

the cosmological expansion scale factor was a thousandth the present value. This spectrum of density perturbations is believed to gravitationally grow to form the galaxies of today. Simulations of the assemblage of matter into galaxies and clusters of galaxies have been fairly successful in evolving initial matter perturbation spectra consistent with the CMB anisotropy observations into galaxies and clusters with abundances and correlation scales consistent with observations of the nearby universe.

However, it is often forgotten that these simulations of the dissipationless dark matter dynamics tell us little about the astrophysics that forms the visible galaxies in the gravitational potential wells. The infall of baryonic matter and its subsequent dissipative collapse or fragmentation involve complex physical mechanisms that are often regulated and sometimes evolve catastrophically through feedbacks. Recent discovery of sub-mm bright galaxies at high redshifts, by SCUBA, and its potential discordance with 'standard' galaxy formation scenarios that have been in vogue for some years now, has served to bring back attention on our lack of understanding of the basic astrophysics in galaxy formation.

The dynamical evolution of a gaseous inhomogeneity, irrespective of whether it is a protogalaxy or an interstellar cloud, is determined by the relative time scales for gravitational collapse and for dissipation.

While dissipation is small, the collapse is quasi-static; however, as the gas density rises beyond a threshold and dissipation is sufficiently high, the cloud is no longer quasi-statically supported by gas pressure and, consequently, will catastrophically collapse and hierarchically fragment until some other physics like, for example, opacity within the cloud, comes into play. The crucial astrophysical input required for understanding this process is the heat loss rate. With the exception of the very first protogalactic clouds that had extremely low metallicities, most protostellar clouds predominantly cool via molecular emission. The bottom line is that the cooling rate, and therefore the star formation efficiencies, ought to be determined by the molecular abundances.

To summarize, it has been believed for over a decade that the basic unknown in the astrophysical evolution of cool gaseous clouds is the chain of mechanisms that lead to the formation of stars. Recent observations of the H_3^+ molecule in interstellar space, first by Geballe and Oka¹ and subsequently by McCall *et al.*², have perhaps detected the key link in this chain.

Whereas molecular hydrogen forms on the surfaces of grains, it is believed that almost all other trace molecules and radicals, including species like H_2O , CO , OH and CN , are formed by reactions involving H_3^+ . In the extremely cold interstellar

clouds, cosmic ray ionization is the dominant mechanism that ionizes molecular hydrogen, leading to the formation of H_3^+ ; however, the cosmic ray flux may be inferred only indirectly. Laboratory measurements of the IR spectrum of H_3^+ were obtained almost two decades ago, but its detection in dense and diffuse clouds and towards the Galactic centre had to await recent improvements in sensitivity and resolution made possible by IR spectrometers using CCD detectors.

Demonstration of the capability of detecting H_3^+ in the interstellar space represents a significant step towards understanding the interstellar chemistry that leads to the formation of the molecules that dominate cooling in the clouds, and hence the formation of stars in cool clouds.

Once again we have a demonstration of how the application of the state-of-the-art has opened new windows and opportunities in our quest for unravelling the mysteries in the Universe.

1. Geballe, T. R. and Oka, T., *Nature*, 1996, **384**, 334.
2. McCall, B. J., Geballe, T. R., Hinkle, K. H. and Oka, T., *Science*, 1998, **279**, 1910.

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OPINION

On recommending students: The curious case of all students being in the top ten per cent

V. Sitaramam

Recommending students for higher studies and research is apparently a simple job of saying a few good things about each student to help them with their careers. There is certainly some merit in that view. That is what we do by and large. What are the minimum statements/data required to justify the recommendations? If the subsequent employers are consumers of our products, how much transparency is required in parceling out our products? Entry-performance-exit triad of

institutionalized learning at any level has comparable problems and these are quite inter-linked. Isolationism does not protect us against long-term decay in standards and performance.

The examination fever is on. The grades are being finalized. The CSIR-UGC results, just announced, leave much to be desired. GRE... let us not mention it. For the students, the MSc is over. What lies ahead? This time, a season for the poetry of recommendations¹, requires

reminiscing things that matter to the student, to the teacher, and to the system. Will some order emerge?

In the period between March to June, each one of us sends out a few to a few dozen recommendations¹. I had the occasion to ask many faculty members at Pune and elsewhere, how they coped with this work. Some universals, nearly axiomatic, emerge: (i) it is our duty to recommend students to wherever they wish to apply; (ii) the choice where the

students wish to apply is theirs; (iii) we teachers can assess, based on our personal experience, what the students' performance has been in other subjects as well; (iv) marks given by oneself are a fair indication of the students' worth; (v) marks given by others are nearly as good²; (vi) aggregate marks are worthless in drawing any conclusions from them; (vii) aggregate marks from other universities are still more worthless, and (viii) Americans and others ask for aggregate scores. Either they know what to do with the scores that we do not know, or they have other methods to assess how these scores are of any worth, or it is really none of our concern how these numbers are used by them³.

I would like to recount a couple of instances wherein I experimented with the selection faculty to see if there are alternative ways of assessing students⁴. Admissions are the right place to begin when we examine the worth of recommendations to capture the spirit of cyclicality.

The story of selection exams for biotechnology

How to select students for biotechnology course, was a topic of hot debate in the early years. The question was whether there is a need to examine the students for a variety of capabilities to make the selection process more efficient. The conclusions we obtained by doing principal component analysis of what contributed to selections would interest many⁵. We set ourselves in the role of observers, and asked the faculty to administer the tests, written (multiple choice and short/long answers), lab aptitude tests, and viva voce (where each faculty member individually marked). The 10th standard, 12 standard, and B Sc marks were also recorded. The weights were fixed by the faculty, and the contribution of each of these to the final binary possibility of selection and nonselection was determined. It was an eye opener. While the fate of the student was decided primarily by the 10th and 12th standard marks, B Sc did not matter. The written test with multiple choices correlated well with the marks of 10th and 12th, and contributed heavily to the selection choice (>80%). Short answers did not. Viva was a disaster as the standard deviations were unacceptably large⁶.

The result of the above-mentioned study was that that was the last year (1987-88) ever when even an argument was made in favour of multiple levels of testing. However, one must recognize that these vivas and lab aptitude tests were very brief, compared to the tests conducted for entrance to defence or medicine, which stretch over several days! It was also my first experience in testing popular beliefs in teaching and testing methods, and finding the answers to be counter-intuitive. I was quite surprised to find the students to be either good or bad, as actually measured, in the sampling domain that we encountered. Exceptional students were rare. However, I was also amazed to find that many faculty members spotted exceptional students who would have been missed but for the unrelenting scrutiny by that particular staff member⁷.

On not throwing the baby out with the bath water

It is apparent the faculty has some intuition in selecting students. However, though they are good in overall assessing of the student in a qualitative way, they cannot assign tedious numbers of performance either in fractions or percentages in a viva voce. The question was: how to get the best of them.

One idea suggested was a modified viva. The faculty usually has a rather uniform opinion about the kind of student they wish to have in the department. They prefer an articulate, inquisitive, and reflective kind of a student, who needs to be merely encouraged to think and communicate (assuming that such species exist and even abundantly). Thus we devised a viva in which we gave some 10 common sense questions of an analytical kind that had multiple choice answers. The students answered these questions. The faculty was not permitted any further questioning of the students on their answers, except perhaps ask the student, 'Are you sure?' or grunt distinctly their disapproval. The faculty members were asked to state whether or not the student is good and be admitted to the particular department. Lo and behold! In a batch of some 40-50 students, there was no debate amongst the faculty regarding which student to select. Contrast this with the usual viva that leads invariably to acrimonious debates⁸.

Why do these debates arise? Basically

the interviewers are of three types⁹. One is the kind that minds one's own business and marks as one feels. While every interviewer claims to be of this type, actually these are a rare breed. The common variety is normative who usually listens and tries to estimate the average opinion of what everybody thinks, and then marks accordingly. There is as much concern in being fair as there is in being seem to be so. This type tends to decrease the variation in marks. The third are the indomitable trend setters. Usually they know exactly how things are to be done and if, the things fail, someone else is at fault. Marking patterns among them show wide variations, and they call it their greater ability to discriminate. Fortunately these types are also small in numbers, though not rare. I am yet to see someone who sat with the data and tried to make out how these tests fare¹⁰.

How do students fare in M Sc and what determines their progress

For many years, the biotechnology and zoology programmes were being conducted by the same department at Pune University. After two separate departments of biotechnology and zoology were created, which once again merged for a while, I had an opportunity to ask some questions concerning the impact of teaching.

In the early days, when almost all the students got through CSIR-UGC in biotechnology, and a good number in zoology, the quality of teaching was considered good. The students who did well in Pune, did so in Delhi, Madurai and elsewhere as well. But over the years, the results have gone downhill in biotechnology, while such passes in NET even disappeared in other departments. CSIR too has recognized the changing trends with regard to CSIR-UGC NET¹¹.

Obviously we don't have a clue as to what is happening or what to do about it. It seems to be a sociological problem rather than a pedagogical problem¹². A researcher/teacher at the PG level is least equipped to handle it, since sociological enquiries have deep methodological problems of their own and interpretations can be tricky when observer-observed interactions are high. The simplest solution was to pose the problem to the students and ask their opinions. A striking observation was; they too don't have the faint-

best clue! Opinion polls were the dumbest thing to do, since we only got polite answers in which neither the students nor we could put any trust¹³. So I talked to them collectively over several evenings. A comparison of the students, zoology and biotechnology, and their performance since school through the first two semesters of M Sc was made. The results were revealing. Figure 1 shows that their marks

at 10th, 12th, and B Sc levels were not too distinct. During M Sc the biotechnology students exhibited a finite drop in their grades, which was much more noticeable among the zoology students. Although both were admitted by entrance tests, and were taught mostly by the same faculty. Why have the marks of zoology students plummeted¹⁴?

To find the answer, the key were the

zoology students where the signal-to-noise ratio was larger. One student made a candid remark. He exclaimed that the answer was obvious: *The students were simply not interested in studies*. Neither did they relate to what was being taught nor were they convinced that it made any difference to them. The frightening aspect in this discussion was that it did not matter to many of them what lay ahead of them. One thing was clear. Doing well hardly mattered. The biotechnology students were no different, though their alienation from matters academic was less acute. This distinction, however, vanished by the second year when the biotechnology students as well adopted the attitude of not caring less. Thus, programmes, the syllabi, the books, the projects, and the teaching do not touch the students, who do not relate to them in any meaningful manner¹⁶.

What do these data tell us? I have summarized this in Figure 2. The students represent a small cross section of those who pass out of succeeding levels of education. Scores depicted for the population indicate that the postgraduate students can only be a highly censored subset. M Sc students show a positive skew in their lower levels, thereby indicating that these have a bias as part

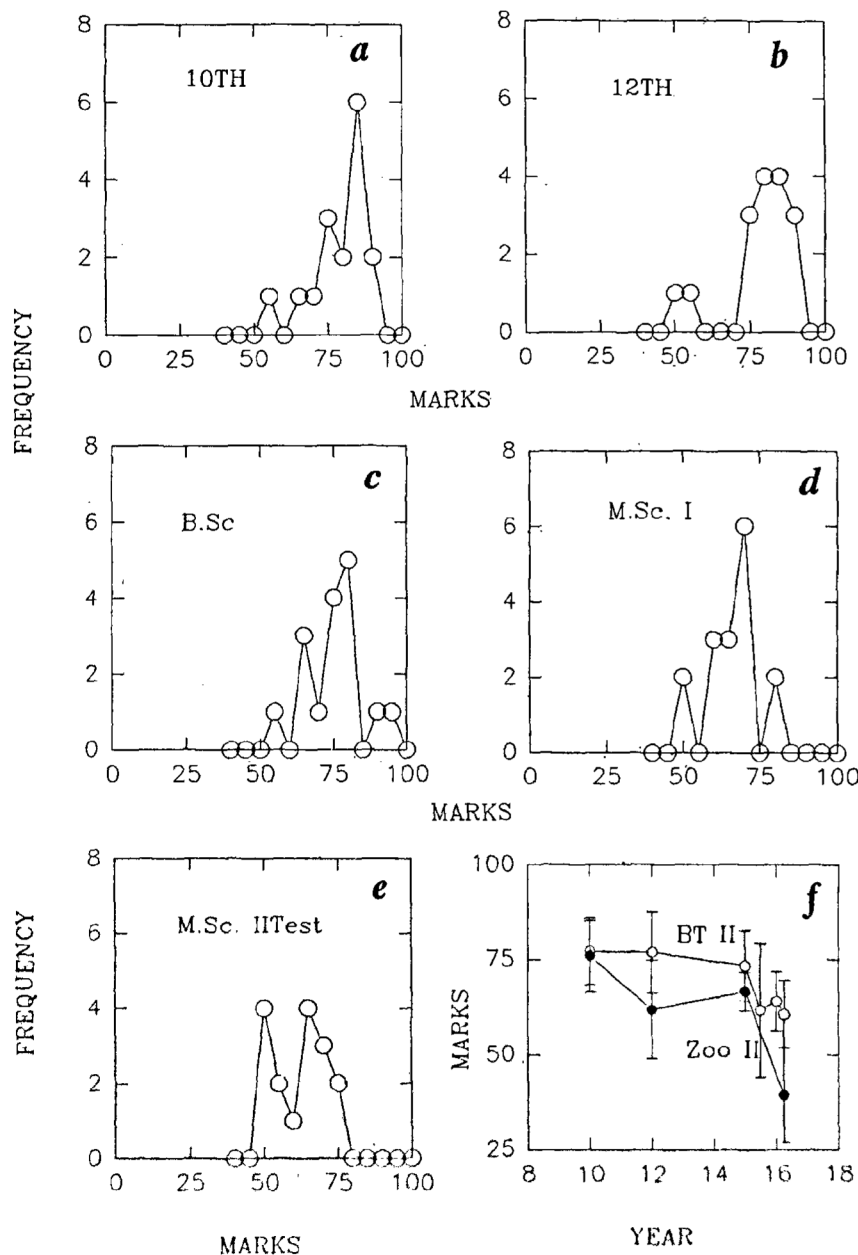


Figure 1. Comparison of performance of biotechnology (1995-1997 batch). Marks of 16 students at 10th, 12th, B Sc and M Sc were compared as frequency distributions. Results of a test conducted in the third semester (e) that spurred these comparisons to be made. Freshly admitted first years scored 25-40% in the same test as also most zoology II year students barring two students. The time progression of aggregates with ± 1.0 S.D. for the II year students of biotechnology and zoology.

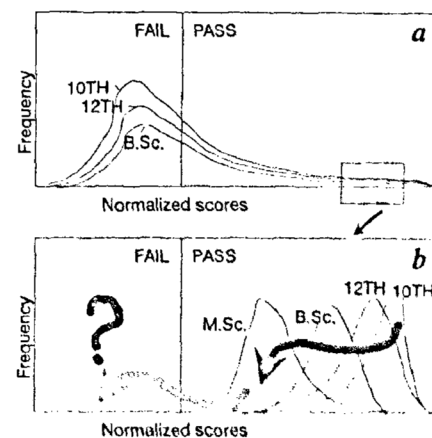


Figure 2. Population statistics of performance at the state level. Impressions based on the usual press reports (a). The box corresponding to a small negative slope represents the cross section that joins for the postgraduate science programmes. The frequency distributions were caricatured for this censored subset (b). The impression is that the students move from a positive skew to a negative skew with time and class. Surprisingly few fail at M Sc level, often due to considerations on humanitarian grounds²².

of their selection process and do not represent a population bias. The positive skew is a result of this censoring process, since the better students have moved possibly elsewhere (as engineering, computers, and medicine). What the performances indicate is that there are dynamics associated with performance, and as education goes higher, the same students get back towards the negative skew for one or many reasons.

Relating is a matter of conscious decisions. Some of the opinions... stated and unstated are: 'Do I watch an amoeba move or a hydra regenerate or go for a movie?' In the world that I move in, the so-called intelligent questions by the teacher hardly create any ripples, and thinking about them or talking about them, including assignments, is generally considered blasé. The faculty talks about science but none of them do what they ask us to read in journals, like *Nature*. My chances of doing something like that any way is very remote. Why not have an easy time?' The logic is infallible. 'Realistically speaking, the curriculum has a definite end point in exams and grades. MSc grades are of limited significance. If I am ambitious, the GRE would be more important. Why waste time in classes'¹⁶

Back to recommending the students

To recommend... is it a moral obligation or a moral burden¹⁷. A few things bother me. Very few students fail the final examination though most teachers express concern about falling standards. One concludes, that the lure of the underdog is irresistible, and the teacher would rather condone than condemn the lack of performance. We have 3 theory courses and 2 practical courses per semester for four semesters. When we send the recommendation letters, the marks are not made available and no one really has an idea of what one is recommending. About 2-3 students do a project with each of us each year and spend a marginally larger time with us than the others. Barring these 2-3 students, most of the others are self-effacing and are hard to spot in the crowd.

Against this background we get the darnedest letters for recommendation from India and abroad. I am asked to comment on students' creativity, zest for life, cordiality, individuality, spontaneity, etc. and

I am at a loss to know if the student is being processed for a Ph.D admission or is being nominated for a Nobel prize. We need to comment on their comprehension as well as practical skills¹⁸. Now, once we agree to write something, leaving any column unanswered makes us feel like a traitor. So we end up filling in a lot of polite grades of the lukewarm kind¹⁹. If every student from a department is in the top 10%, there is something definitely funny going on^{20,21}.

I now know that I cannot get the relative grading of a student from a university. Majority of the recommendations are from impressions, since few bother to look at the actual grades. Therefore I decided to have a look at all the marks we ever awarded since the inception of the programme. We have a pot-pourri marking system (the new syllabus will reduce that problem from the next year) such that each course is a complex mixture of a number of courses and options from the second year. For each student, we summed up the marks obtained for each course, and obtained an individual average and standard deviation, batchwise as well as yearwise. This we did separately for all the theory courses as well as practical courses. Figure 3 a-c represents the marks obtained by students since 1987, when the first batch rolled out. Against this, we have the 1997 batch (a), with the best- and worst-performing students²². Percentiles are a matter of a minute or two to calculate for each student/batch.

When this data was discussed, three responses could be seen: (i) it could be useful; (ii) it could be misleading, and (iii) it is worthless. Another peculiar response was the apprehension that if the marks of our students are revealed, will it reflect on the faculty. More rational concerns were what happens if a student, though very good for one reason or the other does not attend the classes and fare well. The question was, if he/she is actually capable, will not such a marking system doom him/her?. The more charitable argued that GRE and other scores do give relative ranking and it could be used as a useful input in screening systems.

More difficult questions relate to views that dismiss the grades altogether as worthless. When teachers do that, one is somewhat at a loss. Are we degrading ourselves or the system? If the only

objective criterion is the grades obtained by a student, if the University does not reveal the relative position of a student vis-à-vis others, what information can the university give to other institutions where higher studies and research are being pursued? If the system is worthless, and has no meaning, why are we party to this hoax²³?

An amazing number of questions follow any such discussion as possible lines of analysis. We compared various courses

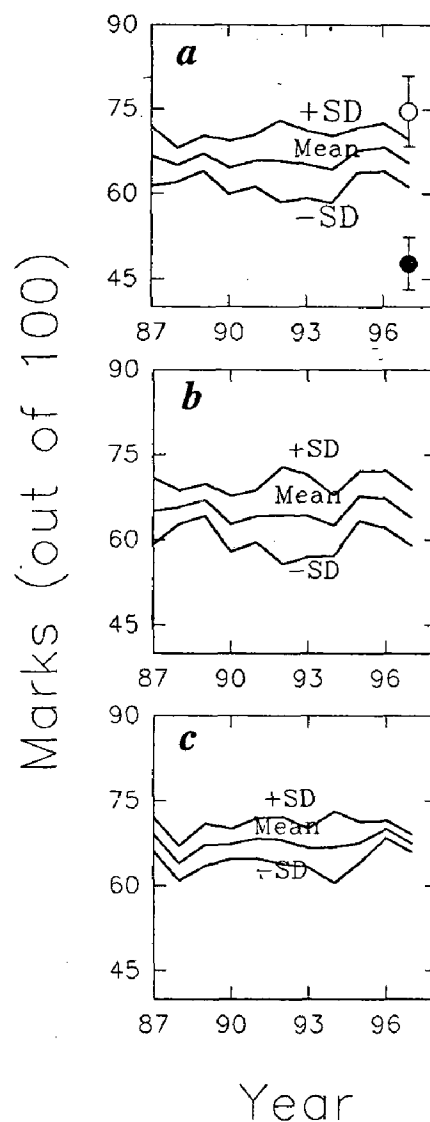


Figure 3. Performance of students of Biotechnology, University of Pune, from its inception (first batch out 1987) to 1997. (a) Aggregate, open circle and filled circle represent the highest ranking and lowest ranking students for 1997, with the standard deviations of the inter-course variation for that individual. (b), Theory aggregate. (c) Practical aggregate.

for intra- and inter-course correlations among students over the years to see any definitive patterns emerge—and none did. The question was also of sample sizes. With 12–19 students per year, the number of correlations we could get was pretty low. The average results in Figure 3 a–c finally showed a sanitized normative process of grades well within the expectations. This is all we can say about our students. *If some students did not participate or fare well or relate well, it was their choice and it was an adult choice.* Some did participate and some did well. Relatively at least.

I must make a few comments on how not to interpret the data, since biologists are notoriously impervious to statistics. This data does not tell our teaching/performance with other universities or other examination systems. It allows for considerable variation in teaching methods and assessment practices of individual teachers and course requirements and even idiosyncrasies. All it tells is how the overall pattern is nearly the same over the last several years (the standard deviations have been magnified by enhancing the scale; otherwise they are as expected). The data allows internal comparison, assuming a homogeneous population for a given year, and when extended, over years. That is all.

Why do we need this information? I don't know. I generally find it safer to take a student with better marks than one with lower marks. I still cannot decide how the student is by any criteria, including day-long viva, since our samples are reasonably small. I need some 6–8 months to decide whether a Ph D student is good. In any event, based on my very limited experience, I cannot vouch for any significant correlation between M Sc and Ph D performance. I have outlined my evaluation of Ph D programmes and what after earlier in this journal. I am only tracing the earlier phase of the history of these students backed by experience and data of more than a decade.

The adult choice

In summary, the students exercise an adult choice at the postgraduate level, be it entry, performance, or exit. The ability, the attitudes, the initiatives, etc. all of which contribute the triad of entry-

performance–exit of a student reflect in a statement called grades, which are specific to each place and may even be comparable with other places. Disenchantment with grades among faculty could be arising due to not exactly looking for the right interpretation, in which the will of the student plays no small role. Information on the performance of students over a few years, and the performance of a given student over the current and previous batches summarizes the adult choices the student made in performing. This reflects in some measure the attitudes and future performance as well, and therefore is worth examining before taking a student in at a higher level.

Adult choices also indicate scope for relevance and innovation²⁴. The main problem that we face is that both teachers and students are mired in the groove of parent–child relationship, and that transition to adulthood is not part of Indian education. The science students (with whom alone I am concerned at the moment) handle their post-graduate education in an adult manner, but their sense of responsibility does not match that of the adults. However, it will not be possible to improve courses and curricula that do not involve social discourse with students as well as peer pressure. Which structures permit these inputs require urgent examination. In the absence of such insights, we can only have contingency plans to cater to but a few based on the elusive promise of merit. Many schemes of this kind, including five-year integrated programmes of different pedigree, promote isolationism bartering away the lives of many. This is a socially unacceptable situation.

1. A breath of fresh ire?
2. There are always special and even convincing reasons for this.
3. Is there merit in asking whether our recommendations matter? Nearly every one felt that no one takes the recommendations seriously unless something very specific is written about an individual. How much of this apathy is plain irresponsibility on our part? Selections are said to be based on the very vigilant faculty, who generally do not trust their own neighbour's method of marking!
4. It is interesting to note that how confident the faculty are of their own ability to assess the students and not quite so of the ability of anybody else to do a decent job!
5. I must regret the loss of original data,

more than 10 years old, due to a corrupted diskette.

6. I understood the general significance of these observations while discussing them with some Brazilian colleagues involved in assessments at the Federal University of Rio de Janeiro. They would have liked to see the actual data and methods of collecting them as we did. Apparently clear documentation of such observations has takers among the educationists; even published in such journals, since assessment and teaching techniques are a major area of study by them.
7. Old (Wodehouse) fishing stories about the one that got away?
8. The practice was promptly discontinued from the next year.
9. To make a point ignoring some overlaps.
10. Educational structures are primarily managed by those who are not trained in its management.
11. Though at a somewhat pedestrian level, considering that they have a host of information on it, if only they dug deeper in to it.
12. Over the years, *Curr. Sci.* has been publishing opinions on what is wrong with Indian science. One most glaring lacuna in all these opinions is that education is not viewed by these as a social problem and that what we do with it (including higher education) is viewed strictly outside the home of the students. The pundits of today are a generation or two too old. Their children have a different way of looking which the pundits have still to learn!
13. This is when I learnt that student opinions are the reverse of viva conducted by teachers. Students are far more susceptible to populist measures and moves, and less discriminatory than one would want to believe on what is good for them, education-wise. Evaluation of teachers by students often runs into a deep mess, since it attempts a sociological analysis by rank amateurs, with vested interests at that! I say this even after having passed successfully through these!
14. It will be more accurate to state that I observed a noticeable drop in the class for a test that I gave in biochemical techniques (Figure 1 e). I checked with the zoology students who fared badly. I presumed that their marks could be remarkably different at earlier levels and asked them to compare. It was a revelation that the grades did not! At least the differences were not commentable. I could either ignore the situation or probe further by dialogue. The frequency distributions point out that for these 'selected' students, they start with marked negative skewness, which tended to change in the other direction by M Sc (Figure 1 a–e).

15. I am grateful to Dr Niranjan Joshi who informed me about options in education that a science student perceives, that I as a professional (medical) student did not. He further informed me that only by B Sc and M Sc does the student really understand that he/she has the full option *not to study*, something that is not often realized at school level. For the first time I understood that we are talking of adult options!
16. A major eye opener for me was the summer training. When everybody was getting through CSIR-UGC NET, whatever we did was good. Even if students goofed during much of the summer (many did not), it was alright. Now that performances are plummeting down, the question became more acute. What were they doing for these two months? Did it add to something? Again the truth is hard to get at over the large barriers of politeness on all fronts. One suspects that an open-ended programme without strong prior commitments is not likely to be useful.
17. When I was a medical student, my chief of surgery told me something that I never forgot. He said, 'If the patient actually lives, you can never be sure that it is because of you. If the patient dies, you can also never be sure that you did not do something worthwhile to prevent it.'
18. Practicals are often a joke since, in the absence of testable experiments, Lowry or Biuret represent the only doable practical, excepting perhaps a language course or statistics (the latter is quite acceptable to me!).
19. The traitorous feeling is only replaced by even a more horrible feeling of being an absolute liar.
20. Anil Gore mentioned to me that an education officer reporting on the status of his county (in the USA) asserted that all his wards were definitely above average!
21. In the last 12 years, I have noticed that M Phil students invariably score less than the M Sc in their so-called course work. Amazingly few publications arise from this M Phil programme. I am equally amazed by the number of theses judged outstanding by the external examiners (usually a restricted breed of obliging souls). Fortunately our Biotechnology programme has been considered interdisciplinary and students are not compelled to join for M Phil, a time-pass occupation for the transit students.
22. Incidentally this data is available for any student that passed through our hands for any year and can be had for asking.
23. Since departmental functioning is democratic, we cannot formally give our recommendation letters in this format. Actually nobody asked us this way either except universities abroad. So far we have been making do with some approximate statements while precise statements are now available.
24. The term adult choice is not restricted to what goes on between consenting adults. It is more akin to the notion of adult education. Teaching adults is characterized by the fact that these adults have a different level of social and interactive abilities, which are different from children. Therefore they have to be handled differently and oriented and motivated differently.
25. The referee adds, 'even fewer at the Ph D level'!

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COMMENTARY

Sustaining development in the developing countries

T. N. Khoshoo

Sustainable development entered in the environmental agenda in the second half of the eighties, more so when the book *Our Common Future*¹ was published in 1987 by the World Commission on Environment and Development (WCED)¹. As of today, sustainable development is fast becoming a composite discipline and involves several major disciplines including science, technology, sociology, economics, ethics, trade and law. But defining sustainability in exact terms has proved to be difficult. This does not mean that the concept of sustainability is not relevant. One of the easiest ways to comprehend sustainability is that the rate of harvest from a renewable system must never exceed the rate of annual increment. If it remains within that limit, and, if there are no major environmental perturbations, the system can go on *ad infinitum*.

In 1992, that is five years after the

publication of the above book, United Nations Conference on Environment and Development (UNCED) was held at Rio de Janeiro with over 30,000 attendees. Thereafter the term sustainable development became very popular all over the world. Most people thought that these two words constituted a panacea for all the environmental ills and problems facing the earth. Considerable euphoria was generated on this account, and, during the last decade, an unusually large number of books and papers appeared on this subject. Increasingly it became clear that sustainable development was not a panacea for all the environmental ills. Furthermore, it also became fashionable to prefix eco- or green- before every word or action so as to make such expressions (and sometimes even the tasks) ecologically respectable and thereby legitimize the same even when these are basically unsustainable.

Much of it was only in words and little in deed. Thus in real terms, sustainable development still remains an enigma. For instance, what is sustainable development for the resource-guzzling industrial world in its megacities, or an eskimo living in the arctic circle, or the ecosystem people in the dense tropical forests of Africa, Amazonia or Andamans, or the very small hamlets in the Himalayan or Andean highlands, or people in deserts of Sahara, or the poor fishermen living in coastal areas, etc. The question arises that for such diverse situations, are there some common principles that would make development sustainable? Regrettably, so far the concept of sustainable development has been treated more as a socio-economic and political concept. Sustainable development would need tremendous inputs from many areas including science and technology. Another dimension of the problem is that