Whither pure science in India: a survey of graduate physics students of a representative University of Delhi college

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Over the past few years, a sudden drop in performance of science students is being noticed in the first year of their college compared to class 12. The issue is examined from the student's viewpoint. Responses from physics and electronics undergraduate students of our college indicate five key factors responsible for this decline in performance. A study of these factors and the ways to improve the performance of students form the focus of this article.

Keywords: Performance, pure science, spoon-feeding, student–teacher interaction.

SCIENCE education at the undergraduate level and above, as indeed higher education, is a topic of serious concern for any developing nation. Scientific and technological creation of knowledge is an act of production involving skill enhancement and technological improvement that results in efficient use of resources and improved productivity of human and other resources. Patent laws, intellectual property rights, etc. are now in place to recognize the importance of this resource.

During the cold-war era, India generated a large pool of science graduates and postgraduates, which unfortunately is not being augmented post-1990s following economic liberalization. What are the reasons? We believe the consequences can be serious and require appropriate examination. A study by the National Council of Applied Economic Research (NCAER), New Delhi[1], considered education in both pure and applied science (engineering). Although the study gives a positive picture about science and technology in India (for example 'The proportion of those doing engineering almost doubled, from 6% in 1995–96 to 11.2% in 2003–04'), the present study suggests that this is not so in pure science and our views are based on our experience and that of science teachers[2].

Our sample includes undergraduate students of physics and electronics at the Sri Guru Tegh Bahadur (SGTB) Khalsa College, University of Delhi (DU). DU is one of the largest central universities in India where undergraduate colleges are constituent colleges of the university. Many students from all over India aspire to get admission in DU[3]. SGTB is a college of repute and hence a good representation of the average Delhi student population. Parental financial stability and influence on their wards in career decisions are also highlighted by our sample selection.

Students applying for admission to DU colleges are guided essentially by two thumb rules – the public/media ranking of the colleges and/or the subjects. Public/media rankings are usually not based on any statistical information; however, it cannot be totally off the mark. This information is based on the previous year's cut-off and hence is driven by a supply–demand cycle. Figure 1 highlights the profile of applicants for 2009 for commerce-related subjects. Since the 1990s, the college has established itself as a reputed commerce institution. A profile of applicants shows that by and large only students with high marks in class 12 apply. The cut-off percentage for B Com (Hons) was 93%, and about 140 candidates were admitted.

Compared to the more popular courses like commerce, economics and mathematics, the marks obtained by students applying for science courses are Gaussian (Figure 2). The cut-off here is closer to the position of maximum. This variation in profile of marks by commerce and science applicants shows that science, specially pure science, is not considered a good option anymore by students. Basically, course selection is driven by job potential[4]. The 2004 report emphasizes the social acceptability/idolization of pure science professionals. While employment is of prime concern for both students and parents, aptitude and interest in the selected subject seem to have taken a back seat.

The hypothesis

Before we report the statistical inferences of this study (and the students' point of view), it would be interesting to go through the views of 'practising' undergraduate

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teachers. Broadly, undergraduate science teachers believe in the following (and these form the hypothesis tested in our survey here):

Fourth-category students

This category of students are those who (i) did not get into the commerce stream[5] in class 11; (ii) failed to get into good engineering institutions after class 12 and (iii) could not also make it to next best engineering colleges. This is clear by looking at the number of students who drop out in August–September after the counselling process at all engineering colleges.

Irregular attendance

Even among the fourth-category students, an overwhelming majority continue their attempts for admission to engineering colleges for at least another year and thus are irregular in attending classes. By the time they reach the third year, the students start preparing for MCA/MBA entrance examination. Thus, a majority of the students study only with the aim to get a first division in the university examinations, without bothering to learn the fundamentals of the subject. Many justify this saying they are unlikely to continue with the subject and so need not take it seriously. This disinterest in the subject is reflected in their performance in classroom and laboratory.

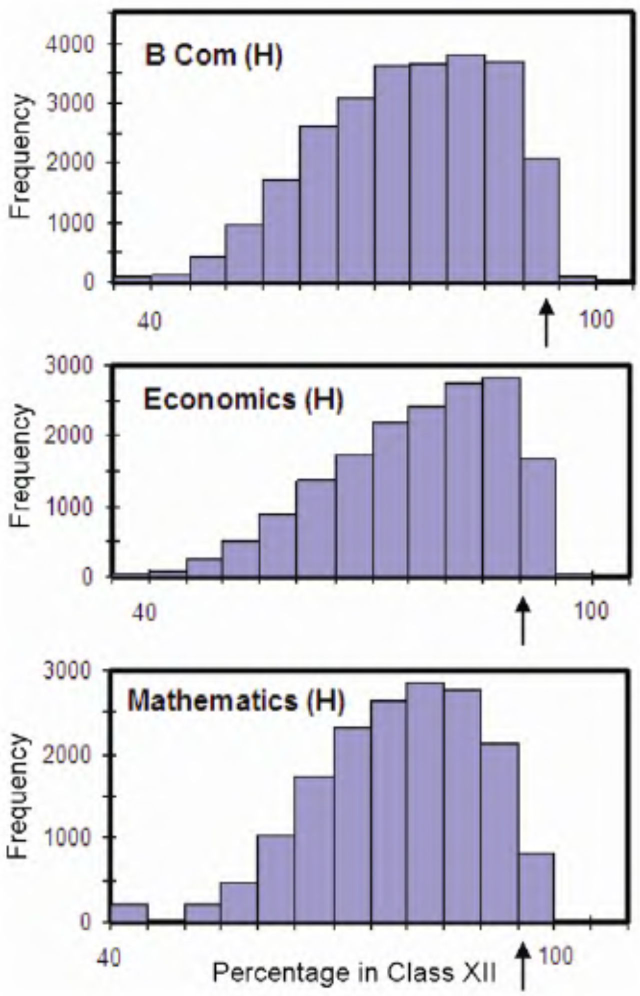

Figure 1. Profile of commerce applicants (2009–10) to SGTB Khalsa College in commerce-related subjects. The x-axis shows percentage range in which the applicants fall. Their numbers are shown along the y-axis.

Inflated practical examination marks

Marks obtained by science students in class 12 are inflated. This is clear by the fact that 60/90 marks out of 300 (admission is made on the basis of PCM (physics + chemistry + mathematics)/PCB (physics + chemistry + biology) are for practical examinations. A look at mark sheets during admission substantiates this notion, with all applicants invariably scoring 57–60 marks out of 60 in their practical examination. The marks distribution is thus Gaussian with the maximum pinned high.

Schools not training students in practicals

Students face problems while performing experiments and understanding observations. They simply lack the skill and keen observation power required in the laboratory. Moreover, they lack the ability to troubleshoot and interpret observations. Most entrants cannot even handle instruments that they are supposed to have used in secondary school. With this poor background, when they are expected to read from books/manuals and perform experiments on their own, they obviously lose interest. The explanation offered by students is that either they have never performed experiments in school or the experiments were just demonstrated by teachers. This shows that a majority of students seeking admission in science undergraduate courses are *not* trained in practicals.

Spoon-feeding

At schools students depend on their teachers, personal tutors and coaching institutions, while at the college they are expected to do a lot of self-study. Unlike in schools, college teachers usually do not provide notes and expect students to be more independent.

Studies lack will to work hard

Students usually do not work hard once they enter college. Either they are (i) exhausted studying for their

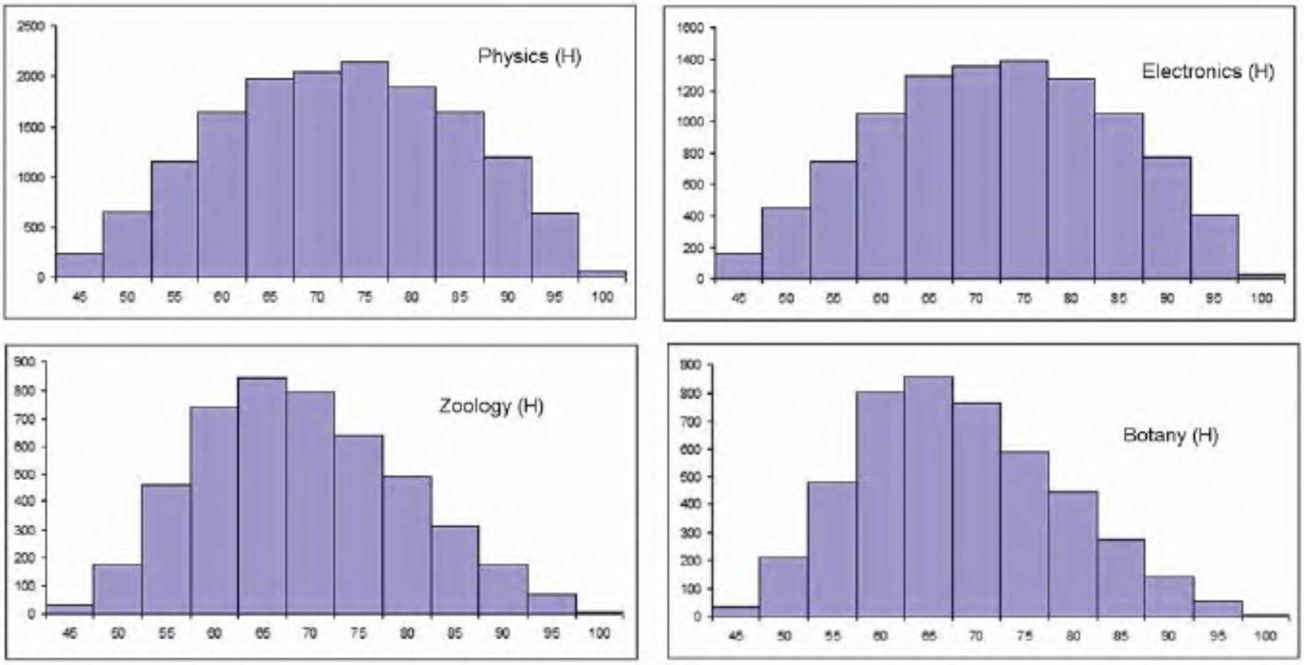

Figure 2. Marks of applicants who applied for various science courses (2009–10) in SGTB Khalsa College. The x-axis shows the percentage range (PCM) in which the applicants fall. Their numbers are shown along the y-axis.

board and competitive examinations; (ii) frustrated having failed to make it to an engineering college; (iii) have a notion that one does not need to study in college, which is only a place to enjoy; (iv) misguided that they can study in the last few days and score good marks; (v) complacent and lack faith in the credibility of the subject, and/or (vi) trying again for engineering courses. Whatever the reason, by the time they wake up to reality, it is too late and are unable to cope with the classes. The course content and academic structure of physics and electronics in the university system require students to work much harder.

The above-mentioned views of teachers form the hypothesis of our study. The question being addressed in this study is whether these notions are sound or ill-conceived? A questionnaire was provided to the students, asking them 'why they under-perform?' and then tried to look at these issues from a student's viewpoint. (The details of this study are available on request from the authors.)

Methodology

To understand the students' viewpoint as to why they under-performed in college, a questionnaire was circulated among them, and confidentiality was assured. The questions were designed to know the academic performance of the students, their understanding of the subject, their ability to perform experiments and solve equations as also their opinion on the syllabus, curriculum, and academic and non-academic staff of the college. Two sets of questionnaires were prepared, one for the first-year students and another for second and third-year students (henceforth referred to as senior students), as it was felt that the issues faced by the two groups are different. Also, the questionnaire for first-year students was distributed only after they completed one month in college, so that they respond after their initial experience in the college and university system. The students were expected to respond to questions in a couple of sentences. This subjective response was deemed fit so as not to stew the response of students along the lines of the person who designed the questions

Based on responses from students after scrutinizing the answers, the questionnaire was converted into an objective type. Care was taken to see that all possible responses to questions were accommodated as options and collectively categorized. Results were then compiled in a form that they could be cross-tabulated using features available in MS-Excel. Tables and graphical results were generated using Pivot-table and Pivot-chart. We report here only the findings that can be considered representative of science students of Delhi region and more specifically to an average college in DU. Also, the Gaussian nature of applicants' mark distribution (Figure 2) and the cut-off lying at the position of maxima indicate that the college is represented by average and above-average students in science, unlike in commerce (Figure 1) where the college attracts toppers.

Results and discussion

Are we really stuck with bad students?

The fact that science students prefer to opt for a career in engineering cannot be refuted. Other than social status, this also has to do with employment prospects. Hence, toppers tend to opt for good technical or commerce institutions. What then is to be seen is whether the above average students can be retained and encouraged to take up a career in pure science? However, as already stated, teachers believe that the above-average students move towards second-rung engineering colleges, leaving behind untrainable students.

To study this we profiled admissions to science courses to our college last year (i.e. 2008). Figure 3 shows the profile (% PCM obtained in class 12) of students who took admission in physics (H) for the session 2008–09. Their admission process was completed between 22 June and 12 July 2008. Maximum admissions were in the 80–85% range. Only 10 admissions were made with PCM less than 60%. These admissions were of students belonging to the reserved category. As observed by the percentage of marks, the students admitted are above average. However, in August–September just before classes settle down, the counselling round for second-rung technical institutions starts and good students among the lot (those with marks above Gaussian maxima position) would go, leaving behind below-average students.

To verify this, we filtered out class 12 PCM marks of physics (H) students who remained with us and went on to appear for the annual university examination 2009. The profile (Figure 4) is surprisingly similar to what we started with. The number of students with 80–85% in PCM reduced from 50 to 20; however, this bracket of students still represents the profile of the class (data not shown). The same trend is seen for all science courses like botany (H), chemistry (H) and zoology (H). Hence, the notion that we end up with below-average students is not true.

Inflated practical marks is an issue

Many students claim that 'less marks in practical and internal assessment by college teachers' is one of the main reasons for a drop in their performance. Figure 5 is a histogram of the marks obtained by the physics (H) students in the university. These students got admitted in 2008. Comparison of Figures 4 and 5 shows an average drop of 20% marks. These students claimed that their marks dipped due to their low practical marks (they expected high marks like in school). This indiscriminate award of high practical marks in class 12 was another issue with the teachers.

This point was analysed quantitatively. Let us assume that students in school get full marks (60/60, their third subject being mathematics which has no practicals) in the practical examinations. If M_P denotes the PCM (in %) marks of a student calculated, including the practicals marks and M_{WP} denotes the marks of the same student without practicals marks, then the difference $(M_P - M_{WP})$ is given by.

$$M_P - M_{WP} = 25 - M_P/4. \quad (1)$$

For higher PCM (M_P) the difference is small, e.g. for a student securing 90% in PCM, the difference is only 2.5%. This difference increases by 0.5% with every decrease of 2% in M_P. A shift more than the above difference (from their class 12 marks to first-year marks, i.e. from Figures 4 to 5) in the peak of the marks profile of students is expected and cannot be avoided unless the practicals marks in college are also inflated. This means that if the cut-off marks for a particular college are higher, the shift would be less compared to the case for a

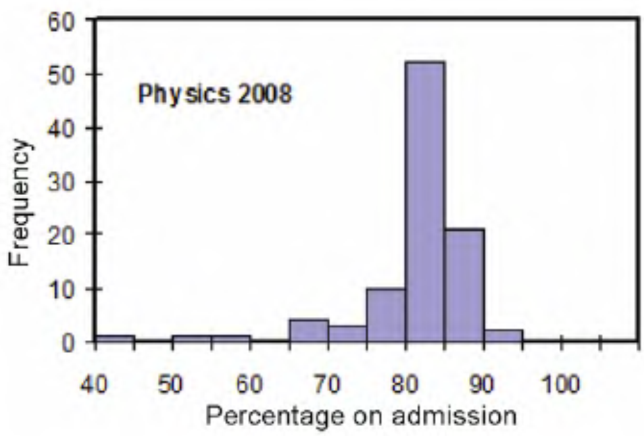

Figure 3. Marks of physics (H) students who took admission in 2008 and started attending classes from 16 July 2008. Students admitted below the cut-off belonged to the reserved category.

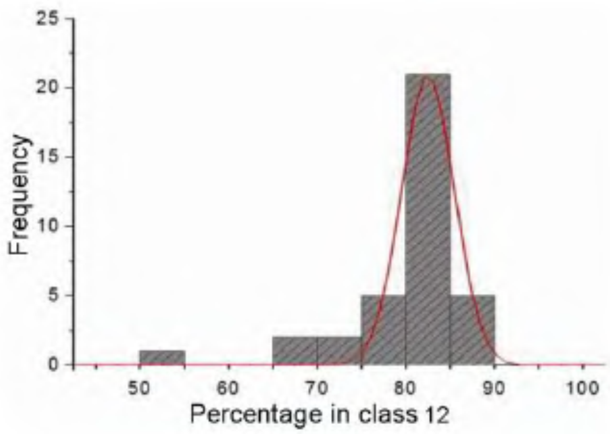

Figure 4. Marks (PCM in % obtained in class 12) of physics (H) students who took admission in 2008 and went on to take the university's annual examination (April–May 2009).

college/course where the cut-off is low, and the shift would be greater (Figure 6).

Figure 6 shows the performance of physics (H) students of Hansraj College, DU, in the 2009 annual examination. The cut-off percentage (first list) of this college in 2008 (when students were admitted) stood at 87%. The histogram shows a negative shift of about 10%. The shift hence is related to the cut-off percentage. Lower cut-off results in higher shifts (the relationship based on actual data however is not linear). This also means that the shift will be larger for biological science courses for which the cut-offs are lower. This was also verified for biological science courses of SGTB Khalsa College (not reported here). This analysis brings out an important point (especially considering the fact that the Ministry of Human Resource Development, Government of India is keen on college ratings) that while comparing institutions the criteria should be based not only on the input (cut-off percentage), but also on the input–output matrix, and for the input only theory marks should be taken into account.

Figure 7 shows that practical marks escalated the class 12 PCM of first-year physics (H) (cut-off 76%) and electronics (H) (cut-off 82%) students (SGTB Khalsa College) by ≤ 6%. Hence a drop in marks (between class 12 PCM and first-year university marks) that falls within this difference can be attributed to inflated practicals marks in schools. Hence we do not consider this to be a serious drop in terms of a student's performance. We put these students under the category 'no serious drop' (for electronics this category includes students having a drop of less than 5%, since their cut-off was about 82%, while for physics where the cut-off was 76%, this category includes students with less than 10%. Here it should be mentioned that cut-off for 2008 and before was lower than that for 2009). If the drop is 5–10% for electronics and 10–15% for physics, we put the students under the category 'enjoyed escalation'. These are the only students who may have a genuine claim that the drop in their marks is due to less practicals marks given in college. The remaining students are those (having more than 10% drop for electronics and more than 15% for physics) for whom the drop in marks is a serious one and cannot be attributed simply to low marks in practicals and internal assessment. This means that these students also obtained very low marks in their theory papers.

Figure 8 shows that the largest number of students falls into the third category, the category that cannot be accounted for just by the lower practicals/internal assessment marks. Hence we tried to study the factors

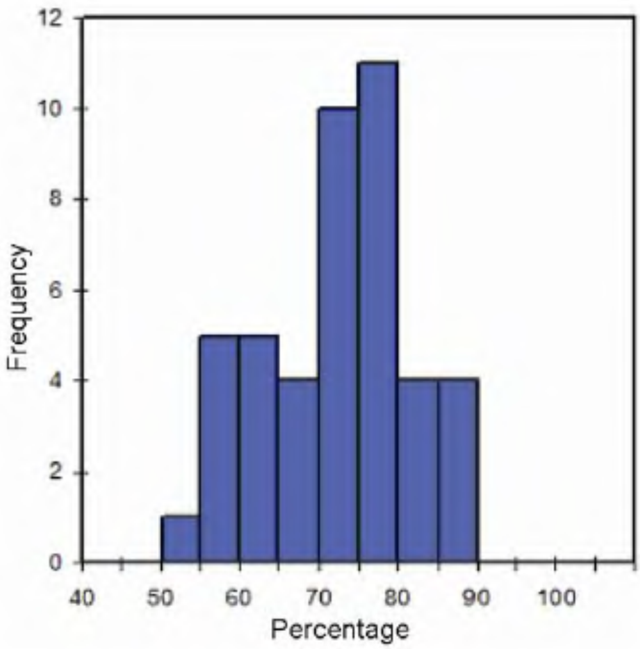

Figure 5. Marks obtained by the physics (H) students who took admission in 2008 in the university's annual examination 2009. The peak position shifted to 60–65%, showing an average drop of 20% in the students' performance after a year in college.

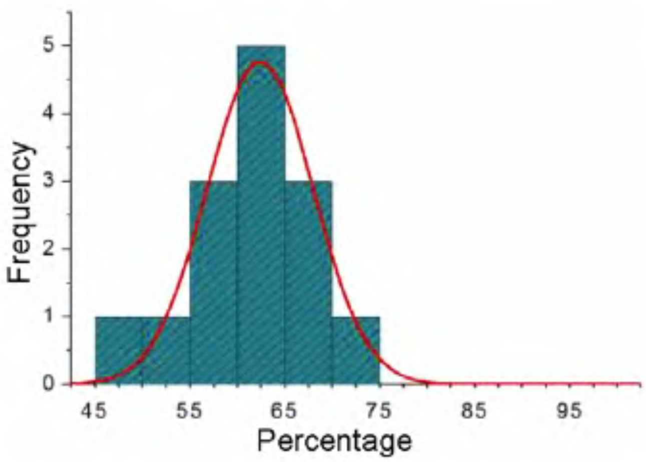

Figure 6. Marks obtained by the physics (H) students of Hansraj College, New Delhi. Considering that the (first list) cut-off of the college in 2008 was 87%, these students too show a drop in performance after a year in college.

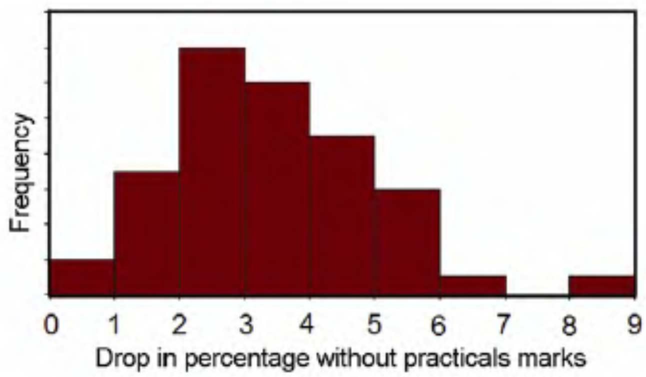

Figure 7. Contribution of practical marks (in %) in the students class 12 performance for first-year students (cut-off ≈ 80%). It may be noted that if only theory marks are taken into consideration, the cut-off would be 2–5% lower.

resulting in such a serious drop in performance. It may also be mentioned that this category includes more of physics (H) students than electronics (H) students.

Thus, the inflated marks in class 12 practical examinations are not an issue as far as the drop in performance of students of pure science at university level is concerned.

Students use pure science as a stop-gap arrangement

We studied the reasons why students opted for a science course in the first place. The replies ranged from interest in the subject, job prospects, pressure from parents, siblings, etc. Figure 9 shows the distribution of the reasons given.

Interestingly, of the students who took admission in 2009, less than 50% joined the subject because of interest, though it has to be acknowledged that they form the majority. Although this might be of consolation for some, the numbers do not tell us the whole truth. Of the students who took admission in 2009 in arts courses like political science (H) and history (H) in SGTB Khalsa College, 20% in political science (H) and 10% in history (H) were science students who could have easily taken admission to science courses based on their PCM marks. This shows that, 'if not engineering, let us give up science altogether' is the stand taken. Thus, the compelling logic of course selection is its viability in increasing job prospects.

Figure 10 shows that more than 95% of the junior students who joined for physics/electronics course had interest in engineering. This negates their claim that they took this course out of interest. That is, those who had selected the course saying that they were interested, actually reserved this course as their second alternative, implying this majority also belonged to the '**t**here **i**s **n**o other **a**lternative (TINA)' category. The 'TINA' category of students explicitly stated that they took pure science because they could not get into engineering. Thus, a large majority actually took physics/electronics because they did not get admission to engineering colleges.

Three months into their course, 52% of first-year students decided not to pursue their quest for an engineering career. The study showed that once admitted a sizable number of students are likely to stay. But even this is of no consolation as 36 out of 40 senior students liked physics in school; however after 1 or 2 years in B Sc, this number came down to 24. There was a 30% drop in the number of students retaining interest in physics after being initiated into the course. About 23 of the remaining 24 students who continued to have interest in physics mentioned that they wanted to continue in physics during post-graduation as well.

The primary motive of course selection is obviously related to getting a job in future. Pure science is perceived as incapable of enhancing a person's chance of getting a job. This results in 50% and more students of a class repeating their attempts in competitive examinations not only bringing down their performance in class, but also affecting the students who decide to continue in pure science.

Students do not work hard enough

As stated earlier, wanting a career in engineering, students repeat their attempts for various entrance examinations. However, these students take admission in the pure science course and try to wade through. This would have serious repercussions for the institutions and more importantly for the department, whose performance would be judged by the students' performance. Under these circumstances, if the quantum of a student's effort remains the same, its distribution in two divergent directions (of preparing for a competitive examination and coping with

Figure 8. Three groups in which senior students have been categorized based on their performance in the university examination.

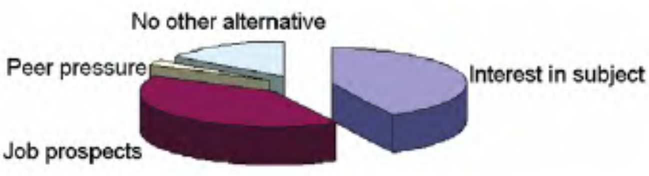

Figure 9. Distribution of reasons given by first-year students as to why they selected physics/electronics for graduation.

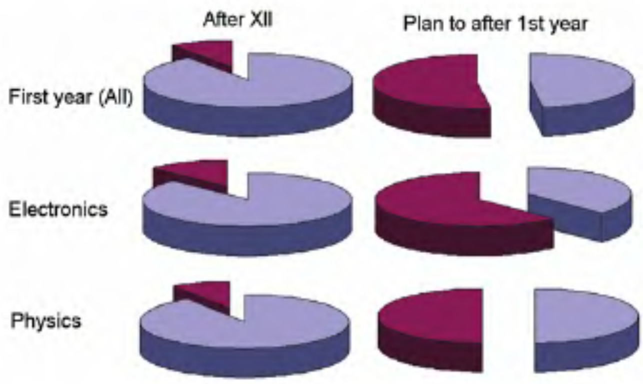

Figure 10. Proportion of students (first year) who appeared for engineering entrance examinations after their class 12 board examinations (left; light shaded). (Right) Proportion of students who plan to reappear in various competitive examinations (shaded light) after their first-year university examinations. Physics students seem to be more interested in repeating attempts for engineering.

an honours course) would have a telling effect on the performance.

As discussed earlier, the senior students were divided into three categories based on their performance in the university's first-year examination with respect to their class 12 marks. Figure 11 shows the distribution of the number of students in these categories. It is obvious that a substantial number of students are in the 'serious drop' category. But it is also important to note that 50% of these students were preparing again for competitive examinations along with their university examination.

Although no one can stop students from appearing in competitive examinations, one would believe that a substantial increase in effort would be present on the part of these students. Hence, we asked senior students how many hours they studied on an average during their first year. Figure 12 depicts the results according to their performance in the first-year examination.

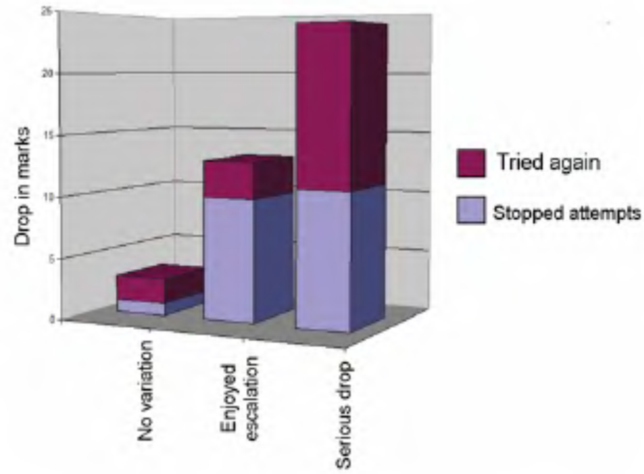

Figure 11. Profile of senior students' performance and the effect of repeating competitive examinations on their performance.

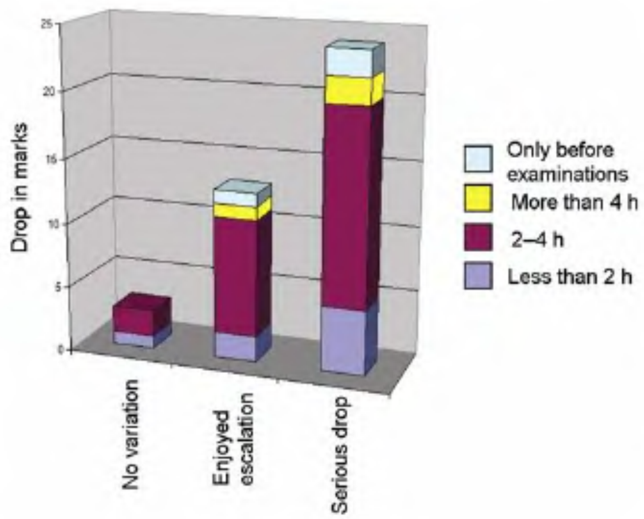

Figure 12. Number of senior students in categories of change in marks (difference in first-year percentage from PCM percentage in class 12) with break-up of study hour at home.

Considering that of the 24 students who had 'serious drop' in marks (Figure 12) who claimed to be studying as much as those who did not suffer 'serious drop' in marks, one needs to study the cause of their drop in performance. Figure 13 shows various categories of students who did and did not repeat attempts in competitive examinations. The graph of 'no variation/enjoyed escalation' clearly shows that a regular study of 2–4 h a day is good enough to get decent marks. However, as can be seen, of the 24 students who had 'serious drop' in marks, 13 were repeating their attempt for competitive examinations. However, about 45% of students whose performance had shown a serious drop were not preparing for a second attempt at competitive examinations. Notice that 50% of this group only studied for 2 h a day or only before the examination. This suggests that there is a drop in effort; however, it cannot be attributed to distributed effort. Also, the remaining 50% who were studying adequately also fell in the category of 'serious drop' in marks, suggesting that there are aspects (variables) other than preparation for competitive examinations and distributed efforts affecting their performance.

Inadequate training in practicals

Teachers believe that students are not able to perform practicals properly. They claim that the students' attitude is mechanical, i.e. they take observations according to instructions without bothering to understand principles. Also, even after obtaining the data, they fail to appreciate data analysis (curve fitting) and error analysis.

We asked the first-year students whether they had performed practicals in school. Figure 14 shows the profile with respect to the type of school they graduated from. It

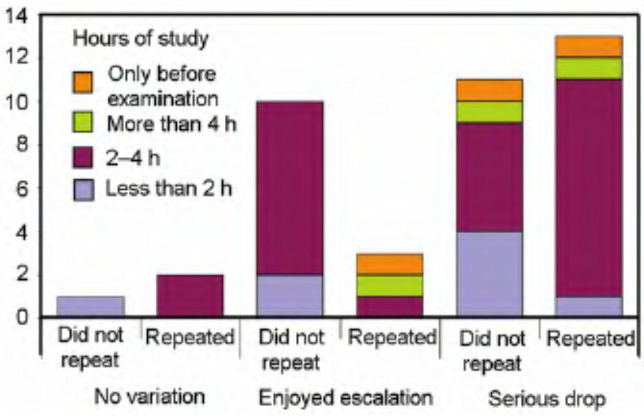

Figure 13. Number of senior students in categories of change in marks broken up into those who repeated competitive examinations and those who did not. The study hours at home is also shown.

is clear that the special government schools like Pratibha Vikas Vidyalaya/Sarvodaya or Kendriya Vidyalayas do a better job as far as practicals are concerned. All students in these schools had done sufficient practical work at their school-level. The percentage of students not doing experiments at schools was highest in government schools, whereas the number was also significant in private schools. It has to be noted that private school students obtain more than 95% marks in practical examinations at school.

While the above data suggest that an overwhelming majority of students have been exposed to practicals in school, the question is whether these students are comfortable and confident in doing experimental work independently? Both junior and senior students were also asked if they felt comfortable in performing experiments. Figures 15 and 16, respectively, show the comfort level of junior and senior students in performing experiments.

The above data show that 50% of government school students, 19% of special government school students and 23% of private school students do not feel comfortable while doing practicals. The lack of resources in government schools and the large number of students in a class can account for this. However, such large numbers in private schools are unacceptable. In these schools, teachers award practical marks. On comparing juniors and seniors, about 20% of the junior students and 32% of the seniors said that they did not feel comfortable doing practicals. Based on the performance of senior students in the university practical examination, they were classified under categories 'good' (≥ 66 marks), 'average' (60–66 marks), 'below average' (50–60 marks) and 'poor' (< 50 marks) (note that the marks are out of 75). Figure 17 shows the distribution with 36% of the students falling under the category 'good'. This by and large is in agreement with the response from seniors (32%) who stated that they were comfortable with their practicals. If the

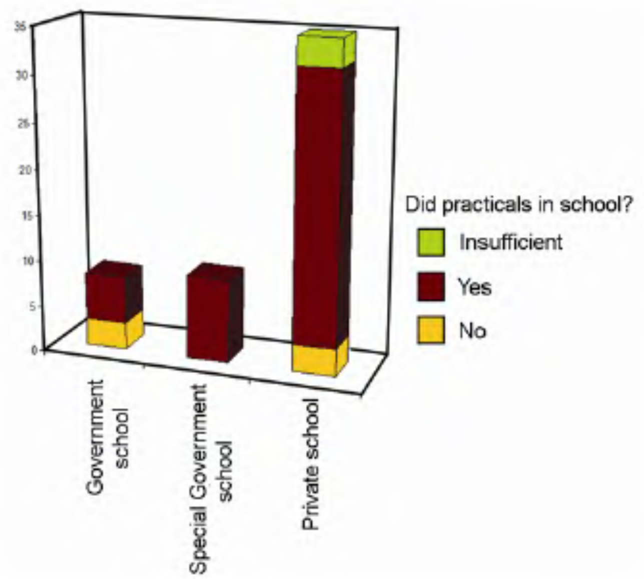

Figure 14. Profile of students based on the type of school they graduated from and their ability to do experiments based on practice in school.

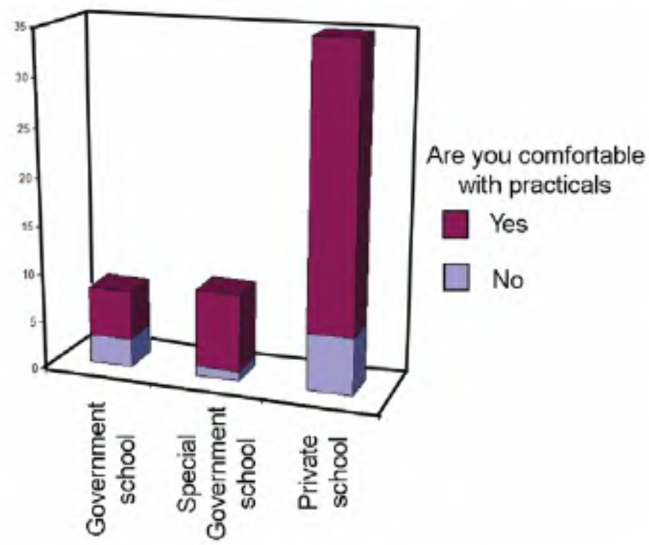

Figure 15. Profile of junior students based on the type of school they graduated from and their comfort levels in doing practicals based on practice in school.

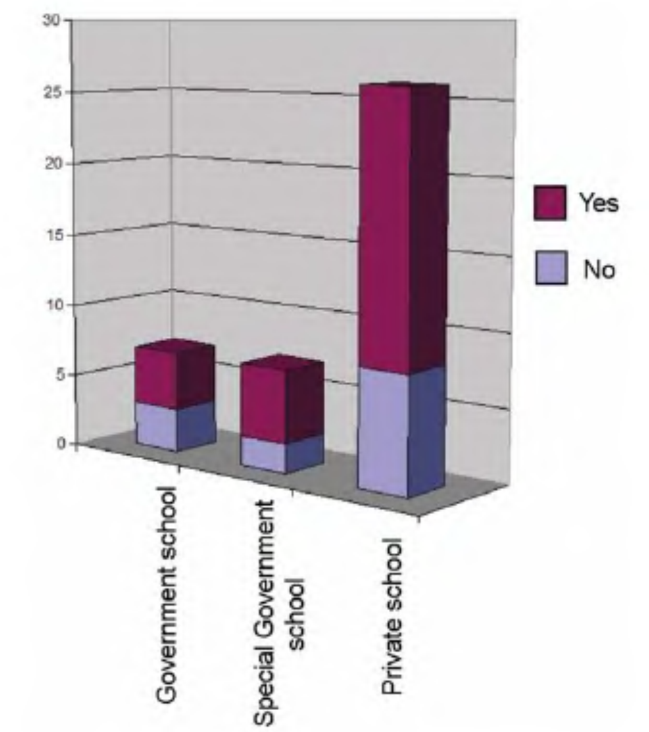

Figure 16. Profile of senior students based on the type of school they graduated from and their comfort level in doing practicals based on practice in school.

Table 1. Overall drop in senior students' performance against their performance in practical examinations

	Rating according to performance in university practical examinations				
Drop in marks	Poor	Below average	Average	Good	Grand total
No variation		2		1	3
Enjoyed escalation	1	1	3	8	13
Serious drop	2	13	1	4	20
Grand total	3	16	4	13	36

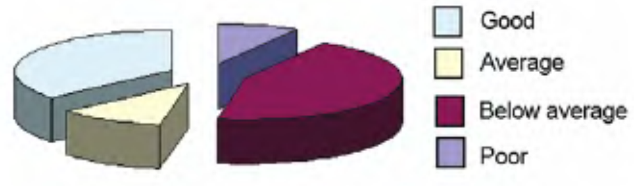

Figure 17. Marks obtained in university practicals examination, the seniors were classified under categories 'good', 'average', 'below average' and 'poor'. A large (52.3%) percentage of students have preformed below par.

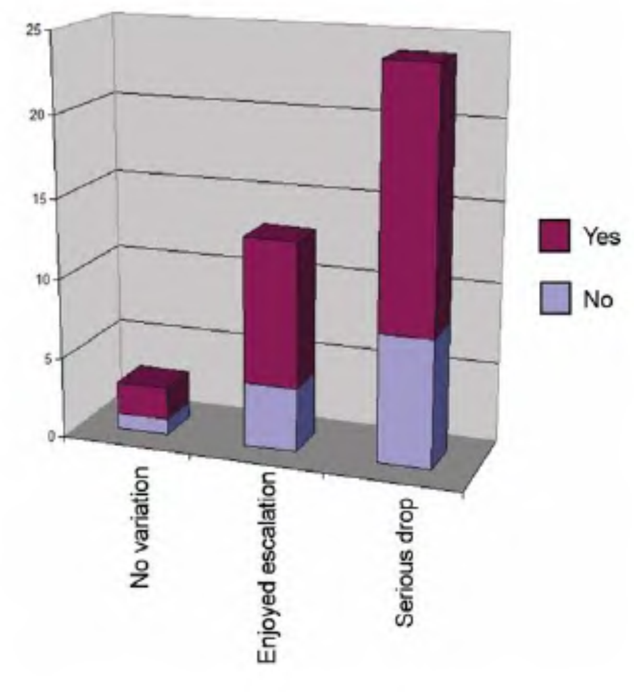

Figure 18. Number of senior students who feel comfortable in doing practical based on performance in university level examination.

average performance is also considered acceptable, 47% seniors did well in their practicals. This is not a satisfactory number for the effort and investment made.

When such a large number of senior students do not feel comfortable in laboratory classes, it also means that 1–2 years of regular training in practicals in college did not help in improving their skills or general interest. This can either be attributed to inertia they carry from school or obsolete methods of training in college.

We believe that students' performance in pure science drops due to poor training in practicals. Hence, we cross-tabulated their response on whether or not they were comfortable with practicals with respect to their performance in the examinations. Figure 18 shows the distribution. Consistently, 30% of all the categories discussed stated that they were not comfortable in doing their practicals. However, a majority of students (52%) performed badly, which indicates that all those who stated that they were comfortable in doing practicals actually were not able to perform well in the practical examinations. This number is quite large considering that this response came from senior students with 1–2 years of rigorous training in practicals. In fact, the present DU curriculum allocates 40–50% of the class for practicals. Also, we found that those complaining about drop in marks in internal assessment were by and large not comfortable with practicals.

To study this further, we cross-tabulated the senior students' performance in university practical examination with overall performance in terms of drop in marks of the students (Table 1 and Figure 19). It is clear that 70% of students under 'serious drop' category also had performed poorly in their practicals. Thus, clearly, inability to do practicals does contribute to drop in performance. However, it is to be noted that eight students (out of 13) from the 'enjoyed escalation' category performed well in practical examinations. Thus their claim that 'the drop in their performance in college is due to poor practical marks' is not true. Out of the 20 students in the 'serious drop' category also, four students performed 'good' in the practical examination. This means that besides 'low practical marks' there are other issues that contribute to a drop in the students' performance in university examinations.

The fact that students are not comfortable with practicals might appear surprising although not unique[7]. Even in European countries where emphasis is placed on experimental techniques, students do not derive what the curriculum was developed for[8].

Spoon-feeding

Teachers broadly use the term 'spoon-feeding' to qualify a larger degree of dependency shown by students, be it discussing issues and stating the obvious, or writing each and every step of a derivation however trivial it might be. Even the lack of initiative by student is viewed under this gambit, resulting in remarks like 'we even have to cajole them'!

Students define spoon-feeding as teacher dictating everything in class. Of the sampled students, 27% complained that teachers follow more than one book for every subject. Table 2 gives responses where students were asked about the difference in methodology of teaching at school and college, their preference, and if they had problems in studies with teachers' attitude. About 60% of senior students blamed their teachers for not providing notes in the class. In short, students demand spoon-feeding or an enhanced level of dependency (Figure 20).

Logical reasoning/thought process and its development becomes the first casualty in preparing for the examination at the end of the academic year. With the proposal of doing away with board examinations in the near future and evaluating students throughout the academic year, one hopes the importance attached to marks would also be done away with. While it is a welcome move, it has to be said that merely replacing one annual examination with multiple class-tests would not bring about independent learning and reasoning capability. Thus, along with doing away with board examinations, a shift in assessment method is required. This would be more of a challenge to a generation of teachers trained in the old school of thought.

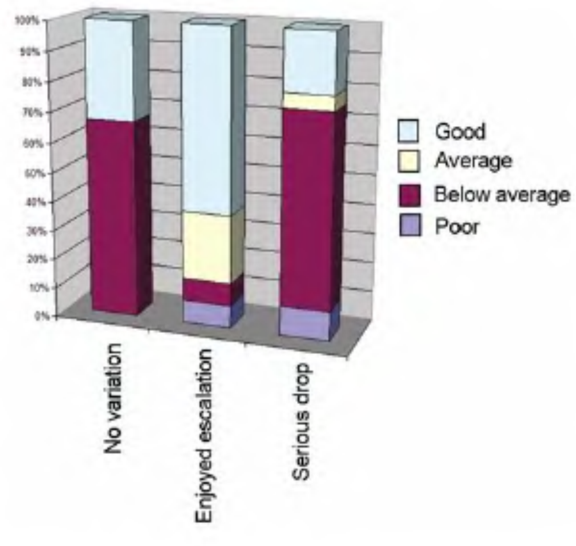

Figure 19. Profile of senior students based on their overall performance in university examination and their performance in the practical examination.

Table 2. Senior students who believe spoon-feeding is a good idea and those who have some grievance against their teachers

	Teachers' aloofness is an issue in college		
Spoon-feeding is required	No	Yes	Grand total
No	14	6	20
Yes	8	12	20
Grand total	22	18	40

Requirement of spoon-feeding is also clear in the responses to our queries about the interaction with teachers. Many students mentioned that they expect their teachers to be more helpful in laboratories. Students want to take observations once the teacher sets up the apparatus and shows each one how to do it. This implies that students are not able to perform the practicals independently. A common observation about Indian scientists during research is that they do not initiate innovative research becoming pioneers in a field and usually end up following a leader, engaging themselves in characterization/repetitive calculations. This inability seems to be germinating at an early stage in student life.

Teacher interaction

Many students have mentioned in their responses that they expect college teachers to take care of their day-to-day problems in college, both academic and non-academic. About 50% of the senior students who were not satisfied with their college teachers basically were complaining of the non-interactive nature of their lecturers (Table 3). A close analysis of the data shows that 60% of the senior students who were not satisfied with their interaction with teachers were from physics (H). Also, among the senior students who suggested that the problem was because the teachers were aloof, 66% were from physics (H).

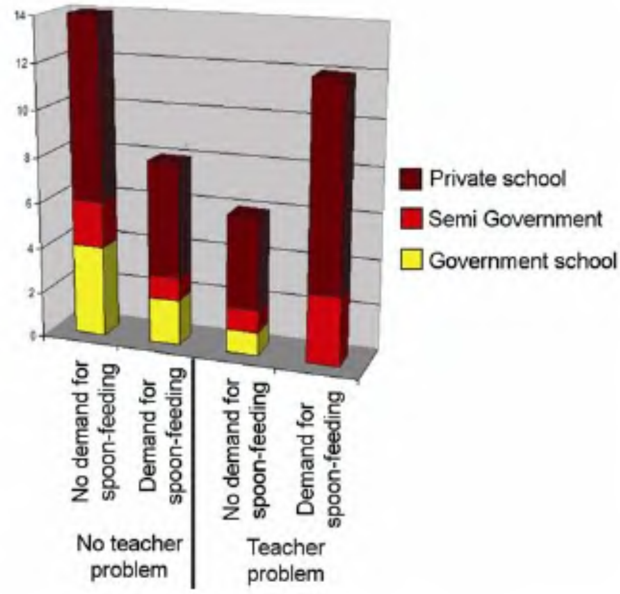

Figure 20. Nature of the institution from where senior students completed their schooling and if they have blamed their college teacher for not spoon-feeding them.

Table 3. Senior students who are not satisfied with their teachers interaction and those who believe that their teachers are by and large aloof, restricting their interaction only in class and that too limited to the subject

	Do you think they are aloof?		
Are you satisfied with your interactions with your (college) teachers?	No	Yes	Grand total
No	15	15	30
Yes	10		10
Grand total	25	15	40

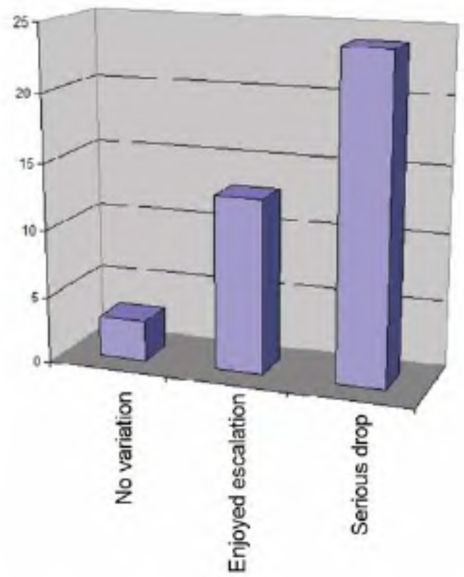

Figure 21. Performance explained for the sampled population by one of the five reasons listed.

Clearly the problem of interaction or rather lack of it is a serious issue for physics (H) students than for students from electronics (H). This is not surprising considering the students–teacher ratio is nearly double for physics (H) compared to electronics (H) in theory classes.

Conclusion

We see the ability of getting a job to be the primary motive for course selection. Pure science is perceived as incapable of enhancing a person's chance of getting a job. This results in 50% or more students of a class repeating their attempts in competitive examinations. This not only brings down their performance in class, but also affects the students who decide to continue in pure science. This however does not mean that we end up with below-average students. Even their inflated practical marks in class 12 is not an issue, because it only results in a shift in the cut-off (to a higher value) and cannot by itself explain the drop in performance of pure science students at the university level. However, a drop in effort by students once they enter college is definitely a cause for concern. This can be due to studying for competitive examinations or due to a cultural change of enhanced freedom. If a student is not preparing for competitive examinations, he/she should be putting in 2–4 h of regular daily studies.

Students also seem to be used to spoon-feeding in school and continue to demand a similar level of dependency in college. Complaints about lack of interaction or aloofness of teachers actually emphasize the need for spoon-feeding[9]. The drop in performance is shown to be related to the inability to do practicals.

Based on the above discussion, we conclude that there are five reasons (mathematically for us, five variables) that contribute to the drop in a student's performance. As can be seen from Figure 21, these five factors completely explain the drop in performance of the students: (i) preparing for competitive examinations, (ii) drop in effort on student's part, (iii) language problem, (iv) lack of spoon-feeding, (v) not comfortable with practicals.

To encourage students to take up pure science, we believe that the above points should be addressed soon. From the parents' point of view, a commerce graduate can get a decent job as soon as he/she graduates, whereas a science student invariably has to do postgraduation. To this effect, industry has to be made a partner in higher education and be convinced to hire science graduates. A survey of the newspapers shows that even for routine testing and quality control jobs the industry prefers engineers to science graduates. In recent times the growing IT sector has led to large-scale employment of science graduates immediately after graduation with the on-job training, bringing on-campus placement drives in non-engineering colleges. If manufacturing and R&D companies also step in, impetuous could be given to employability of science students. On the academic side also certain corrections need to be made – the curriculum should be more application-oriented based on experimental projects. Experimental science is expensive and to cut corners have been compromised. It has to be viewed as a national investment and not a wasteful expenditure. Increased experimental work and more stress on conceptual learning would in turn demand a reduction in the quantity/load of the syllabus.

The cultural change faced by students also needs to be addressed. On entering college they are expected to be mature enough to take care of themselves and study independently. While on the other hand, there is so much pressure because of the vast course, large number of books they have to follow and the assignments they are expected to do. Many students complain that physics in school was different from physics at the undergraduate level. So teachers and authorities can reduce the sudden impact by making the process slow. The course work could be staggered rather than evenly distributing it over three years. Colleges may also associate each student of the first year to one teacher of the department to take care of his/her academic/non-academic problems. The student–teacher ratio must be reduced in theory classes at least in the first year so that more interaction is possible between the students and teachers. Also there needs to be more tutorial sessions with smaller number of students in a batch. This again demands a reduction in student–teacher ratio.

1. Shukla, R., India science report: science education, human resources and public attitude towards science and technology, National Council of Applied Economic Research, New Delhi, 2004.
2. In fact, extracts from the NCAER report would be quoted wherever data of about science and technology are reported distinguishably to show how our minute statistical sample agrees with a larger national sampling.
3. The NCAER report shows that 'Delhi has the best-qualified population, and 16% of all Delhiites have at least a graduate degree'.
4. This public impression is supported by NCAER's statistics, 'Of the graduates who are unemployed, 22.3% have studied science. The share of postgraduates with science background in the total unemployed postgraduates is significantly higher (62.8%)'.
5. Again from the NCAER report, 'The number of students wanting to take up commerce at a higher level of education rises almost three-fold as one moves from classes 6 to 8 to 11 and 12', emphasizing how employability becomes an issue on growing up.
6. Even in the NCAER report 'half the (nation-based interview) teachers interviewed said that more computers/equipment were required for teaching science subjects since inadequate practical training was a serious issue'.
7. Abrahams, I. and Millar, R., Does practical work really work? A study of the effectiveness of practical work as a teaching and learning method in school science. *Int. J. Sci. Educ.*, 2008, **30**, 1945–1969.
8. This response we got from our students is similar to that reported by NCAER, 'One of the reasons for the declining trend in pursuing science education at the higher levels is the increasing dissatisfaction of students with teaching of science in the higher classes in school'.

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