and revising human knowledge and experience on various aspects of life. It is crucial for the overall development of human society. As the economic paradigm undergoes a change in the globalized world, future economic progress will increasingly be a function of the intellectual capital that a nation can create. This in turn depends crucially on the quality of academic research that is done in the nation. Thus, if India is to play a key role in the envisaged Knowledge Economy of the world, a significant investment in research, accompanied by sustained vision and policy is vital to achieve a long term competitive advantage. While the importance of research and development in science and technology is increasingly recognised, basic research in many other areas like economics, management, social sciences, arts, etc play an equally important role in the overall development and well-being of a nation.

Historically, India has had an enviable standing in the world of research. However, the current situation is unsatisfactory across multiple dimensions, and the reasons for this are manifold. An important factor which impacts the quality and quantum of research is the scarcity of talented and dedicated manpower engaged in research. We need qualified doctorates for our research laboratories, to teach and engage in research in our universities and to work for research and development in all sectors of the industry. The number of researchers in India was 112 per million inhabitants compared to 633 in China and 4374 in USA in 2002. The growth in the number of doctorates has been only a modest 20% in India from 1991-2001 compared to 85% in China during the same period.[1] The current state of affairs thus requires urgent policy intervention.

Research in any area requires continuous intellectual engagement along with a passion for ideas and creative thinking. We thus need to create a system where these qualities are nurtured and encouraged, thereby providing a pool of students wishing to pursue doctoral studies. Simultaneously, it must be ensured that once they acquire a Ph.D, further employment opportunities are attractive. This is essential to justify the amount of time and effort invested in doctoral research, even more so in today's modern world where there are many other seemingly easier and more lucrative career options. While achieving a critical mass of researchers in the country is important, it is necessary to ensure that quality standards are maintained at the same time.

With this objective, NKC initially conducted a wide spread survey across the country and abroad. A detailed questionnaire was sent to all the universities, academic and research institutions, government agencies, and other stakeholders. More than 250 people responded to the survey. A one day workshop was also held where prominent members from diverse industries, academic and research institutions and universities deliberated on these issues. A list of participants is attached in the annexure. This note captures the main suggestions that evolved from these consultations. Some of the recommendations below have systemic linkages to the previous NKC recommendations in the areas of education, entrepreneurship, intellectual property rights, knowledge network and attracting talented students to Maths and Science.

[1] "Measures of Progress of Science in India", Report by NISTADS 2006

## Part A: Attracting potential doctoral students

In order to sustain research in the long term and for it to flourish, creating a critical mass of researchers and academics is of the foremost importance. Serious policy interventions are required to ensure that this is achieved within a specified time frame in the country.

**Recommendation 1: Create greater awareness and acceptance towards pursuing teaching and research as a career, by communicating the opportunities and excitement at a broader level.**

**Issues**: The Indian society at large, especially the younger generation is not well-informed of the career opportunities, excitement and freedom that a research career offers. Consequently, the acceptance level for embarking on such careers is rather low.

Societal pressure affects career choices significantly. A multi pronged approach needs to be adopted to bring about a change in the national mindset towards recognition and acceptance of a career in research. For long term wealth creation, it is important that the nation trains academics, scientists and teachers, rather than bankers.

**Awareness**

Media: The media has an important role to play in bringing about a fundamental change in attitude and in the nation's consciousness on this issue.

- Short and engaging television or radio programmes related to research can be aired at prime time.
- News channels should highlight and publicise various achievements of academics and other scientists.
- Print and electronic media should be encouraged and incentivized towards promotion and engagement of the intellect.

There are various other means to increase the awareness of society at large:

- Annual R&D shows can be held, where leading research institutes and companies interact with the public, thereby providing a wider exposure.
- Museums, exhibitions and popular lectures are other avenues through which public attention can be engaged. These should be encouraged at as many places as possible. For this purpose, the resources and infrastructure of various educational institutions throughout the country should be used.
- Academic societies should be generously funded and members should be encouraged to participate in the outreach programmes.
- In schools and colleges, career awareness workshops and seminars highlighting research careers should be held regularly.
- Important academic events and visits of reputed academics to India should be publicised and shared with the entire educational community through the use of various channels. This will help create enthusiasm in teachers, students and also acquaint society with academia.
- Talent residing in rural areas remains completely untapped because of various reasons. Basic education and learning resource materials should be made

available to all. At the same time, it is important that targeted initiatives be undertaken to identify talented students and to provide them with opportunities for greater exposure, learning and bridging language gaps.
- Women and especially their parents must be made aware of the possibilities and flexibilities that a research career offers, and should be encouraged through targeted initiatives towards such a career path.

**Acceptance**

- Nobel Prize winners, reputed academics and other scientists should communicate and publicise the joy and opportunities in a research career.
- School teachers play a very important role in orienting students as well as their parents. Hence teachers should be trained and engaged in this endeavour. Parent-Teacher Associations provide a platform where role models can interact with both parents and teachers at the same time and increase their acceptance towards research.
- Open competitions and projects at different levels should be conceptualized, encouraged and widely publicized. Industry can be involved in such activities.
- Recognizing good research work is important for two reasons. It gives a sense of pride to the researcher as well as encourages others to do research. Hence, various means of recognition such as awards, felicitations, publicity etc should be taken up at all levels.
- Higher learning, along with research and innovation, plays an important role in development of knowledge areas. Its impact on society needs to be publicized widely.
- Both the monetary and non-monetary aspects of a research career, especially the accompanying academic freedom and the international nature of research, should be communicated to students.

**Recommendation 2: Expose undergraduate and post graduate students to cutting edge research and engage them in serious research wherever possible**

**Issues**: The major decision points where a student decides to pursue doctoral studies are towards the final year of either an undergraduate or a master's programme. These students are often not well exposed to various research opportunities and hence remain untargeted.

2.1 **Undergraduate Research:** A good undergraduate teaching programme is vital for grooming prospective students towards research. Currently, our education system remains largely unimaginative and monotonous with a stress on rote learning and with problems handed down to students. Wide-ranging reforms that encompass pedagogy of teaching, curriculum and evaluation are a pre-requisite to nurture and encourage interested students towards a research path[2].

- Relevance and application play an important role in attracting applied researchers, while general abstraction and challenge attract theoretical researchers. Taking this into account, a judicious mix of projects and courses

[2]See National Knowledge Commission's recommendations on Higher Education, http://www.knowledgecommission.gov.in/recommendations/higher.asp

may be designed, of which one kind offers an exposure to real life problems from the industry, economy etc. and another imparts foundational training in theoretical aspects of the subject.

- Courses that orient students towards research need to be specifically designed and made part of the curriculum. An important component of these courses should impart knowledge on identifying and defining problems, various research methodologies, analytic methods and presentation. Team projects comprising of different disciplines can be introduced as an optional course for students. This could be combined with changes in syllabus that allow one research-based course even at undergraduate level.
- Summer internships, summer schools, workshops, competitions should all be encouraged. Exciting undergraduate research projects that can involve larger number of students should be rolled out. The vacation period should be utilized to provide undergraduate students with a comprehensive training comprising of exposure to problems in rural areas, industrial training, research project in academic or research institutions and an exposure to foreign universities through various means such as exchange programmes. DST, ICSSR and other organisations can fund a programme of small research projects to be undertaken at undergraduate level, which would introduce students to the actual practice of research.
- Teachers need to be trained to promote research and should be incentivized to create innovative projects where undergrads can participate.
- Exposure to and acquaintance with frontier research should be facilitated.

Overall, undergraduate education needs to be strengthened in the country. Creativity should be encouraged at all levels. A continuum of quality institutions from the undergraduate level in all disciplines is required. Residential undergraduate programmes should be increased.

**2.2 Post graduate research and training:** To encourage research and innovation at post graduate level, several measures can be undertaken.

- Post graduate students should be given the opportunity of spending a semester at research labs or other Indian or foreign universities, outside their own university to broaden exposure. The home universities should facilitate such exposure by entering into alliances with other well established places of research. The BITS Pilani programme is an excellent example of such an initiative.
- Research projects which have the potential to be extended as doctoral projects need to be encouraged at the post graduate level. Projects should be offered in emerging areas to retain student interest. Faculty must regularly update themselves to be in a position to guide students. Group research projects among post graduate students will create more interest and add enthusiasm towards research.
- Reduction of course load with a corresponding increase in the research component for students who show deep interest and commitment to research would incite potential doctoral students.
- Post-graduate courses in Social Sciences and Humanities should have a component (perhaps a full course or paper) that requires either desk-based or field research, which could be an optional choice.

- All post-graduate departments should organise and hold regular research seminars, and students should be encouraged to attend these. Programmes that facilitate establishing links between interested post graduate students and their prospective guides should be encouraged.

**2.3 Integrated doctoral programmes**: There should be flexibility of moving from undergraduate degree to a Ph.D degree when substantial interest and aptitude for research has been shown at the undergraduate level by the student. S.N. Bose Centre for Basic Sciences runs such a programme.

An integrated programme covering bachelors, masters and doctorate degrees with various exit points has multiple advantages. It will establish a vital link between students at all levels. Networking among students at different levels will give rise to new ideas. It will bring much needed fresh energy into research by exposure and induction to research at an early stage.

However, many precautions need to be taken while designing the integrated course, for instance

- Curriculum must be planned well and subject to periodic reviews. It should have a provision for multiple exchange semesters which will enable wider exposure, interaction and exchange of ideas.
- Selection procedure should take research aptitude into consideration.
- The programme however should have multiple exit and placement opportunities. There should be enough flexibility provided to students so that while opting for an integrated course, a student should not feel that they are bonded by it for seven to eight years.

In view of all these requirements, it is suggested that a restricted pilot be launched at select institutions. This program is especially directed towards science streams.

**2.4 Linking researchers at all levels:** Within an institution, relations among different levels of students (e.g. undergraduate, postgraduate and Ph.D) should be fostered. This could be achieved by judiciously mixing students in projects. Apart from facilitating peer learning, it provides a learning platform for potential doctoral students.

A comprehensive National Projects and Research portal is highly recommended. This is essential for connecting students and researchers at all levels, facilitating formation of virtual peer groups, disseminating information related to various projects and schemes, and providing information of various positions for doctorates etc.

**Recommendation 3: Restructure incentives for doctoral degree students to attract and retain them in research**:

**Issues**: The gamut of opportunities available to graduate and post graduate students today has made research in India an obvious secondary choice. Apart from financial unattractiveness and substantial investment of the prime years in their lives, there is a perceived lack of challenge as well as future career opportunities.

**3.1 Remuneration**: It is generally true that interested and talented people choose to pursue doctoral studies. They could have easily opted for better paying career options. Also, there are many more students whom the system fails to attract on account of remuneration issues. Thus it is important that while deciding remunerations, opportunity costs are factored in.

- There should be a regular upgradation of the amount of fellowships offered for Ph.Ds, and in general for the entire academic profession.
- Various forms of additional compensation should be explored.
- Teaching assistantship to bright Ph.D students should be provided to add to their earnings. This would also have the additional benefit of training and preparing them for a career in academics and teaching. This is vital considering the current serious shortage of competent faculty being faced by our institutions of learning.
- Other possible methods could include summer projects, summer internships in industry and involvement in organisational work as part of academics.
- Subsidized health insurance, home loans etc could be looked at.
- Generous travel grants should be ensured.

A good placement office for Ph.Ds should be given priority in all universities and institutions. They should have tie-ups with various universities, research institutions, industries at the regional, national and international level.

**3.2 Entrepreneurship**: More students can be attracted to doctoral studies by providing a platform where they can convert their ideas or research into reality. To foster such an environment,

- Incubation centres must be facilitated and promoted in academic institutions.
- Universities can offer courses on Entrepreneurship.
- Mechanisms should be framed to support start-ups.

While application-oriented research is important, care should however be taken to ensure that

- Traditional base of academic research is not eroded.
- Intellectual property of the university is well protected.
- Core values and requirements of research are not diluted.

**3.3 Joint Ph.D programmes with industry:** To address the needs of people from industry interested in doing a Ph.D, academic institutes should focus on networking with industry and work out joint programmes with interested companies. This will create a talent pool of researchers in industry. Consequently, research in private sector will get a boost, thereby creating attractive job opportunities for researchers which, in turn, might entice many students to enrol in a doctorate programme. Thus, a virtual circle can be created.

The opportunity cost of pursuing a Ph.D is very significant for this target group. Hence, a favourable proposal needs to be designed which not only allows but also encourages employees to go for a Ph.D. There should be Memorandum of Understanding (MoU) between the partnering institution and the industry. The MoU could include the clause that the company pays their salary during the period of Ph.D. The Reliance Life Sciences (RLS) model is noteworthy in this aspect. RLS has a

mechanism whereby its employees may pursue a doctorate degree at Mumbai University. BITS Pilani also runs a doctorate programme for professionals. The programme has inbuilt flexibilities which attracts people from industry and simultaneously has a very strong scrutiny system to ensure quality Ph.Ds.

One important factor that should be kept in mind is that academic freedom is maintained and an enabling environment is created wherein prospective guides and doctoral students from industry can interact.

This will also potentially attract those bright students who chose to work in industry because of attractive financial packages.

**Recommendation 4: Create attractive post doctoral opportunities to provide fresh doctorates with a valuable cross disciplinary research and teaching experience.**

**Issues**: Postdoctoral opportunities in India and abroad are limited. The opportunities existing in India right now do not stand any appeal against post doctoral offers from abroad. The brightest go abroad and tend to prolong their stay as far as possible. Simultaneously, there is a lack of synergy between research and teaching experience.

This is an important stage where effective intervention should be made to broaden our academic and research base. Therefore, it is vital to create

- Dedicated central fund for Post Doctoral Fellows (PDFs) so that senior researchers can employ post docs for their research projects.
- More flexible positions for researchers with various institutions, centres of excellence, advanced research labs and industry.
- A large pool of post doctoral fellows. Projects of national importance, faculty for teaching institutions as well as private companies can choose new doctorates for temporary, yet financially very attractive positions from such a pool. Such centralization of resources will lead to better information dissemination and effective resource sharing.

Longer term offers could be made to PDFs by including teaching as a vital component. In many universities, a purely post doc research position is not recognized as teaching experience while making faculty appointments.

- Effective utilisation of the PDFs in universities should be facilitated by flexible and innovative appointment modes. This can provide a means of upgrading university departments in general, and also addressing the faculty shortage. Teaching experience will also increase opportunities of employment in universities after post doctoral work.
- Mobility across organisations should be facilitated during post-doc tenure. A group of five to six universities can be formed with an understanding that a Ph.D of one university can do a post doc at another. International peer review mechanisms can be established for PDFs. Overall, this calls for greater coordination among universities and research institutes, better sharing of resources, and for convergence of teaching and research experience.

## Part B: Quality

A quality degree which is universally recognised as such, and which is acquired after consistent hard work and application of mind both acts as a magnet to attract talented students and inspires awe in the minds of the general public. It is therefore essential that doctoral programmes in the country aspire to attain the highest standards of excellence. At present, the quality of research output in the country is completely uneven across institutions. While, it is necessary to maintain the high quality standards in elite institutions, it is simultaneously imperative to encourage the transition to cutting-edge research in others. It is also crucial that quality in the output of academic research is ensured by a variety of metrics like publications in peer-reviewed journals with good impact factor, academic activities like workshops and conferences, patents, technology transfer activities, etc.

**Recommendation 5: Rejuvenate the Ph.D programme and adhere to quality standards to attract talented students.**

**Issues**: Other than the financial benefits, a key deciding factor in making a career choice in academics is the intellectual satisfaction that one expects. The quality of research undertaken at a majority of institutions in the country is however so low that it deters potential students.

**5.1 Entry level screening**: Usually, an entry level examination is conducted to ensure good quality of the intake of doctoral students. A prospective doctoral student's aptitude and attitude towards research should also be considered along with other qualifications. At all times, adherence to good standards at the entry level is essential.

- Multiple pathways should be used to fill research positions.
    - Flexibility should be given to universities for conducting their own entrance examinations.
    - A demonstrated research potential should be given due consideration. If an applicant has published a good quality research paper, filed a patent etc, his/her application should be accordingly considered.
    - For working professionals, who may find it difficult to pass an entry level test, other flexible methods of assessment should be put in place.
    - Online testing of students should also be worked out. This is particularly important to attract potential students from abroad.
- Examinations
    - Testing aptitude for research should be made an integral part of the selection process. Apart from a written examination, a personal interview will be greatly useful.
    - Syllabus and quality of the current NET examination needs to be massively reformed.
    - Unlimited attempts should be allowed to pass the qualifying examination.

- As the borders between disciplines are getting increasingly blurred, it is important to examine the entry requirements for lateral entry across disciplines.

- Adequate care should be taken to ensure that screening methods are transparent and objective.

**5.2 Pre-Ph.D courses**: It is important to identify and bridge the gaps between the present and the required knowledge of a doctoral student.

National Pre-Ph.D programme: In order to utilize the limited pool of talented faculty, a national Pre-Ph.D programme of suitable duration, run by major national institutions can be launched. The programme would help in broadening the perspective of a future doctoral student and also increase networking within the research community. The necessary infrastructure for such an initiative needs to be created.

- It should involve qualified researchers who should be sufficiently incentivised to teach in the training programmes. Other distinguished speakers can also be invited for delivering lectures.

- Qualified applicants with a Pre-Ph.D degree can return to their respective home institutions once their training is over.

- The programme should be tailored to cater to different disciplines and should include a study of latest trends in particular streams. It should also train students in analytical skills, research methodology, instrument use, dissertation writing, etc.

For students registering for a Ph.D directly after a bachelor's degree, the importance of a Pre-Ph.D programme increases. It would not only impart students with necessary background training but also examine their research aptitude. In an integrated doctorate programme, Pre-Ph.D can serve as one of the exit points. The Pre-Ph.D degree could be recognized as a qualification to teach undergraduate courses.

R&D laboratories can prepare teaching material for Pre-Ph.D courses. Lecture notes should be made available on the internet, thereby ensuring wider accessibility. This will also contribute towards greater access to quality educational material among students and faculty. At the individual level, the guides must give sufficient self-study coursework to students.

**Recommendation 6: Create effective monitoring and assessment mechanisms during the course of doctoral research and encourage broader engagement with research**

**Issues:** Research in India is carried out solely on the basis of internal motivation. Effective external mechanisms which ensure good quality of research largely do not exist. At the same time, there are no sufficient mechanisms to guarantee broader engagement with research.

To ensure effective monitoring and assessment mechanisms

- Students must be continuously monitored and mentored to ensure that the research output is of requisite quality. Regular seminars by students will

ensure that the students adhere to their research work plan and show progress. Regular reporting in lab meetings could be used for informal feedback.

- Experimental projects should be monitored through a well maintained log book. The guide should insist and regularly check whether log books are maintained.
- Independent committees can also be set up before which the students make regular presentations. Any such committee should provide feedback and counsel the doctoral students. External co-guides from industry/ other institutes could facilitate a way to ensure better monitoring.
- Any mechanism used for monitoring should check for possibilities of plagiarism. Further, to enable an overall healthy research environment, Ph.D students should be taught ethics and standards of academic research as part of curriculum.

Before designing any new monitoring and assessment mechanisms, it is important to identify why the existing ones have failed and the lessons learnt should be taken into account.

To promote broader engagement with research,

- Regular interaction among the researchers should be facilitated through group meetings, research seminars etc. At some places, lab group meetings are held every week in which each student presents and discusses his/her work with the entire group.
- Wider exposure to research in the form of participation in international conferences, workshops, seminars etc will strengthen the student's research base and should be encouraged.
- Journal clubs where students discuss articles other than those in their own areas of research provide a means to broaden the academic horizon of students.
- Mentoring doctoral students for meaningful participation by means of poster presentations (individually or in groups), group discussions would provide further impetus in helping the students towards gaining confidence about their research. It will also lead to a larger networking among peers and established researchers from around the world.

**Recommendation 7: Comprehensive assessment of doctoral thesis and wider dissemination of research work**

**Issues:** Often there is no objective assessment of doctoral thesis, thus leading to theses of poor quality. The evaluation committee does not subject the thesis to a strict scrutiny. There is a huge problem of uneven quality across institutions, and this is particularly marked in the Social Sciences and Humanities, even to the point where Ph.Ds can be “purchased” on the basis of minimal work in some places.

One of the fundamental requirements for running a quality doctoral programme is to have a strong faculty involved in front-line exciting research. It is equally important

that reputed examiners are appointed to validate the quality of output of research thesis.

- A combination of internal and external examiners should be used to make the system more robust. The names of members of the respective evaluation committee should be attached to each approved thesis. It is important to bring transparency in the system and attention to quality.
- Open defence of thesis could be mandated. If a student fails to defend his/her work suitably, a second defence can be planned after six months. Honourable exit options should be provided for doctoral students.
- Publications in quality research journals should be encouraged. Open peer review of publications should be aimed at.
- Ph.D thesis should be uploaded on the internet, preferably on the proposed National Research Portal. In any event, open and free access to research output in archives and other digital media resources should be made mandatory.

Alternative systems to grant a Ph.D can be explored. As practised these days in Germany, five published papers in peer reviewed journals should be deemed sufficient to acquire a Ph.D. This does not stipulate registration, time limit or supervision. Such students should publish in reputed and internationally recognised journals, and these papers may be reviewed collectively by a panel of examiners (at least two from developed countries and two from India). If a minimum of three pass the standards test, Ph.D degree may be awarded to the student and should be recognised in the existing system. Such innovative and alternative systems need to be explored and put into practice.

## Part C: Nurturing a research environment

In order for research to flourish, it is vital that the entire academic system be made more conducive and vibrant. Universities are the natural homes for academic research the world over, and it is vital that research culture be brought back to our universities. Other stakeholders like industry and government can play an important role in this endeavour.

**Recommendation 8: Enable university environment to produce quality Ph.Ds**

**Issues**: Various compulsions in early policy making in the post-independent era led to a large number of stand-alone research institutes. It is now increasingly being recognised that separation of research and teaching has been at the cost of creating a good research environment in the universities. We have already lost a couple of generations of talent because of the resulting breakdown in the university system. The present academic environment in many universities remains largely unattractive for researchers.

**8.1 Facilitating research opportunities in university environment:** University reforms are urgently needed and an integral part of this should be aimed at enabling a research culture in universities. A vibrant research atmosphere in the universities will definitely attract more students towards research. The most essential enablers for such

an environment include the presence of a facilitating administration, talented faculty and the availability of adequate research facilities.

**Conducive administration:** Often university administration itself militates against creating conditions conducive to research. This is largely because of the centralisation of decision-making, restrictions on faculty autonomy and imposition of rigid financial rules that makes "managing" projects very demanding. Administration should be sensitive to academic needs and should aim to encourage and help faculty to deliver better results. In order to enable a favourable administrative environment, it is essential to

- Ensure a capable administration headed by an able Vice Chancellor and Registrar.
- Grant autonomy in making recruitments to achieve higher standards.
- Undertake steps to completely eradicate politics and inbreeding in the system.
- Simplify bureaucratic procedures to make the system more responsive, transparent and efficient.
- Provide technical help or guidance to potential university researchers for writing grant applications.

**Collaboration for sharing resources and expertise:** It is vital to provide researchers with the required infrastructure to carry out their research work. Universities should be given adequate funds for upgrading infrastructure. Often, the lack of funds acts as a hurdle in building and maintaining capital-intensive infrastructure. Hence, sharing of infrastructure with joint responsibility of maintenance among institutes should be greatly encouraged. For better, meaningful sharing of physical as well as intellectual infrastructure among institutions,

- Collaboration should be formalised by entering into alliances, signing MoUs etc.
- New research and academic institutions should be co-located as much as possible.
- Library facilities, access to journals electronically etc. should be provided freely. The upcoming National Knowledge Network should be leveraged for this purpose.
- Top down systemic linkages from elite institutions to universities and to colleges should be established and encouraged to ensure capacity building.
- Joint doctoral research where students are allowed to select guide and co-guides from across academic and research institutions should be undertaken.
- Research institutes can allocate sub-projects to universities to begin with.
- Inter-disciplinary projects involving multiple agencies should be explored.
- UGC should promote conferences with industry and research institutes to enable conversion of ideas into research to be implemented at universities.

**Revamp of Laboratories:** An inseparable part of research and teaching in Science and Technology is the laboratory. Laboratories play an important role in creating research attitudes, arousing interest and curiosity. They help in gaining experience in scientific methods and learning the process of scientific enquiry. Given the current

state of affairs, there is an urgent need to begin an intervention aimed at addressing the quality issue in laboratory training. It is important that even schools are provided with good laboratories and specific attention should be paid to lab training at the undergraduate level.

A major problem with all laboratory experiments is that they do not attempt to challenge the student sufficiently and the whole exercise is conducted at a very rudimentary level. Vital aspects of experiments are not highlighted for the students. The student is typically not involved in important areas of the experiment such as designing or selecting the apparatus, deciding what measurements need to be taken, or what variables need to be controlled. Students are given no opportunity to think for themselves. Laboratory courses thus need a complete revamp.

- There is a need to redefine the objectives with which experiments in a lab are performed, so as to make the laboratory training more concept based rather than 'result based'.
- It should lay emphasis on a student's contribution to planning, execution and analysis of the experiment.
- Error analysis, up to and including calculation of error bars should be essential requirement for each experiment.
- Training should include maintaining lab journals and technical communication skills.

This will help in guiding the talent towards hard-core experimental sciences.

**8.2 Changes in the university system to encourage research and good teaching**: Both teaching and research should be promoted by creating mechanisms which provide freedom, encourage innovation, and recognise and reward good work. Good teaching plays an important role in encouraging students to pursue an academic career and this aspect is often unrecognised.

- Faculty should have sufficient resources to carry out research as well as teaching activities. Teachers should be especially encouraged to create innovative teaching material and for providing wide-spread access.
- Good working conditions are absolutely essential in creating a vibrant academic environment.
- Free flow of researchers between industry and academia should be initiated. Sabbaticals to work in industry for academicians and vice versa for industry employees should be instituted. Sufficient provisions should be made for granting sabbaticals to faculty for undertaking research.
- Liberal rules should be looked into for providing faculty members with the flexibility to hold dual appointments between R&D institutions and universities.
- Flexibility in extramurally funded projects to university based investigators should be given so that they can travel and participate in international meetings/ workshops.
- There should be provisions for mentoring of young faculty by established scientists which involves spending brief period at the mentor's laboratory/ institute.

- To incentivize research, performance appraisal for promotions should give a higher weightage to research.
- A component of funding should be used for rewarding good teachers and researchers.
- Separate research wing in universities could be developed with as few bureaucratic hurdles as possible. Group recruitment with a specific mandate of developing frontier areas in research should be explored.

Flexibility should be accompanied with a component of accountability, the norms of which should be periodically reviewed.

**8.3 Reduction of teaching load**: There is a serious shortage of faculty across institutions. Further, with a large number of teaching posts in colleges and universities remaining vacant, there is severe stress on the existing faculty. Also, in the current system, the whole profession of teaching has been severely undermined with contract teaching in colleges becoming more and more acceptable. Teachers have no time or inclination to participate in anything innovative which has led to a lack of involvement and enthusiasm in the whole system, thereby leading to gradual decay and degradation. It is crucial that these issues are addressed and acted upon with the utmost sense of urgency.

Some steps that could be undertaken to reduce teaching load are:

- Duplicity of courses should be avoided. This calls for greater interdepartmental collaboration at the level of individual institution. Inter-institutional collaboration to offer common courses can also be worked out by means of sharing credit.
- Lectures can be delivered to a large class combined with tutorial sessions in smaller batches of students.
- Positions of Adjunct Faculty must be created and strengthened. People from research institutes, industry, abroad etc should be invited to teach few courses every semester. Services of retired professors can also be used. This will also bring in much needed fresh inputs from outside into the university.
- PDFs and Ph.D students should be effectively utilised in teaching or teaching assistantships. Specially, bright students should be allowed as well as encouraged to teach junior classes.
- ICT should be used extensively for teaching wherever appropriate. This will give access to quality educational material to a larger section of the student community.
- Issues regarding new recruitment should be sorted out and new appointments should be made as soon as possible. Adequate facilities for research, seed money, housing and incentives for sponsored research should be offered to attract new faculty.

**8.4 Data collection, organisation and access:** While there are numerous agencies involved in data collection related to different aspects of Higher Education and Research, the organisation of, and access to these data remain largely nebulous and inaccessible. This should be rectified. It is important to recognise that such data can

play a vital role in policy issues, funding, reforms, etc. Data collected should be cogently organised, analysed and made accessible to a wide section of stakeholders. We also emphasize that there should be strong, vibrant and systematic linkages in place between institutions like NISTADS, NUEPA and the actual stakeholders in the system that these institutions are supposed to address. Just as the modern knowledge system necessitates continuous knowledge upgradation of the academic and scientific personnel, it also necessitates that the university administration be continually exposed to best management and administration practices in the university systems around the world. It is thus essential to create a vibrant and pro-active platform for the skill and human resource upgradation of the administration personnel.

**Recommendation 9: Foster inter-disciplinary research, translational research and basic research in social sciences, arts and Humanities:**

**Issues:** New interdisciplinary areas of research are emerging rapidly in the global context and these are not adequately represented in the country. Almost in all important professional streams like medicine, engineering, management, law etc, actual practice is divorced from research. Despite the tremendous diversity, rich history and cultural heritage, credible basic research in the social sciences is conspicuous by its absence in most universities.

The face of sciences, or for that matter, every discipline today, is changing rapidly. Conventional boundaries between different streams are fast disappearing. Interdisciplinary projects and doctoral programmes in interdisciplinary areas need to be encouraged to propel research in emerging areas. To facilitate this, interdisciplinary faculty options may be created. Interdisciplinary guide and co-guide combinations should be permitted for guidance towards a doctoral thesis. Generous funding should be provided to encourage research in new areas. Appropriate modification of entry barriers to such doctoral programmes should be looked into.

Translational research, especially in the area of medicine and engineering is largely absent in the academic landscape. As a specific example, Medical Education and Research lack in innovation due to the present lacunae in the education system. This field is largely service oriented with less or no emphasis on research, reasoning and rigour. In order to drive innovation, it is imperative that a medical education straddling programmes from diverse disciplines such as clinical, epidemiological, laboratory, pure sciences (physics, stats, optics, med chem, organic chem, cell biology, biochem) be rolled out in front-ranking institutions. An option of having a component of clinical research in Ph.D programmes in the natural sciences should be introduced. This will require co-mentoring of students by faculty drawn both from a surgical/clinical/para-clinical pool and basic biology/physical/engineering sciences. In general, translational research linking practice, field and lab work should be generously funded and encouraged. The existing regulatory structures make this highly difficult and this needs serious intervention.

The training in the humanities has to be reformulated so as to provide a sound, but preliminary, theoretical classical foundation which is in the end solidly geared towards training the student to understand social life as it actually is. It should equip him/her to tackle its vast range of problems in their full magnitude, reinforced by

solid and practical training in the field. Integrated courses which allow for a creative and imaginative choice of subjects should be designed. There could also be a component of Management Education within the Humanities stream. Integrated Masters programmes in the Humanities that initiate a congruence of many components ranging from communication skills, traditional knowledge systems and practices, disaster management, community life, local government, international diplomacy, governance and conflict, public administration and beyond should be designed. These courses could also be made open to international students, especially from the developing world. The courses should relentlessly focus on the centrality of human living, and represent a thorough amalgam of its constituents, with the first two years devoted to theoretical foundations, the next two years to applied aspects, and the final year to practical field work. Such programmes would also improve the quality of work at the doctoral level.

Industries probably do not have a tangible stake in funding basic research in social sciences. Hence public funding is vital to ensure research and progress in these areas. It should be recognised that knowledge in these areas contributes directly to the well-being of society and also in nurturing a sense of pride about our cultural heritage.

Overall, undergraduate and postgraduate courses should offer a wider bouquet of subjects within a credit and semester system.

**Recommendation 10: Promote excellence at research institutes and universities**

**Issues**: Research institutions have maintained a lead in research activities in the country. However, they need to play a larger role in academic activities by means of linkages with universities, etc.

**10.1 Research Institutes**: To promote better managed institutions, it is essential to groom leaders who can take the institutions forward. Governance of the institution should be based on democratic principles. Wider feedback from scientists at all levels should be taken. An independent Board of Governors with respectable members from academia and civil society should be constituted for each institution. Transparency in recruitment of faculty members is necessary and promotions based on appraisals should be encouraged. An efficient administration totally devoid of corruption should be put in place.

The research institute should be nimble and dynamic in developing new areas of research. Industrial consultancy group should be developed in application research based institutes. This will bring in funds, ideas and much needed efficiency in the system. Better managed institutes should be encouraged to lead and mentor others. Research institutes should be encouraged to work with universities.

The interaction between research laboratories and universities should be institutionalized. It is important to work towards aggregating research institutes and universities rather than creating new stand-alone research institutes. Possible ways of doing this are to convert research institutes into small-sized research universities, aggregating various CSIR research labs under a common university system whose strengths are inter-disciplinary teaching and research, co-location of teaching

institutions and research institutions, as between IISER and NCL in Pune. Some research institutes which have outlived their utility can be absorbed in regular universities. This will also give much needed access to quality research personnel at universities.

**10.2 Periodical reviews**: A good periodical review system of departments to support centres of excellence can be undertaken through independent accreditation, out of turn rewards, and conditional grants. Advisory committee of Alumni can be constituted for internal review of the departments.

Ph.D thesis, publications, patents, commercialization of research and peer review can be included as measures of performance review. Quality of faculty should be strictly monitored.

**Recommendation 11: Establish more centres of excellence for research and teaching from the undergraduate level for different disciplines across the country:**

**Issues**: There is a serious shortage of institutions which provide both good undergraduate training and research environment. Currently, in most of the existing centres of excellence where doctoral studies are undertaken, the focus is largely on the Ph.D and/or Masters programme.

Sound training at the undergraduate level is vital for students wishing to embark on an academic career. Often, students entering a doctoral programme at elite institutions are found to have an inadequate background for research even after having completed a Master's degree. A high quality four year programme should be rolled out in select institutions[3] which will enable direct entry to a Ph.D programme, thereby effectively reducing the total time spent on doctoral study. A new system of research based universities starting at the undergraduate level focusing both on teaching and research is essential to create the right environment needed to nurture research. Existing universities or research institutes may be transformed into a smaller research based universities. Smaller universities ease administrative hurdles. Universities without attached colleges have a higher chance of developing a good research culture. Excellent resources and infrastructure should be created. Also, adequate communication channels should be established with existing universities to provide holistic (broad based) education. The Government has taken a step in the right direction by starting Indian Institutions of Science Education and Research (IISERs) in the field of sciences. Corporate houses could be involved in starting some of these new universities. Research universities for thrust areas can be created in public-private partnership mode.

However, some caution needs to be observed while setting up new research universities.

- An able director is essential for developing a new institute.
- These universities should not become isolated islands of excellence.

[3] See NKC's Publication on "Attracting More Talented Students to Maths and Sciene", Pages 9and 22, http://www.knowledgecommission.gov.in/downloads/documents/nkc_maths.pdf

- Faculty will remain the most serious issue in expansion and appropriate steps should be taken in this direction.
- Serious investigations into the existing system should be undertaken in order to identify the gaps and to ensure that mistakes are not repeated.

Simultaneously, a comprehensive process of repair and reforms within the existing system should be initiated. This can take the initial form of identifying select departments/colleges/universities with a potential for substantial improvement. Funds should be invested in upgrading and monitoring the progress of these. Vital components of this exercise are transparency, academic autonomy and establishment of systematic linkages.

Colleges within universities which are engaged in quality teaching and research projects should be encouraged and supported with free access to funds, investment of infrastructure, more academic and administrative autonomy. A useful metric for evaluation of colleges could be the placement of its students at research and academic institutions within and outside of the country. On the whole, there should be an overall empowerment of colleges providing quality undergraduate education.

**Recommendation 12: Augment available sources of funding, optimize allocation and provide greater flexibility towards utilization**

**Issues**: Funding remains a key issue in facilitating quality research in most universities. The low quantum of funds, the cumbersome process of acquiring them and the lack of fund raising capabilities in the university/ faculty members have severely hampered growth of research.

Concerted efforts are needed in funding research. Various sources of funding should thus be explored.

- Large scale public funding is necessary for nationally relevant research projects.
- Recruiting companies should contribute towards university research funds. Industries should be encouraged to sponsor and collaborate on research projects. Laboratories named after sponsoring companies can be established. Also, Sponsored Chairs by industry can increase the number of faculty and researchers without any additional cost to the university
- Universities should formulate strategies to convert research findings into commercial applications, thus generating funds. Alternate means like consultancy, online courses, etc should be explored. Universities should also establish and leverage alumni network.
- Government funding agencies should proactively encourage and guide faculty members from universities to submit research proposals. A system of open competition for research grants should be developed.
- Collaborative funding between countries and universities should be encouraged.

To increase research funding in the longer term, alumni/ corporate fellowships should be looked at. For instance, NASSCOM has developed a Public Private Partnership framework under which fellowships could be provided to students. Collaboration with foreign universities in which students and co-guides get a chance to attend foreign universities has been worked out as part of the initiative. Academia should evolve strategies to increase such funding avenues substantially. Such initiatives also have the merit of wider industry academia interaction.

Primarily however, professional financial management is needed at universities. There should be in-built flexibility and lenient guidelines for utilisation of funds. It is also important that faculty in research institutes and universities are trained in the utilization of funds.

**Recommendation 13: Encourage private participation in research activities by fostering industry-academia interaction.**

**Issues:** The two worlds, academy and industry, are viewed as divergent, because of perceived vested interests, which often leads to mistrust.

It is important that there is a change in this mindset and that new ways of establishing and institutionalising permanent linkages are explored. The value of domain knowledge expertise is bound to increase as the economy matures and knowledge gets integrated as an important component of the economy. Industry should take cognizance of this and should support doctoral programmes in both basic and applied research disciplines. Further, social sciences can contribute to innovation in business processes, and in the overall understanding and progress of the society. Industry can participate in academic research activities by -

- Investing in infrastructure building,
- Inviting students to spend a semester in industry,
- Allowing people from industry to take special lectures in universities,
- Getting involved in monitoring and updating curriculum,
- Offering research projects to people in academia either alone or by collaborating with other industries,
- Conducting or participating in science fairs, seminars, workshops and popularization programs etc and
- Sponsoring research in universities directly. As an example, TCS sponsors research projects in various colleges instead of giving one time infrastructure grant. This ensures more than just monetary support and leads to healthier interaction.

At the same time, academia should open its doors to industry. Lateral entry provision should be facilitated for those interested in academics with a background in industry. It should also facilitate continuing education of industry employees by designing and delivering short courses. Appropriate methodologies should be developed to carry out all collaborative efforts. It is essential to clarify issues such as sharing of intellectual

property rights. Industry associations must facilitate interaction and collaborations between industry and academia.

A culture of research in the private sector is essential to develop more prospects for doctorates and increase efficiency and diversity in the system. To encourage Indian as well as foreign industries to carry out research activities in the country,

- Industry should be incentivized to use indigenous technology.
- New science and technology parks in the private sector should provide research and development facilities at subsidized rates for all companies.
- Knowledge hubs should be created in each state, which should provide space and other facilities like patent cell, entrepreneurship cell. Multinational companies which aim at creating large research centres in India can pilot launch their operations in the knowledge hubs. Knowledge hubs will facilitate market driven research and product development.

## Part D: Fostering a global outlook in research

Research as an activity requires exchange of ideas and sharing of knowledge at a broader level. In today's globalizing world, there is a pressing need for India to provide its students and faculty with international and multi-cultural exposure.

**Recommendation 14: Attract NRI/ PIO Scientists by providing attractive opportunities in the country.**

**Issues:** Researchers often leave India for a better environment that offers variety of choices, opportunities and intellectual freedom. Such researchers find it difficult to return back because of the absence of an enabling and nurturing system in the country.

**Provide flexibility in the system**: Currently, the rigidity of entry in the university system repels the scientists who might otherwise consider coming back to India.

- The system should be made more flexible to encourage talent at all levels. Respect for talent rather than "seniority" should be built into the system. To attract the best people, it becomes important to offer them positions that are professionally better than what they currently have in their country of residence.
- Positions of Research Professors with advancement capability based on research excellence and not age should be created. Young scientists should get equal independence as their senior counterparts.
- Adjunct positions in industry and research laboratories should be created for inviting NRIs.
- Institutional mechanisms should be created to allow scholars to go back and forth and to freely invite other researchers and collaborators. In case, the scientist returns back, he/she should be encouraged to continue to maintain contact with the researchers in the lab and guide them.
- The system should also enable appointment at the level of Director, Dean, Vice-Chancellors, and Technical/Scientific advisors to Union and/or State

Government. At the same time, there should be effective monitoring mechanisms to ensure accountability and to prevent misuse of such positions.

**Offer more resources and create nurturing environment**: Creating a challenging and excellence-oriented environment with appropriate resources is vital.

- Substantial amounts of "start-up funds" for setting up labs and hiring post doctoral students should be made available to the researchers. The researchers should also be given freedom to generate their own funds.
- A congenial environment to foster independent thinking and working is a must. This requires providing facilitating administration as well as maintaining best standards in research.

**Recommendation 15: Formalise collaboration with foreign institutions and researchers.**

**Issues:** Failure to attract foreign students and collaborate with foreign universities and researchers has led to an absence of multi-cultural and international exposure for both Indian students and faculty.

Collaborative programmes with foreign universities and research institutions will encourage faculty and students to learn and exchange ideas and practices on latest developments.

- Indian scientists should be given generous travel grants to attend international conferences. Further, they should be given adequate and comprehensive support to organize international meetings.
- Visa procedures for research exchanges should be simplified. Just as credible business travellers are granted multiple entry visas valid over a longer period, similar facilities for scientific visas can be looked into. The post of Academic Attachés in various consulates should be created and filled. They can play an important role in facilitating scientific exchanges between countries. In addition, this will also provide an alternative employment avenue for people with a research background. Multiple entry provision for foreign researchers would also benefit frequent collaboration by considerable reduction in the hassles of obtaining visas.
- Joint supervision of doctoral thesis is one area where cooperation should be promoted. Length and type of exchange programmes should be so designed that our faculty as well as research students gain adequate benefits.
- Other forms of collaboration which could be looked at are joint degree programmes with foreign universities.
- Initiatives should be taken to invite faculty from abroad to not only give special guest lectures but also teach partial or full courses.
- A public/private non-profit corporation like Carnegie, Ford and Rhodes Scholarships of high brand value can be created to pay for faculty exchanges from both industry and research institutes. Individuals who are capable of mobilizing funding for such corporations could be chosen to head such institutions.

- Indian Institutions should tap the benefits of multi-institution networks by participating in the good ones that already exist or by creating such platforms themselves. The McDonnell International Scholars Academy and McDonnell Academy Global Energy and Environmental Partnership at Washington University in St. Louis are examples of such networks. The two academies collaborate with select universities from across the world. They provide opportunities to the partners to interact, discuss, and learn from each other by working on collaborative projects.

Many funding agencies from the developed countries are conscious of the demographic advantage that India has and are keen to participate in joint initiatives in research, training, etc. Funding and collaborative opportunities for the younger people should be widely publicised and national funding agencies should play a pro-active role in directly linking up scientists and such diverse international funding agencies. Collaborations should be based on win-win models and should facilitate a need-based, two way flow of knowledge. One must also ensure the following:

- Intellectual property is well-protected.
- Collaborations are based on synergy and not brand name alone.
- Students are not just made to do repetitive work without any meaningful exchange of knowledge.
- Students spend considerable amount of time in the home institutions.

To conclude, excellent infrastructure, favourable research environment, reforms in Higher Education - especially university reforms - and increased funding with sustained investment are all needed to attract students to doctoral programmes. In this context, there is an urgent need to give special attention to the dire situation of the lack of qualified faculty, and to overall spark national interest and attention towards academics. Any initiative or investment in this direction may not produce tangible results in the short term. However, given the enormity of the problem, further procrastination will only lead to greater damage of the system which will render future repairs vastly more expensive, both financially and academically. Hence it is imperative that the Government acts with a sense of urgency and embarks on the remedial path immediately.

**Annexure 1: List of Participants in the Workshop**

1. Dr. K V Subramaniam, Director, Reliance Life Sciences
2. Mr. Venkatesh Vallury, Managing Director, Agilent Technologies
3. Dr. Shilpa Vora, Principal Research Scientist, HLRC
4. Ms Valsa Williams, Intel Technology India Pvt Ltd
5. Dr. Sandhya Chintala, Director, Education Initiative, NASSCOM
6. Dr. Vidyasagar, Executive Vice President, TCS
7. Dr Meenu Singh, Additional Professor of Pediatrics, PGIMER, Chandigarh
8. Dr. Bala Subramanian, Director, LVPEI
9. Dr. Y S. Rajan, Principal Advisor, CII
10. Dr. R. B. Grover, Director, Knowledge Management Group, BARC
11. Dr Gyan Arora, Tata Motors
12. Prof. G.D. Yadav, UICT
13. Dr. Sushma Gupta, Ranbaxy Laboratories
14. Prof. B.D. Singh, Dean Sciences, Banaras Hindu University
15. Prof. E. Haribabu, Dean Social Sciences, University of Hyderabad
16. Dr. A.N. Desai, The Bombay Textile Research Association
17. Prof. Balaji Parthsarthy, IIIT Bangalore
18. Prof. Pankaj Jalote, IIT Delhi
19. Prof. Shashiprabha, Jawahar Lal Nehru University
20. Dr J.K. Bhasin, NEERI
21. Dr Ajit Ranade, Chief Economist, Aditya Birla Group
22. Dr Rajendra Singh, CMIR Dhanbad
23. Prof Varyam Singh, Dean Languages, JNU
24. Dr. Ashok Ganguly, Member, National Knowledge Commission
25. Dr. Sujatha Ramdorai, Member, National Knowledge Commission