hide the purportedly poor productivity of applied research is cynicism of an extreme order. Finally, we take particular exception to Balaram's description of the work of national labs as 'apparently applicable'. The comment reflects Balaram's ignorance of the work of India's national labs and does not behove the editor of what is perhaps India's best-circulated science journal.

We take this opportunity to educate by providing an example of the 'apparently applicable' research of one of our national labs. In the 1990s, the Indian Institute of Petroleum (IIP) in Dehra Dun developed a process to convert a petroleum distillate called naphtha into liquefied petroleum gas (LPG) and gasoline (known as the NTGG process). The Gas Authority of India Limited recently commercialized this process near Baroda in Gujarat. In the year 2000, India had 11 million applicants waiting for an LPG connection. IIP's process has the potential to impact at least a few of these several million households. In our minds, such research, notwithstanding the 'apparently applicable' labs, is highly desirable from the context of national relevance.

This example also has something for the academic whose definition of impact is limited to the impact factor. The elucidation of the fundamentals of the NTGG process resulted in at least 1 Ph D student and several peer-reviewed publications. However, we provide this information not to support the (valid) argument that applied research also results in papers, but to argue that publications alone should not be used to evaluate research. Other factors, which should be considered are technology commercialization, employment generation, contribution to the innovativeness of Indian industry, and impact on the lifestyle of the poor. Policy makers of Indian science need to develop tools to quantify these impacts instead of ignoring or, worse, disparaging them just because they are not easily quantifiable.

Balaram's editorial, while raising an important issue, loses credibility by attempts to disparage scientists who manage science. Management of science is an important activity. One of this letter's authors (TSRPR) takes pride in being one of the 'managerial scientists' that Balaram seeks to disparage. In our view, the productivity, progress, and direction of scientists, irrespective of nation and institution, strongly depend on the leadership provided to them. A conscientious 'managerial scientist' recognizes an institution's strengths and weaknesses, fortifies its strengths, redresses its weaknesses, recruits and nurtures new talent, obtains new funding and facilities, aligns an institution's research agenda with its mandate and national interest, develops a committed and qualified second rung of leadership, and motivates workers to dream and think big. In all, a successful 'managerial scientist' provides an enabling environment for scientists to enhance their productivity measured in terms of publications, patents, technologies, or impact. We wonder which scientist would oppose the existence of such 'managerial scientists' whose output if measured merely in publications would have little meaning. This is not to suggest, in the least, that 'managerial scientists' do not produce good papers or are poor scientists.

Balaram's comments on 'managerial scientists' is particularly surprising because every once in a while *Current Science* features suggestions that India establish a science administration cadre that better understands science and technology. While such suggestions are bandied about, we have an editorial that disparages those scientists who choose to curtail their research interests to help develop a climate that truly fosters and cultivates science. This, in our mind, is hypocrisy and has to be replaced with respect for those who help manage science in good faith and with honorable intentions.

The saga of Indian science needs to be viewed with a balance. In the absence of such a balance, it is equally easy to dismiss the impact of Indian publications, which, by Balaram's own admission, seem to have minimal impact as determined by science citation indices. However, just as Balaram's views on applied research are untrue; so is such a sweeping dismissal of academic research. We strongly believe that applied and industrial research has made a positive and substantial contribution – papers or no papers – to India and this needs to be better understood, recognized, and appreciated.

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Academic standards in Indian universities

Print media often publishes reports on the deplorable situation of academic standards in Indian universities. The common causes discussed mostly are 'political appointments of Vice-Chancellors' and/or 'unscrupulous interferences by governments and/or political parties'. In my opinion, these are peripheral issues and the root cause lies in the 'standard of teachers and teachings' in the universities. Gupta[1] once rightly commented, 'hospitals cannot be run and dams cannot be constructed by second-rate and third-rate graduates'. The same is true for universities. 'Excellence in universities cannot be achieved by average and mediocre teachers'. Here are some factors, which have contributed to the lowering of academic standards in the universities.

(1) Ph D as a minimum qualification of university teachers – Though it may sound unusual at the outset, it has distracted university toppers and brilliant students from joining the universities. A topper automatically finds his position in

the administrative services or private organizations soon after his/her graduation, but the university expects him/her to spend an extra 3–4 years (for doing a Ph D) to attain minimum qualification. Mediocre students who cannot flow in the former stream follow the latter path.

(2) Defective recruitment system – The piling up of 'temporary' and 'ad hoc teachers' in the universities for many years has badly aggravated the situation. Excellence cannot be attained by these teachers who always fear about their retrenchment. Inbreeding in the appointment is another offshoot of recruitment system in the universities.

(3) Over-flooding of self-financing courses – Delivering a lecture and textbook teaching are quite different. The former needs thorough knowledge of the subject, which is acquired by perpetual self-studies. A university teacher can efficiently deliver lectures for 12–15 h per week. Today, in universities, almost every department is engaged in self-financing courses without adequate faculty and an average university teacher delivers lectures for 20–25 h per week. Obviously, a compromise has to be made with the quality and contents of the teachings.

(4) Researches in university shifted from part-time to full-time – Entry into and further promotions in university teaching services largely depend on the published work. Unfortunately no method has been developed till date to judge the teaching aptitude of a teacher.

These factors have largely contributed to the lowering of academic standards in Indian universities. The ultimate hopes for lifting up the standard rest on the UGC whose decisions, guidelines and directives have always moulded the curriculum and destiny of the universities. Will the UGC officials listen?

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Beyond the laboratory

This is in response to the correspondence by Gupta (*Curr. Sci.*, 2002, **83**, 542). He has indicated the nature of chemistry practicals at the Intermediate level. However, Fuhrman *et al.*[1] pointed out that practical work plays a central role in chemistry. The main aims of practical work in chemistry are (i) make accurate observations and describe chemical phenomena, (ii) practice identifying problems relating to chemistry and seek ways to solve them, (iii) verify facts and principles already learned, and (iv) develop certain disciplined techniques and logical reasoning.

However most teachers in developing countries use practical work just to verify scientific knowledge[2] and give little attention to the development of practical skills in students in their assignments and assessments.

Gutpa did not indicate the cause for declining trend in chemistry practicals. I would like to mention a few causes which are common for all developing countries like India,

(a) The science curriculum has failed to construct a coherent picture of the subject, its methods and its practices, leaving pupils with fragmented pieces of knowledge[3].

(b) Under the impact of information technology, the skills needed in different occupational sectors are converging as more and more jobs demand generic and abstract, rather than sector-specific skills[4].

(c) Nowadays, the science curriculum is over-loaded because of which the students are demotivated and think that science is 'difficult'.

(d) The laboratory is in no way providing effective learning environment.

(e) The strategies that can develop the skills of science such as encouraging learners to discuss scientific ideas with their peers, evaluate evidence and develop practical competence for understanding science have been squeezed due to the precarious economic condition of our country.

The following suggestions are being made for sustainable development:

(a) There should be greater emphasis on the explicit teaching of procedural understanding and reduced emphasis on the teaching of conceptual content[5].

(b) The framing of curriculum should be such that it enables pupils to study up-to-date application in more detail and pursue their particular local and personal interests via extended project-type investigations.

(c) Practicals should be used as an effective method of teaching and understanding[6].

It is high time our policy makers think about the sort of science education we really need.

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