

**Report on**  
**Brainstorming Session on Science Academies' Initiative on Post-School Science**  
**Education, held on 12-1-2009 at INSA, New Delhi**

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**INSA, New Delhi**



**IASc, Bangalore**



**NASI, Allahabad, India**

## **Science Academies recommend a broad-based education in sciences**

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A Position Paper entitled “Restructuring post-school science teaching programmes” was prepared by the Joint Education Panel of the Indian Academy of Sciences, (Bangalore), the Indian National Science Academy (New Delhi) and the National Academy of Sciences India (Allahabad). The Position Paper carried a variety of suggestions to improve the quality of teaching of sciences with a view to provide a holistic and integrative learning in science and technology. Presidents of the three Academies presented this document to the Fellowships of the Academies and to various governmental agencies, universities, research institutes, IITs, IISERs etc with the “hope that the suggestions will be seriously considered by the concerned agencies for their effective implementation”. The Position Paper was also published in *Current Science* (25 November 2008) and *Resonance* (December 2008) for a still wider awareness.

Following the wide circulation of the Position Paper, the three Academies jointly organized a brain-storming session on 12<sup>th</sup> January 2009 at the Indian National Science Academy auditorium to discuss the various suggestions in the above document and to consider specific steps required for their implementation.

The brain-storming session was attended by, besides a large number of Fellows of the three Academies, several heads/representatives of different agencies. These included Prof. S.D. Thorat (Chairman, UGC), Dr. T. Ramasami (Secretary, DST), Dr. Katoch (Director General, ICMR), Dr. S.K. Sikka (from office of the PSA to Prime Minister), Prof. S. Ramdorai (Member, National Knowledge Commission), Prof. Prem Krishna (Vice-President, Indian Natl. Academy of Engineering), Prof. Yashpal, Prof. M.G. K. Menon and others.

Prof. N. Mukunda coordinated the meeting and welcomed the participants. Prof. M. Vijayan (President, Indian National Science Academy), Prof. D. Balasubramanian (President, Indian Academy of Sciences) and Prof. Asok Mishra (Ex-President, National Academy of Sciences of India) in their inaugural speeches highlighted the urgency of reforms in curricula of science teaching programmes at under- and post-graduate levels and also emphasized the need for a proactive role of science academies in sensitizing and advising the regulatory and implementing agencies about science education and policies. All the three Presidents expressed their happiness that the Academies are working in concert in this sphere of activity.

Prof. S. C. Lakhota presented highlights of the Academies' suggestions for restructuring post-school science education contained in the already widely circulated Position Paper. It was pointed out that the main emphasis of these recommendations was to:

1. Replace the existing highly compartmentalized B.Sc./M.Sc. courses with broad-based pyramidal and choice-based semester system at all existing under- and postgraduate programmes to foster concept-based interdisciplinary and integrative learning of the desired discipline of science.
2. Ensure adequate laboratory facilities at all colleges/universities and to have at least 30% of course work through actual laboratory work which should include some open-ended experiments to provide not only adequate laboratory training but also inculcate the spirit of enquiry.
3. Introduce, initially at select places, a new 4 year B.S. Honours degree following which the qualified graduates can directly join Ph.D.
4. Provide for easy switch-over between technical and basic science education.

Keeping in view the recommendations of the Academies' Education Panel, the following specific questions were presented for further discussion at the brain-storming session:

1. **Would broad-based pyramidal curricula dilute learning of specific discipline?**
2. **Should B.Sc. degree be provided in narrow specialized disciplines?**
3. **Is it desirable to introduce the proposed 4-year B.S. Honours course at select places?**
4. **Should multiple options for Science courses be available to +2 students?**
5. **Should there be mobility between basic science and professional courses?**
6. **How are the suggestions to be actually implemented? – Are the universities/autonomous colleges free to adopt them or do they need UGC/AICTE mandate?**
7. **Should the Academies undertake exercises to suggest broad frameworks for different curricula?**

Speaking immediately after the above, Prof. Thorat, Chairman of the University Grants Commission, whole-heartedly supported the Academies' recommendations and stated that the Position Paper of the Academies for restructuring the post-school science education was a well-analyzed and timely document. He assured that the Commission will provide all help in implementation of these proposals for which it would seek guidance of the Academies. Prof. D. Pental, Vice-Chancellor, Delhi University, speaking on implementation of the recommendations in the university/college sector

highlighted the urgent need for drastic reforms and agreed that the Academies' recommendations provided a significant step in that direction. He was of the view that the multiple choices make it easy to implement the various recommendations keeping in view the local needs and capabilities. Prof. P. Rama Rao highlighted the dearth of qualified scientists and well-trained engineers and technocrats compared to the actual needs of the country and of waning interest in original research. He strongly advocated the proposal for easy switch-over between basic science and technical education since this would facilitate new technical developments based on original research.

During the open discussion session, Prof. Yashpal emphasized that availability of more money for education alone would not make for better science but better facilities have to be matched by appropriate interdisciplinary curricula and stimulating teaching methods that evoke curiosity in Science. Dr. Sujatha Ramdorai noted that there are many points of convergence between the recommendations of the Science Academies and those of the National Knowledge Commission and thus the two should work together. Prof. Gnanam pointed out that the UGC Committee's recommendations also converge with those in the Position Paper. Prof. T. J. Pandian pointed out that Agriculture and Medicine should also be included in the proposals for post-school science education reforms and that the Academies should not only develop the curriculum for the various proposed reforms but also define the minimum eligibility for admissions. Prof. P.T. Manoharan mentioned that M.Phil. should be scrapped and the proposed 4-year B.S. (Hons.) course should be started only in universities with good research base. He mentioned that language is a major problem in most state universities since a majority of their students are not proficient in English and good reading material is not available in regional languages. Prof. Manoharan also suggested that similar reforms need to be introduced in disciplines other than Science. Prof. D.P. Roy of Homi Bhabha Centre, Mumbai, strongly felt that the existing 3 year B.Sc. programmes should continue since the European countries are switching over to the 3 year B.Sc. pattern.

Prof. M.G.K. Menon strongly defended the proposed broad-basing of Science education since the B.Sc. degree was "Bachelor of Science" and not Bachelor of a specific discipline in Science. He categorically stated that all the recommendations in the Academies' Position Paper should be accepted and the issue of governance need to be discussed with the concerned regulatory bodies. Dr. Sikka, speaking on behalf of the Principal Scientific Advisor to the Prime Minister, stated Dr. R. Chidambaram would be happy to implement the recommendations of the Academies and that the earlier recommendation made by Prof. Mukunda Committee in 2004 that the research institutions should start under-graduate teaching needs to be followed widely. Dr. Soumitro Banerjee while supporting the Academies' recommendations cautioned about credits earned by students in unconnected courses since that would seriously dilute the learning of core courses. Dr. Ananthakrishnan, while agreeing to all the recommendations, suggested that some institutions should be mandated to train teachers. Likewise Prof. Rudraiah stated that the Academic Staff Colleges need to be revamped to ensure that the various courses offered by them help the participants really learn newer developments in the subjects and methods of better teaching, rather

than conducting the refresher and orientation courses merely to fulfill the requirements for promotion etc. He stressed the need to regularly fill in the faculty positions as vacancies arise. Dr. Rajendra Prasad emphasized that B.Sc. degree must be the terminal degree for a majority. He suggested that Indian History, especially of Science, should be taught to all students. Prof. D. V. S. Jain agreed that all the suggestions are good and need to be implemented, although he raised concern about the feasibility of semester system with many colleges in the country being “run” without adequate faculty or even without regular water or electricity supply. These aspects also need urgent attention for remedial steps. Prof. Jain further suggested that the rules and regulations governing different state universities need to be changed to free them of the political controls and that the examination system at all levels needs to be transparent so that the examinees have opportunity to see their evaluated answer books.

Prof. Prem Krishna (Vice-President of Indian National Academy of Engineering) lamented the sub-standard quality of education due to poor infrastructure and inadequately qualified faculty in most of the engineering colleges in the country. He welcomed the proposals that would facilitate mobility between basic sciences and technology and proposed that the Science Academies and the INAE should work together. Prof. Yadav (UDCT, Mumbai) emphasized the need for industrial training in all engineering/technology courses. He also suggested that the academic institutions should have six-days of working per week and that the retirement age in state and central universities should not be different. Earlier, Prof. Ashok Mishra, while welcoming participants on behalf of the National Academy of Sciences India, also strongly argued in favour of the proposed 4 year B.S. (Honours) and of easy switch over between science and technology streams.

Dr. Ramasami (Secretary, DST) while summing up the discussion agreed for implementation of the Academies’ suggestions but cautioned that we must remain conscious of the difference between ideal and real world. The multiple education programmes available after the school education would help segregate those who wish to be scientists/teachers at colleges and universities from those who wish to go in for other jobs. He emphasized the need to significantly improve the quality of Ph.D. in Science.

Prof. Vijayan, in his concluding remarks agreed that the problems facing higher education are formidable but it is the right time to take the first steps. He expressed satisfaction that the Science Academies are working with synergy and with clear understanding that the Academies need to play advisory roles and work in concert with the implementing agencies.

**Based on the discussions at the brain-storming meeting, the Science Academies recommended the following for implementation**

- **Multiple options be available to students who have completed +2 level and wish to continue in Science stream:**

- 3 year B.Sc. → 2 year M.Sc. → Ph.D. (existing)
  - 5-year Integrated M.Sc. programme, followed by Ph.D. (existing)
  - 3 year B.Sc. followed by Integrated or dual-degree M.Sc.-Ph.D. programme (existing)
  - A new 4 year B.S. (Honours) programme followed by Ph.D. programme, without the need for a Master's degree (details given later)
  - Vocational courses to facilitate self-employment
- Learning of Science (and all other disciplines) in all the above models must be pyramidal and not a vertical high-rise. The curriculum must provide a broad-based training of different disciplines of scientific enquiry with specialization introduced as the student advances in training.
  - All courses should be semester-credit based.
  - The 1<sup>st</sup> two semesters of the 6 semester (3 years) B.Sc. should provide for learning of all major science disciplines by all students with the next four providing core training in 2-3 disciplines; the last 2 semesters may provide for Honours in one or two disciplines.
  - All semesters at B.Sc. and M.Sc. should provide 15-20% credits through courses in disciplines (in and outside Science faculty) other than their major/honours subjects, including communication skills.
  - Courses in highly specialized subjects like Biotechnology, Bioinformatics, Computer Applications, Nanotechnology, Nanobiotechnology etc should not be allowed at School and undergraduate levels.
  - All core courses must provide for 30-40% credits through laboratory/field work; several of the lab exercises must be based on open-ended experiments.
  - Students at M.Sc. level must undertake a dissertation and prepare a research project proposal.
  - After completion of 6 semester B.Sc., provision be made for a 2 year B.Tech/B.E. programme
  - A new 4 year B.S. Honours programme may be introduced following which the graduates can join Ph.D. programme:
    - The B.S. (Hons.) programme would be credit based semester system available to those passing out of the +2 level in Science stream
    - The first 4 semesters will cover all major science streams as core courses. Students will opt for a Major/Honours subject in the last four semesters. Each semester would have 15-20% credits for elective courses in other fields, including communication etc. The last semester should provide research experience
    - On successful completion of the 4 year course, they would be eligible

for seeking admission to Ph.D. programme, since it is expected that the 4 year period would prepare them better than the conventional 3 year B.Sc. + 2 year M.Sc. courses and any deficit in a specific area can be made up through courses during Ph.D.

- The first two semesters of Ph.D. programme will have credit-based lectures as well as laboratory courses. Those not desiring to continue with Ph.D. may exit after successful completion of the course work with M.Sc. degree
- The 4 year B.S. (Hons.) programme be introduced only where a good research base is available.
- Mobility within basic sciences and between basic and professional courses be facilitated, including for Ph.D.
- A system for regulated transfer of credits from one major to another major within the institute and also between institutions may be evolved.
- Vocational courses for those who complete +2 or 3 yr B.Sc., or 2 yr B. Tech. after 3 yr B.Sc. be strengthened so that those not interested in an academic career can take up self-employment or join appropriate industry
- Laboratory training courses be initiated to provide for increasing need for laboratory technicians in educational/research institutions and in industry
- All science teaching colleges and universities must have adequate laboratory facilities – this must be rigorously monitored and audited
- Simple and exciting experiments, doable with minimal and inexpensive facilities, need to be designed and popularised
- The existing faculty must have opportunities for continuous training in new concepts/techniques
- Adequately trained and motivated new teachers be regularly appointed on existing vacancies
- The Science Academies can assist the implementing agencies in preparing broad frameworks of syllabi at various levels.

## N Mukunda

For over a decade the Indian Academy of Sciences has had a Science Education Panel to conduct activities related to science education. Very happily, since about two years ago the Panel has been expanded to include members from INSA and NASI so now all our efforts and activities are jointly sponsored and supported by all the three national Science Academies. Starting about two years ago the joint panel has been looking at the general area of post school science education in the country. We have held discussions with teachers as well as discussions within the Panel, this has led to preparation of a Position Paper titled 'Post School Science Education' which was issued last October jointly by the three Academies. It has also been very widely circulated to many agencies, organizations, individuals all over the country and it was published in Current Science during November last year. It examines critically the existing system. The purpose of today's meeting is to present the Academies' point of view and initiate a serious discussion on the contents of the paper. Issues of implementation will be outlined later by Professors Lakhotia, Pental and Rama Rao. Following these presentations we have provided two hours for open discussion coordinated by the speakers and myself. It would be valuable if we could hear from as many of you as possible. Let me say in advance, there are two components to the recommendations, one is to improve the structure, quality and content of *existing patterns* of post school science education so that there is deeper coverage of fundamentals and greater flexibility in choices of subject combinations. This can significantly improve the employability of our graduates and post graduates\*. The second point is to suggest a new additional pattern of post school science education, to be introduced initially in at least a few good institutions. So it is worthwhile emphasizing that there are these two components to the Academies' recommendations.

I may also venture to add that if the concerned bodies and agencies take up some or all of the recommendations for implementation, the Fellowships of the three Academies would be happy and willing to assist in any ways that are needed. As Professor Vijayan said more than once yesterday, the Academies are not major implementers or executors of policies and programmes, but can only act as catalysts and beacons that guide.

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\*According to a World Bank study in 2007, only 10 to 25 per cent of our general college graduates are fit for employment.



May I now invite the Presidents of the Academies to address us and set the tone for the discussions. May I request Professor M Vijayan, the President of INSA to speak.

M Vijayan

Distinguished colleagues and friends: may I add my own words of welcome to those of Mukunda. All of you are in the premises of INSA and in some sense this is the first operation of its kind. The three Academies together have produced a document. The genesis was described and outlined by Mukunda. In the last couple of decades, our colleagues in IASc initiated activities that led to this document eventually. As you mentioned we also at the INSA and NASI joined the efforts. I also would like to emphasize that more than the details of the document what we are concerned about is the spirit of the document. The current fragmented situation of higher education is a cause of concern for all of us. Only yesterday from the same platform Prof. Yash Pal emphasized this point. Then the Academies document has offered a plethora of proposals including the new 4 year degree course. It is the spirit of discussions that we hope to have and also how to implement the major thrust of our recommendations to get a concrete shape. Let me also take this opportunity when we have many Fellows to say a couple of words about the Academies. Historically the Academies have evolved together, in point of fact in the fellowship, there is so much commonality, I personally myself am a Fellow of all the Academies, I have worked in the Council of Indian Academy of Sciences for 9 years, in the Council of NASI for 6 years and of course, in INSA I have been involved for a long time. Also it turns out that the hallmark of all the Academies turns out to be excellence, but with a measure of emphasis in different areas: publications and other activities are with IASc, adherence to international operations etc by and large much is done by INSA, outreach is there with NASI, Allahabad more than other Academies. As far as education is concerned, all of us are together. The areas in which we work collectively are increasing year by year. Undoubtedly, one concern that all of us have, I am sure all of you have, is the state of education in the country. I hope this will be the beginning of a serious involvement of Academies with education and we work together; and all of you being involved will make the content of education better than what it is today. Thank you.

N. Mukunda May I next request Prof. D Balasubramanian, IASc President, to speak.

D Balasubramanian

I also feel the joy of all three Academies getting together on an important mission. All three Academies have been celebrating individual platinum jubilees, 75 years in the existence of an Academy should bring some goal posts, milestones, achievements and so on. Until recently people used to think of academies, any academy for that matter, as a scientific old boys club. It has now stopped being called like that particularly in the area of sciences. Moving from being such a club into engaging ourselves in some of the more important activities for which we really exist have become our hallmark. Quality publications for example, that has come largely because of people like Prof.

Mukunda. IASc, INSA and NASI share our concerns in a much greater urgency: what is the status of Indian science, where do we stand with ourselves and the rest of the world? What should be action plans and so on. In doing so, not only do we wish to revamp, modify, improve, jettison the methods that we had but also look at the methods we have. The content is important. This is being given some attention in the booklet that each one of you have with you. I particularly want you to see pages 16, 17, 18, 19 which actually speak about what kind of content we need to have. The classical methodology will have to give way. We need to engage ourselves in that. Today we are talking a lot about restructuring the science teaching programme. One important component of this is what we should teach. Over time many much heralded and new disciplines have emerged. Biology has stopped being descriptive and has become more and more analytical. It has merged quite a bit with information science, material science and clearly physics, chemistry and mathematics. Post graduate education in India has a remarkably changed biology curriculum. The new biology that India ushered in the middle 1970s has given quite a bit of enthusiasm and led to achievement, particularly in the areas of pharma and biotech. Likewise, merging of chemistry, physics and engineering, technology has given birth to brand new areas of sciences. Mathematics, information sciences, physics, engineering have brought together information and communication technologies. In each of these, we teach rather well in colleges and universities in the country. We need to start looking at what is in the horizon and can we catch up with it. This, I think is important and we need to do. When we started new universities, for example in the middle of 1970s, we went through a paradigm shift. When we started IITs likewise, there was a paradigm shift not just in terms of what you teach but even how you teach and whom you teach. It is important for us to keep this in mind. For example, the old research programmes and projects people used to write in chemistry gave way completely to newer methods. It is important to see that people who practice science and teach science come together. That's why I am particularly happy that today there a confluence in this room, of those who are practicing scientists, people who pursue science, and people who analyze the progress in science, who have antenna that sense what needs to be put in the curriculum. I stop here with a congratulatory note for the people who have put in remarkable efforts in bringing about this document. The task for all of us is having done this we also consider what kind of curriculum we should have. Biology went through that in the US. People got together and said that this is the kind of curriculum that should be taught. Hence came new books. Likewise, physics went through a similar transition, and that was the Feynman series. I think along these lines, if we think what is the kind of teaching we need to put in, for a 3 year, 4 year or 5 year programme that we have, so that at the end of this curriculum, graduation and so on a student is fit not only in terms of knowledge he has gained but also in terms of pursuing education. This I think would be the target we need to keep.

N. Mukunda Thank you very much. May I finally request Prof. Ashok Misra, NASI President to speak.

## Ashok Misra

Prof. Vijayan, Prof Balasubramanian, scientists and distinguished guests, I am actually representing at this point of time NASI where my term finished on 31 December and I am basically past President. However, Prof Asis Datta requested that I should come and say a few words and as I have been involved like Prof. Balasubramanian, it would be appropriate. NASI as you know is the oldest Academy and as nicely put by my two colleagues we have worked together to bring some new features. The progress and excitement of science in the country. Prof. Vijayan said that this is the first thing that we did, bringing out a document. I must also mention and appreciate the cooperation between the three Academies in the Summer Research Fellowship Programme. This is again a joint initiative which is paying rich dividends like exciting the young minds to science. My colleagues have made many points: one of the challenges we have is to enhance the quality of post school education in the country, our challenge is to excite the youth in the area of science as there is extreme shortage of scientists in the country. And also make it user friendly. Right now the process of BSc MSc Phd and all that is not user friendly. So we have to make that something that the youngsters would like to do. Where are the opportunities for over 40 lakh students who have finished their 10+2 in science alone. It is equivalent to a population of a country like New Zealand. So many people are finishing science in our country, and then on the other hand we say that there is a shortage of scientists in the country. For the science streams, the details will be projected, I want to give my thoughts. If we can have a B Tech programme of 4 years, then why not a 4 year B S programme which will be of equal value? Through B Tech programmes of IITs and private engineering colleges, people are highly employable. A 3 year programme which is only one year less is not 75% but much less employable. Many have to go through one more level of education, may be an M Sc programme. Today, as of last year at the IIT-Bombay where I was the Director, we introduced a flexible B Tech programme. The flexibility is like this, it's a 4 year programme. The mainstream could be chemical engg, electrical engg etc and one can take a minor area in physics, chemistry, mathematics and sankshrit etc. This cross fertilization is possible. Today, the science studying students do not have this facility. If we introduce a 4 year BS programme as you are calling it, then these students will be able to take some engineering courses. In my opinion, it is extremely important. The 4 year B Tech flexible students are much sought after. Thirdly, we have a 5 year integrated M Tech programme, similarly you can get a MS or B S in five years. If you have a four year parity, you can get a B Tech or M Tech and an MS. So you can have B Tech in chemical engineering and an MS in Biotechnology or something. These things are possible only if the science and engineering degrees are on par. Today they are not on par. Today a B Tech student will have 7.5 or 8 point. If you do the same thing for B S 8.0 or higher go straight for PhD, in eight years we start getting PhDs of high value. Make it user friendly, make it such that people want to go into research in science. In NASI, we discussed this and gave thoughts to cover the two other academies and the commonality of thought and exchange of ideas between the academies was there. Lastly some people may say that one needs technology.

Perhaps as a corollary to this we can say that the 3 year diploma programme in chemistry, physics and so on so forth. Those who do routine jobs in labs can jump to the B S programme. That kind of programme is also necessary I am absolutely delighted and bring the good wishes of NASI and hope that our proposal is accepted allowing us to attract more young students to science.

S C Lakhotia

Highlights:

-Honorable Presidents of the three Academies, members present here, Fellows of the Academies, it's a privilege for me to present the document which has been prepared by the 3 Academies based on various inputs, now its up to the community, people who are stake holders in this process, the agencies concerned, the students who have to look out and see how we can make it better. There is no question that we are in a difficult situation. Prof Mishra mentioned that over 40 lakh students are appearing for +2 education, yet there is a dearth of science students. Very few of our graduates are employable. And that's where everybody now seems to be worried. We need to do something about this. The Science Academies also took note of this and decided to look at the system and problems, why things are as they are. Thats where the major exercises started. And so the three major points that came out are:

- 1) poor infrastructure in most universities and colleges, limited or no lab facilities
- 2) paucity of staff members, both numbers and competence
- 3) poorly structured curricula

Keeping this in mind two years ago two Science Academies presented a document to Planning Commission on policy of science education. I am happy that some of these suggestions are being partially implemented. We are happy that yesterday PM Manmohan Singh emphasized on the quality of education and that's what the Science Academies are also working on. The one part of the problem i.e infrastructure can be taken care of. The other thing about curriculum is how to start and where to start and that's what we want to discuss. Today's program is centered on what should be taught and how it should be taught. And how the whole process should go on. Based on the last two years meetings with the Education Panel and 24<sup>th</sup> May meeting at Bangalore and subsequent suggestions of the Fellows of the Academies and all those who were concerned, a small group representative of the Panel produced this document called the Position Paper which is being discussed today. At present the options available to the student in Science stream who has passed +2 levels are: a professional course in engineering, 4 year B tech offered by IITS, NITs, the state run, private run colleges, and a 4 and a half year medical degree +internship, given by the Central, State and private medical colleges approved by MCI. Students who do not get into one of these come to the three year B.Sc. There is basically a bifurcation of biological science, physical science, and earth science streams in some places. This is by and large an absolutely clear demarcation. This is typically followed by a two year MS or MSc in one subject. There is also something that has been recently started, a 5 Year Master of

Science offered by some of the IITs, IISERs, and some of the state run colleges. And then vocational courses are there. This is what a student has as options as of today. They do not provide a holistic way of learning science. Learning does not prepare the student either for research or for employment. This is where the problem of unemployment comes in. I can just quote an example with which all of you will agree . Masters or even students who have qualified for Masters or JRF or anyone. The standard question I ask is: how will you prepare a NaCl 10% solution. And believe it or not, 90% of them flounder in this. Some of them do not even know that it is solid or how much to weigh, some of them will even start to calculate the weight, and this is a very harsh reality. The problem is to identify where we have gone wrong and identify and improve the situation. The other problem is very little training As on today any biology student who comes for research wants to do chemical biology. Ninety nine per cent of the students say this. They do not have the training even. This is where we have problems. Our students are not able to make progress. Of course, we hardly provide them any exposure to anything like Culture or art or philosophy or anything. They don't need to learn anything in humanities. We seem to be going in one particular direction. If I want to study physics, study only physics and nothing else. The curriculum must provide broad based subjects . As Prof Yash Pal yesterday mentioned I would like to take up two things. We should have core subjects but knowledge should flow across. We should make the syllabus pyramidal. I think the main philosophy of this special discussion is how some of the suggestions are being made. I will quickly list out the suggestions.

1. All courses whether bachelors or masters should be semester and credit based, so that there are internal assessment and credit systems, multiple choices of choosing several subjects. They need not be watertight compartments where they have no choices. The first two semesters of BSc should provide learning of all science disciplines which could include chemistry, physics, mathematics, biology, the earth sciences. Basically each one of them must be grounded in all aspects of science. That's the one major point that we wish to make. And then the next 4 semesters will provide core training in 2 to 3 disciplines; and the last two semesters will provide for an honors. But it should be understood that specialization in one subject should not exclude the student from moving later on to something else in which the student is really interested. All semesters in B Sc and MSc should provide 15 to 20 credits courses and disciplines in and outside science faculty. This is equally important. A student who is interested in music should not be deprived of it if it gives her an impetus to learning better science. And courses in highly specialized subjects like biotechnology or biophysics should not be allowed at school level. It is very clear that we have done enormous damage to the basic sciences right from schools where they learn biotechnology without learning biology. They talk about certain techniques which they can neither understand nor carryout. In the name of specialized courses we have opened up business schools only which are doing business. No teaching or learning, and students are completely lost at the end. This is something that we think should be stopped. All courses must provide 30 to 40 percent credits to lab and field work. Several lab exercises must be open ended experiments. We must design the experiments which are open ended so that they

will allow the student to think about what possible explanations can come out of it. With an MSc level dissertation they learn to ask questions. At least that exercise must be done. After completion of six semesters of BSc there should be provision so that they move to BE or BTech and also opt for other courses. One of the suggestions is a new 4 year B S honours programme. Mobility within basic sciences and professional courses must be created. Today what happens is that somebody who has done an MSc in Physics cannot do PhD in biology except in some select institutions like NCBS, or TIFR, CCMB or IISc or such places. In most universities it is a taboo. "You have done MSc in physics, you are not allowed to do PhD in mathematics or chemistry". We need to break down these compartments. Then if we can we may want to transfer credits from one major to another major, and also between institutions. Vocational courses for those who after school level are not interested in academics. Those who are not willing to go to an academic career can make use of their expertise as Prof. Misra has mentioned, we need them for laboratory; laboratory needs technicians and hence vocational courses.

Then for the 4 year programmes: at this point I must make a clarification, For some reasons the general impression is that the Academies are championing the cause of only 4 year B S programme! That's not true, that's only one of the suggestions. As part of the overall restructuring the main idea is pyramidal learning, broad based learning and one of the ways that we can do that is by having 4 year BS. It may not replace the existing pattern. Ultimately we will leave it to multi choice. About the 4 year option the idea is those passing out of the +2 level in science will be eligible for admission. B S Hons programme would be credit based semester system. The first 4 semesters would cover all subjects as core courses. The last four semesters will have elective courses in other fields. We said that this should apply for the existing 3 year course also. In 4 year course there should be a course in communication and last semester should provide a small research dissertation. On successful completion of the course they will be eligible for seeking admission to PhD programme. since it is expected that a 4 year continuous period will prepare them better than the conventional 3 year + two year MSc course. Any deficit in a specific area can be made up through courses during PhD. The 4 year B S programme can be introduced only where research base is available. This is very critical. They must taught at places where there is a research base and they should begin to experience what research is while they are studying. Some of the advantages of the programme, Prof. Misra had already pointed out: it can provide better time management for teaching, otherwise, there is a break, and we will not know what he or she would have learnt, then we start teaching the same thing again which becomes repetition and boring for the graduate students. Better broad based training including humanities that is taken by individual choice is essential because with better time management we can provide such opportunities. Students and parents do not need to worry about one more entrance test. This point of time, I am sure one would have experienced this. After +2 then after B Sc running around the country for this entrance test and that entrance test, the energy, time and the money wasted is unbelievable. And then we hope with this there will be better employability after 4 year BS as compared to 3 year BSc. They have better

grounding in variety of subjects. And then once again as emphasized by Mishra the equality of B Tech/BE programmes after 4 year duration should make switch over easier. I should also mention here that the medical courses have to be discussed, there we need to engage the MCI. Can we think of some such equality in the medical courses and science because at this point of time the medical courses have hardly any research. There have been enormous developments in genetics and other things. We need enormous understanding by professionals of these areas but at this point there are no opportunities. That's another area that the Academies will need to think out in conjunction with discussion with the MCI and UGC and other agencies as to how we can integrate them as well.

Now once we think of implementing this we need to worry about infrastructure as well because these are very essential components. All science teaching colleges and universities must have adequate laboratory facilities. This must be rigorously monitored and audited. I would like to draw the attention of Dr Thorat who is the Chairman of the UGC to this. This has to be made sure that once we talk of better curriculum we must also talk of better infrastructure, funding is required. At the same time monitoring is also required, they must be rigorously examined. Need for designing simple and exciting experiments which are doable with minimal inexpensive facilities. Another problem today is that students in biology think only of a PCR without knowing that PCR is not the only biological technique, they can do many simple things in simple ways. Provided we are able to think of such, provide such details that these are doable, teachers also begin to think and do some research on what kind of laboratory experiments we can do and also the students learn the basics of the laboratory.

Now new teachers has become another serious issue. Recently The Hindu had an editorial which says the government is opening new institutions but there is a serious limitation of faculty. What do we do about this? I and many others think that its not that we don't have manpower. Lets think about it and I would like to share my thoughts. Can we not identify bright PhDs and give them jobs, giving them facilities to start their careers instead of waiting for them to do science in western countries and then come back? I think if we do that we will have many post doctoral fellows in our own country and this shortage we are talking about may be significantly reduced. If they get a sense of belonging, they are being cared for and are being looked at, in fact all the Academies have young scientists; if you identify them as bright young people why should we not do this? We can also provide them jobs. This is something that I am saying outside the document. But I thought it is worthwhile and let us see what we can do.

In summary, here are the programmes we are suggesting: i) all courses must be broad based, whether it is 3 year BSc, 2 year MSc + Phd. We can talk of integrated or dual degree Phd programme, after doing 3 years they can go to a PhD programme; or we can talk of 5 year integrated MSc programme for +2 students, or we can think of the new programme that is being now suggested by the 3 Academies that we can have a new 4 year programme which permits entry straight

to PhD programmes without the need for a masters degree. And then the mobility between the basic and professional courses. And of course, the vocational courses where after +2 or after BSc somebody wants to learn a particular vocation: it could be a simple mechanic, simple carpentry; they also need good training so that we are not in short supply of people who will manage and maintain our expectedly better training facilities. And then finally, a flow chart which has been given in the document, two arrows which are missing there are added here. After 10+2 they can have multiple choices: they can go for a 4 year B S programme if it is agreed, at least at some places, Integrated MSc, or ongoing 3 year B Sc following which either they can go for vocational or one year diploma or 4 year profession course like B Tech and they can move on to MSc. As of now this is the standard line that goes on: 3 year B Sc, 2 year M Sc then P hD. This is main point that should be emphasized. Or after B Sc they can go for integrated PhD. Give them a dual degree of MSc and PhD, or there are institutions like IISER where after plus two they go for 5 year M Sc straightaway and then they can join PhD. Or from 4 year B S they can go straight for employment or they can join a PhD, they can exit if they don't want to continue with M Sc degree after one year course or they can continue to do PhD. From vocational course they can come to do PhD doing a BTech or medical degree and likewise, that's the idea. I would suggest that these are issues that we need to discuss. The issues are: would broad based curricula dilute learning of science disciplines? This is one argument that is often given if you make it broad based then students cant get deeper into one particular subject. This is one issue that we need to discuss: is it really going to happen or is it more fear of ourselves. Should B Sc degree be provided in narrow specialization like biotechnology, computer applications, bioinformatics, they are very narrow subjects at B Sc level, like genetics and so on. Do we need to do this or do we need to make it more broad based? Is it desirable to introduce a 4 year B S programme at select places, should we have multiple options for science courses for students at +2 level; should Academies get into broad basing or get deeper into subjects or is this the work to be done by other agencies. That's where I will stop and I thank you again for the opportunity and for your patience.

S D Thorat, Chairman, UGC

Distinguished participants and friends,

I am delighted and happy to be here. Because of several preoccupations I did not go through the document. But colleagues recognized the importance of the document and insisted that I should come. I must share with you how immensely I have benefited with this presentation. It was a brilliant and necessary and timely presentation. I really congratulate and appreciate the effort undertaken by the Academies and other persons associated with this Committee for coming with a proposal for reform and restructuring the curriculum. Restructuring of degree and post graduate programmes in the sciences and the like disciplines. Let me share couple of things with you: why should I say it is timely and why do I value it, why it is most important. When I took over sometime in February, as the UGC Chairman, it was coinciding with the formulation of 11<sup>th</sup> five year



plan. Review and preparation of approach and strategy for higher education was a major agenda of the UGC. This includes sciences, social sciences and many other disciplines. When we began to prepare documents and look for literature I was little surprised that there was nothing substantial available around on the basis of which one could really get an insight of higher education system. I think probably 1964/65 Kothari Commission report was the last comprehensive document on the status of higher education in this country. Thereafter we had several committees but those committees addressed the issues in isolation. The UGC in the month of March and April - when I joined – had sponsored seven to eight such reports on higher education. It varies from access to quality to relevant curriculum and education offered. It deals with privatization of higher education, deals with curriculum to certain extent. Those studies have brought out a good deal of the status of higher education. In fact they have been put together now and a big volume has been brought out on higher education related to India with quality of finance. Sometimes later we will have a get-together, some of you will be a part of it. But I am telling you this for a simple reason: status of higher education and the concerned higher education needs was neglected for the past 20-23 years. Fortunately we have Hon'ble Prime minister Dr Manmohan Singh who was the chairman of the UGC we appreciate this. Because of his concern and because of his understanding he could appreciate the problem that has been faced by the higher education and so does our Hon'ble minister Shri Arjun Singhji who is dedicated to higher education for several years. And that brought the due recognitions. What I am going to share with you is that when we tried to locate the problems of higher education, issues of higher education came like a flood to us, to those who are in the framing of the policy. But not only one issue but a number of issues. We recognize that access to higher education measured in terms of the enrolment was only close to 10 to 11 per cent; if we include certificate of diploma our enrolment will not be more than 30 to 40 per cent compared to world average of 33 per cent, 37 per cent in developed countries like China, 55 to 80 per cent in other developed countries. Although in absolute numbers we have so many scientists and also social scientists but in ratio it is only 11 per cent. The first problem that we recognized was that of access to higher education: after a student completes plus two, there are very few who continue. We are talking of a number with a given enrolment ratio, but if you increase it upto 30 per cent or 40 per cent imagine what will be the number that goes to higher education. The first issue was how to make access easy. Second, we improve their access but also bring all those sections which are lagging in the past, to higher education. Because we realize the concentration of certain sections of society for promotion of science or social science and technology will not help. In fact, one of the greatest achievements of higher education in my view is that it is the state universities which are the catchment areas of talent from rural areas, small towns, medium towns. The state universities really promote the galaxy of scientists in this country. So it was recognized we will have to increase the canvas of our catchment area and bring in as many people as possible. Therefore the emphasis on inclusiveness. But one of the most important problems is the quality of higher education. Everybody talks about quality. There is no data, somebody picks up the head of the elephant, somebody picks up the tail of the elephant, somebody picks up the leg of the elephant, that's the quality. When we tried to look at it in the UGC, then we at least try to collect some data. There is a National

Assessment and Accreditation Council which assesses the universities and colleges. For 140 universities and some of the other institutions, 3200 colleges, we got those voluminous data by a professor from Jamia Millia Islamia. Then they classified them into A, B and C. Goverdhan Mehta and his team has revised that methodology. We discovered only 10 per cent of the universities fall into A category and bulk of them are in B and C. Thus only 10 per cent of them are into A, another 40 percent into B, remaining are C. But more than that, what we discovered are the causes, the causes are as you have pointed out in your presentation, the physical infrastructure in the colleges and universities is not satisfactory. More than physical infrastructure, the human resources, particularly the faculty was a problem. All those A class colleges in the universities had good physical infrastructure, had permanent teachers, had more PhD and Mphil; and all those with C and some of D had bulk of temporary teachers and part time teachers due to outsourcing. Therefore we understand why the quality was a problem. Excellence is another story. I believe that the excellence emerges from the college, if you have good infrastructure and good faculty; then you become innovative and creative and create knowledge in different areas. But we also discussed not only physical infrastructure, not only quality but the way we need to teach we discovered the bulk of the universities continue with the annual examinations, assessing the students with giving marks, conducting only one examination. But there were others who are doing better, they had a semester system, they have a credit system and more internal assessments and the students give the feedback on teachers. Coming to the expectation of the student and therefore the academic practices, curriculum and how it is being taught and in what structure. I think this was brought to the notice of the policymakers and authorities. I am very happy to share with you that we got this issue on the agenda of the Ministry, Planning Commission. I just want to link what you are doing here very quickly that we recognize a couple of things and steps were taken. We recognize our enrolment and access to higher education has to increase from at least 10 per cent to 15 per cent in this Plan and taking it to 22 per cent in the next Plan. A number of studies show minimum 20 to 25 per cent of the available human resources must go into higher education even for a sustainable economy. To be able to get 15 per cent what we require was more universities, more colleges and increase in the intake capacity of the existing universities. Otherwise you will not be able to provide the access. If you have more access and more boys and girls going to the colleges and the universities, then there is a possibility of creating talent. To get human resources and what to teach them and how to teach them is a secondary issue. I am happy to say that there has been a 9 fold increase in finance allocation to higher education. The government took initiative to increase 2 per cent cess and it has never happened in the history of higher education that at one go we have so many new institutions coming up. Thirty central universities, several IIMs, IITs, Polytechnics, under the programme of skill development ITIs, several model colleges, But also increase in the grant to the universities and the colleges several times, increase three to four times their intake capacity, so that more students could be accommodated. And there comes the question of infrastructure, and faculty. The first thing was recognized and we have been able to do that. As a result of that the allocation to the higher education has increased from 7 or 8 per cent to 19 per cent. Allocation to education as a proportion to GDP has increased from .37 to close to .7

per cent. Its a big jump. That is the first initiative that has been taken, Of course, there have been many other initiatives which I would like to share with you for inclusiveness, there are several decisions taken by the UGC and the Plan. But there are two issues that are more important and I request you when you go for discussion please discuss them also as far as quality is concerned. Particularly in science, infrastructure, faculty and academic structure what to teach and how to teach: these are three issues which are very important and to some extent UGC has tried to address them. I think lot more needs to be done and we are in the process of creating that and this has come very very timely. As far as the physical infrastructure is concerned, I must say that before I appeared on the scene in the UGC, there was already prior recognition through the MM Sharma Committee, that science is lacking there is a disincentive in terms of students going to science, and that recognition was there in the very elementary stages. But when this MM Sharma Committee was converted into a task force of the UGC, the agenda of doing something to science education, I am extremely happy that they are working hard. For the last three years I have seen them regularly every month; they develop certain major steps which in my view will lead to promotion of science education in this country in the medium term. First thing that they did, as you rightly suggested here, is to increase the infrastructural capabilities, giving a grant to the state universities and also state departments, the autonomous colleges, now will be given to some central universities. This assistance 2 lakh to 20-25 lakhs has come as a surprise to the colleges like a windfall. I think there is a happy feeling among the colleges and I get a feedback from Prof Rama Rao and others that colleges are happy and are utilizing these funds quite effectively. Second, creating infrastructure is not enough; you should have students and to be able to have students at the M Phil and Ph D level you cannot ask them to be self financed. They are a human resource to the country. And rightly before the empowered committee then instituted fellowship programme to all departments, with ten fellowships to each department, leave it to the department to select the student based on their earlier experience of guiding PhDs. 3200 fellowships have already been sanctioned and approved in the sciences through the empowered committee. Then to hold on to the PhDs who are going to foreign countries, they developed what is called the DS Kothari Fellowships, about 500 fellowships. And to do it on fast track we outsourced this work to Pune University, Prof. Gadre has developed a software online issual of application, online declaration of the result. 250 post doctoral fellowships have already been declared. Then recharging of faculty. The concept that has been giving to the committee is we want to recharge the faculty, they developed a scheme which is a modified form of earlier scheme, that 1000 post doctoral persons will be selected and placed at the doorsteps of different departments to be able to get them absorbed in future as faculty. I think, friends, this is a major initiative and has really addressed some of the issues that had been raised. This is not adequate but is a beginning. At the other level, when I joined and discovered that there are 25 central universities, there are students who are admitted through the proper screening and examination, Viva voce examination but there are 3 to 4 percent of the students who get fellowships and others who do not. We expect them to pursue the programme on their own finances. I took courage with a lot of reservation that all those who do not get regular fellowships will get a fellowship of 5,000 for Ph Ds and 3500 for M Phils to every student admitted in the central

universities. As on today, in all 25 central universities every student has a fellowship either in net or in nonnet through the empowered committee, through this fellowship. I am told that these have brought thousands of students to go to Ph D, and the dropout rate has gone down and we will have many of them now who will be completing either M Phil or Ph D. Some of them might disappear to foreign countries, some of them might join private sector but I am quite sure that bulk of them will go to the education sector. But this is not good enough, we require more to be done. I will address one question to you, please discuss that we are not doing good enough at the undergraduate and master level fellowship programme. Masters is also expensive. You are proposing 4 year programme which is a wonderful idea but please give a thought to the financial assistance at the UG and PG programmes, why we are not doing as much as we are supposed to. I just want to tell you one or two more points and then I will stop. Exactly the issues you have addressed. what to teach and how to teach. As far as how to teach is concerned we are very concerned. About a year ago, I issued a letter to all the universities to follow semester system, credit and grading system, the internal assessment of teachers by students and change the whole thing. It was a short letter. I thought we should have a more detail, We appointed a committee with Prof Gnanam, with Pental and Anant Director of IIT, Chennai to develop the academic practices and the structures, They submitted the report approved by the Commission. I think all that you have suggested here as a part of the semester system, credit system, internal evaluation are dealt with by this committee and we will be sending it very soon to the universities. As far as mobility of students is concerned, on a very selective basis, I am so impressed that I like this suggestion. In fact, I am going to take this report and put it up immediately for discussion in the UGC now. This has come in very timely. We can prepare a scheme of mobility of the students. Why not a student in Delhi University or other college do two courses in JNU and come back and get the credits transferred? Why not a student in Bhagalpur university come to Delhi university, do two semesters in Delhi University, get the credit and go back? If he doesn't get an admission at JNU at least he can do it. We will develop that scheme on a selective basis. I think you have captured rightly as a major suggestion, as a major policy that there should be mobility of students, students should be allowed to take courses and get the credit transferred on a larger scale. So I think the academic issue we have agreed, please do discuss in greater detail. If there is any add on to the committee we will certainly add to this and we will send to universities. It is an ongoing process. I will only make a point here: please address the issue of language and text book. In ordinary colleges teaching is being moved from English to regional languages. Not only the undergraduate courses but even some of post graduate courses are being taught in regional languages. There are no text books, there are reasonably good text books at UG level but not at the PG level. Therefore same UG books are being used by the PG students, teachers who do not read English books cannot translate into regional languages. I think we will have to address that: how do we make latest material available at the disposal of the student and even at the disposal of the teacher; if possible we will have to have a separate organization to prepare text books, to collect materials and give it to the students. Please discuss that issue. But the first issue, what is to be taught, curriculum division we will set up a committee. I am happy Prof Yash Pal is here, we set up the committee under his

chairmanship. I know he is busy in another committee. But we are soon going to have a talk, this committee will start functioning and it will take a review of the curriculum in the country. Science group has done lot of work and I am going to take a similar exercise for social sciences and humanities and all that will come from the part of Prof Yash Pal committee. Within 6 months or so we will have something in front of us. These are some of the points that I wanted to share with you, that both on the curriculum front and what to teach and how to teach, that is, academic reform: UGC has taken considerable amount of lead. But I think UGC indeed needs support. I am so happy that this document which has come is a very concrete proposal and we will take it. To the extent UGC has power we will implement and we will not lag behind. Because as I said earlier, once we recognize that higher education has problems and we should address them, these problems are coming like a flood and we are trying to address them. The problem of public private partnership, problems of globalization and cross country education, quality of deemed universities and private universities: number of issues are staring at higher education. There are committees, each of these will come with policies; but I am extremely happy that this initiative has been taken by you and no other society is better than you to tell us, the policy maker, what to teach and how teach. UGC will support and get many of you involved in that exercise which is being headed by Prof Yash Pal. These are some of the issues I wanted to share with you. Once again with great appreciation and congratulation for your effort, you will have my support, we will carry it now to the UGC and see what we can do. Thank you.

#### P. Rama Rao

The major need is mobility between science and engineering streams. The situation in science is as follows: about 21000 colleges, (260 of them autonomous); 3,80,000 BSc students; 73,000 MSc students, declining in recent years; about 5,500 Ph.D's per year, not increasing; and research is only at university departments. About science within the IIT's: years ago the BTech was a 5 year course. It was possible for a 3 year BSc to enter the 5 year B.Tech at the 4<sup>th</sup> year. But this was discontinued because of different admission processes. At the IISc for a long time there was a 3 year B.Tech after BSc, but not anymore. As Prof. Mishra mentioned, a 4 year BS programme will help switch over between the two streams.

In engineering we have 1600 colleges and an annual intake of 6,00,000. As per AICTE norms, the teacher-student ratio should be 1:15; and the ratios Professor:Reader:Lecturer should be 1:2:6. We need 4500 Professors, 9100 Readers and 27,200 Lecturers, the shortage of teaching staff is more than 40,000. At the present rate of at most 1000 PhD's per year, it will take atleast 15-20 years to catch up. (And the less said about Science in engineering colleges, the better). Ph.D. level engineering research is possible only at about 40 institutions – 7 IIT's, 20 NIT's, IISc and another 12 institutions.

The framework of a 4 year BS programme, of parity in Science and Engineering courses, has the potential of generating double the present Ph.D. output. The system of science, as well as engineering, education should be so designed as to bring about

a cultural change – the kind of change that encourages borderless appreciation of what now are regarded as separate, even unrelated disciplines.

### Deepak Pental

Good morning, Like many of the colleagues sitting here my obsession for many many years is more than what we are doing in the laboratory research, rather the important subject of what we are teaching and how we are teaching. Before I make my comments and some suggestions, I would like to say that there are three important things which have happened which are I think great acts of positive development or movement. One which Professor Thorat mentioned that people who are doing PhDs without any scholarships that means that PhD was such a devalued and useless degree in the universities and we didn't think that even the students are even fit enough to think to be given scholarships. I think this is a major development which has taken place under his leadership at the UGC, The second thing is INSPIRE scholarships, which has been recently launched by the Prime Minister of India where the science departments like DST and the advisers to the Prime Minister took a major initiative and I think this is going to help attracting students towards science. The third one which was a smaller initiative but I would believe very positive is the Summer Research Fellowships which was started by the Bangalore Academy but taken over by both INSA and NASI. As far as these points here are concerned, I would just quickly say that point one my reaction is we must introduce broader curriculum. Second one we are a prime example at Delhi University of one subject, following it and killing the subject in the process. If it botany, not even biological sciences, botany, zoology, microbiology, biochemistry and so on, too much compartmentalization and I don't think that is good. The 4 year B S Hons course I think if people are not convinced as Prof. Mishra said and what Prof. Lakhotia said then I don't really have more arguments. But I think it needs to be done. What makes us believe that we require 5 years (3+2) for a science graduate and only 4 years for an engineering student? I think this is because of inherited part of our education system from the British and part of it from the American system. For agriculture and technology we took the American system, semester system and 4 years. For science we took the British system. We wanted to have best of both the worlds. But we ended up having a fractured system of education in our country. Should multiple options for science courses be available for +2 students, yes, yes, yes. Should there be mobility between basic sciences and professional courses? science is also professional. Everybody who studies wants to join some professional course. What do we mean by one set of courses are professional and other set is non-professional? What kind of courses are they? So I think this whole business of saying that the liberal education should be with the universities and professional courses should be with small institutions. Why, who thought of it? What is the logic behind it? So, I think this mobility between basic sciences and professional courses has to be there. How are the suggestions going to be implemented? It is very nice to hear from Prof Thorat that UGC will and AICTE will hopefully do their best to allow this kind of cross mobility. Should the Academies undertake the exercise to suggest different curriculum? Why not, what are these Academies for? This is not a club where some chosen few come and sit. This is place who should be most interested and concerned about the future of science and technology in India. I think the Academies have a big role to play.

Now I would like to take just a few minutes to say why we may not succeed with all this. Let's look at our development. We all know that universities in the seventies have been the place of great turmoil. There are ideological questions, there are questions which are made up also. They don't exist. We just like to be involved with something or the other as so called teacher activists, we have to keep ourselves occupied. So lot of the questions which were being asked that time were reckless. But still took lot of good energy out of the system and we started developing these models for small, small institutions. Some of these institutions which deal with major engineering and developmental projects like in space, satellites they were very much required and will be required in future also, because these are interdisciplinary and we will have to get together and do things. Why did we have institutions for immunology? Why did we have institutions where general biology is being done? Neurosciences, brain sciences, because the smaller institutions are more attached to their parent body like DST and DBT, they are smaller, they look neater, they look good and the universities with all their huge structures are unwieldy. I do understand why these institutions are made. Sometimes I think it was made to satisfy those who were no longer interested in the universities. This may sound little harsh piece of judgement. Now that the government is putting back some emphasis on the universities, how should we proceed? What should we do? Because there is a realization that education without educating people, without having good curricula, without having practicals we will be dealing with a small set of people whose model is: do your PhD in India and can go away to the United States for post doc. Or some other country. I think all the new universities which are going to be started must have the 4 year science, 4 year technology, 4 year humanities courses, allowing the students to take up subjects outside the main subjects. This can be done in the new universities without any problem. We just make up our mind that the new universities will be unitary. They will not be affiliating colleges. Because all of us know that if education is done in an atmosphere where no research is being done you will not be able to inspire the students to think in terms of research. Today in our own university, Delhi University which happens to have second place in terms of number of publications in the past few years. In spite of it being in such a big plus in terms grants that have come the number of papers, but undergraduate education is fractured away from the post graduate education. And a very important point was made. All post graduate universities like JNU tell me or even Delhi University post graduate department. We have to make students unlearn what they learnt at undergraduate level and make them re learn. What a wastage of time! So its for no other purpose I think we need to have 4 year courses in the new universities and have research professors, so called, people who are busy in research and also teaching. If we don't want to follow this and we want to keep the pyramidal structure in India of institutions which only do post graduate education, institutions which only do research and colleges which only do teaching. I think we will be repeating ourselves. The tendency to do so will be very high because we are used to this pattern, there are comfort zones which have developed and therefore to agree to this new development, I think people will resent or people may drag their feet on this, How do we bring in, in the larger universities this kind of structure. I think at the University of Delhi I can cite only the case of my university. We started doing internal assessment, we are now committed to move to semester system so as to bring the system to uniformity with the country. This uniformity is not taking away, any freedom of the teachers

to teach the way they like, will not take away the liberty from them for the special or whatever they want to say, this is not taking their liberty of doing the science or great research in humanities. All we are asking is don't open a bazaar. Where every kind of ware is sold. Try to make it uniform so that there is mobility between subjects, there is mobility from one university to another, and university education is given the kind of respect which all developed countries give to their universities. You can take US, you can take Europe. You can even look at Academies, how much, how many FRS in the UK or how many members of the National Academy of Sciences in the United States from the universities and how many are from the institutions, that will be the answer. So I think this question we will have to face. We have started some M Tech courses now of 3 year duration after B Sc. The total period spent will be 6 semesters. The credit earned will be the same as 4 year B Tech and 2 years M Tech. I think this will be allowed. Because science graduates also have a right to develop new gadgets. In fact, the new developments in science and technology require knowledge of both science and technology. I can cite hundreds of examples from biotechnology. I do not know whether they will appeal to you, but areas like materials. If we do not have good background in science, agriculture ... Dr C Pandian just mentioned we have consigned agriculture to some kind of primitive science where do not need modern technology, modern knowledge and therefore we are suffering in our agricultural research very badly. So I think another point which was raised, how many entrance exams? in the United States it is SAT, GRE GMAT. Here everybody has opened a shop of examinations. Students are not studying their subjects they are going to the coaching classes, there is a bigger economy today for coaching than it is in the colleges of India. We are not realizing, What a big damage we are creating to the type of students who are coming from one exam, even from management. This CAT, MAT ZAT, SMS and there are some more exams, Is anybody looking at the quality of these exams? Who is looking at the quality of these exams? There is a very important message or very important recommendation which has been given by the Knowledge Commission. In fact, they have given wonderful suggestions. We are just reluctant to take them on board because they will upset the present comfort zones and the present systems. One of them is an independent regulatory body and agency, what's wrong with that idea? This idea should be taken up in a big way. I think the academy should make a strong statement to the govt to support it. So, I think there are lots of good ideas floating around and these ideas are not going to perhaps, be fully implemented because college teachers have a vested interest in teaching what ever they have kept on teaching; the post graduate university are not willing to take under graduates because it is coming down in hierarchy. The institutions are in the best comfort zone, and the best minds are being wasted because they are not teaching. Why are they not interested in teaching? there would be adjunct faculty in the university and the adjoining universities and teach them but they are not willing to do all those things because we still remain very feudal in our mind sets and still remain hierarchical. If the academies want to contribute, this is the time as has been said by Prof. Thorat also there is more money in education, there are more possibilities and therefore we must go out and grab these possibilities and even try to do certain things which will be little unpalatable but I think we will have to put in place if we really want to make India very strong in education. Thank you very much for giving me this opportunity.



### **Extracts of comments and suggestions received in response to 'Position Paper.'**

1) R.H. Sawkar, Secretary, Geological Society of India, Bangalore

Increase Earth Sciences in curriculum in first two years of 4 year course, as important as Physics, Chemistry, Life Sciences. Scope should be Earth, Environmental and Planetary Sciences.

2) Baldev Raj, Director, IGCAR, Kalpakkam; and colleagues

Comments on 'Position Paper':

p. 4 – No suggestion given for improving school level science teaching

p.9 – statement that only poor students choose science is harmful, creates stigma, lowers self esteem. Expose them to brilliant scientists.

p. 12 – Combining 3 year BSc + 2 year MSc into a single 4 year course is constructive suggestion, with better use of time. Present 3 year BSc hardly produces employable students, is irrelevant today. Call 4 year degree a Masters, make it intensive, include summer courses if necessary.

4 year course can lead to academics (include research methods course) as well as industrial scientists (analytical chemistry course will help). Offer it on campuses having engineering courses as well, for wider choices, transfers between science and engineering, dual degree options.

PhD after 4 year course: include course work, also one year teaching experience.

p. 13, 20 – simplify lists of options, too many options will result in no takers for some. Remove 3 + 2 pattern, have 4 year alone.

(From K.S. Viswanathan) Good engineering colleges to have strong science departments, good in teaching as well as research. Many advantages in switching to science after engineering background.

(From C.S. Sundar) Assess employability in teaching, R and D laboratories, Industry after present course options. See how this may change with 4 year BS stream. BS should be employable, and equivalent to 4 year B.Tech. Permit 4 year BS followed by 4 year B.Tech and vice versa. Compare proposals with situation in some developed countries.

3) Written comments received at 12.1.2009 INSA meeting

R. Nagarajan (UM-DAE-CBS, Mumbai) Examine international recognition of any proposed new degrees.

H.Y. Mohan Ram (University of Delhi). Avoid BSc in narrow specialized disciplines. Teachers need motivation. Education degree needed for school teachers, courses in lesson planning, philosophy of teaching.

G.K. Mehta (IUAC, New Delhi) State Universities need autonomy; Ph.D's should be only through universities. Keep research and teaching, science and technology together.

S. Sriramachari (Institute of Pathology, New Delhi) Promote trans disciplinary exchanges of ideas and methodology.

T J Pandian (M.K. University, Madurai)

Include Agriculture, Engineering, Medical Academies in efforts – Academies to frame and update syllabi, curricula; to initiate writing and publishing text books relevant to our conditions. Maintain eligibility requirements to join courses. UGC to provide Rs 10,000.00 per MSc student to prepare dissertation; if published, give Fellowship to do Ph.D.

S. Ananthakrishnan (NCRA, Pune)

Both UG and PG: improve laboratory practices, provide funds for instruments and good experiments. Motivate UG students in rural areas; run 4 week bridge courses before joining PG courses; interest them in basics of mathematics, physics, chemistry, biology.

Soumitro Banerjee (IIT – Kharagpur)

Primary aims of (Science) education: ability to think logically and scientifically, questioning mind, character building. For education, use 'budget allocation' rather than 'investment'. Flexible course credit system (as in IIT's) should be used properly, ensuring integrated knowledge in basic discipline. In Indian context, science education and raising scientific literacy are services to the nation requiring adequate budget allocations, not commodities available for money. Cross-disciplinary exposure to be carefully structured, not haphazard. Each science department to design and offer introductory elective course covering the breadth of the subject.

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