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GUEST EDITORIAL

The case for a broad undergraduate science degree

There is widely felt dissatisfaction with the standard of the undergraduate science degree – the average B Sc from a typical university. Entrance tests and interviews of B Sc candidates, even those with high marks, bring out gaps in understanding and skills. The creation of the IISERs was one response to such a situation. Many of the strong UG science programmes in the Central Universities and the five or four-year science degrees in the IITs predate the newer initiatives and have sent many students into research. The Indian Institute of Science started its undergraduate programme six years ago. All these programmes measure their success by the number going on to a Ph D – all the better if abroad. Against all odds, a few B Sc programmes in the universities have kept pace, with a significant fraction of their graduates going onto research. For a country of our size, there is room for even more such ‘quality’ programmes training potential researchers. However, these will always be a small fraction of undergraduate science degrees awarded in the country. This editorial is about the remainder.

In rough numbers, rounded from the UGC website, our country has about 5 million students at any given time enrolled studying science at the undergraduate level. The proportion of women is about 45 per cent, which is higher than that in the engineering streams. The curriculum in many places has been ‘modernized’ and ‘upgraded’, often with the help of well-meaning scientists from nearby research institutions sitting on the board of studies. The usual trend is to simply add more and more advanced and specialized topics. A student who grasped this material would be very well prepared to enter a good M Sc or even a Ph D programme. In reality, even after all the filtering at input, masters level and doctoral programmes start with coursework which revisits the more advanced part of the undergraduate science syllabus. Clearly, what is emitted in the classrooms is not absorbed by the students. With honourable exceptions, our current UG science programmes have become something of a ritual. They cause widespread intellectual indigestion amongst millions of young people in the prime of their lives, year after year. In the current model, these graduates are the tailings, left over after the talent which feeds institutions of higher learning and research has been mined. Considered purely as an industrial process, it would be criticized as too wasteful.

Note that an M Sc is now essential to teaching science at the tertiary (11th and 12th standard) level. Whether this really raises the standard of teaching is debatable, but it is a ground reality. The teaching stream accounts for a large fraction of those who take up postgraduate degrees. This is a very important fraction as this stream feeds back into the next generation of students. The undergraduate degree therefore has at least three outcomes – (a) research/research cum teaching, (b) mainly teaching, and (c) the rest. The numbers increase by a large factor from the first to the last. The design of these courses does not cater to the ‘mainly teaching’ and ‘general’ categories. It seems glaringly obvious that undergraduate science programmes should give the majority of the entering students something they can learn, appreciate, enjoy, take away, and use. Is this at all possible?

Augmentation of the syllabus is not the answer. I see this most strongly in my own field of physics, where the more advanced parts of the subject come with strong prerequisites in the basics. The contents of the first and second courses in mechanics, electromagnetism and heat were pretty well understood in the late nineteenth century. Perhaps the imperative to add to the syllabus comes from a genuine desire not to leave the students more than a hundred years out of date. But the net result is often a weak foundation. Hurried coverage in the interests of more advanced or trendy topics leaves its mark.

There is another justification, on paper, for the stronger B Sc syllabus that we see in many places. Most of basic physics along with the calculus, linear algebra and vectors needed as foundation to move ahead already form part of the 11th and 12th standard text books, and the most prevalent entrance exams. This is only a paper justification because the tertiary syllabus is overloaded, and hence dealt with in a rote/drill-oriented manner more geared to competitive exams than understanding. The material is indeed retaught in the first year in all the ‘quality’ programmes I mentioned earlier.

Today, we have a framework in which a more adaptive and responsive system of undergraduate study can function. This is the CCBS, the choice based credit system, which now has the stamp of UGC approval. The official (and somewhat officious) guidelines strive hard to say all the right things, among which the trinity of efficiency, equity and excellence stands out. Interpretation of the

guidelines is a different matter – CCBS is a double-edged sword. One university which shall remain nameless kicks off with fluid dynamics and acoustics in the first semester. Mechanics makes its belated appearance in the fifth semester, garnished with rockets and satellites and the floatation – or otherwise – of ships. This is well after electromagnetism and thermodynamics have come and gone. Relativity and quantum physics – not descriptive but in technical detail – come packaged along with mathematical physics in a single course in the final semester. In addition, there are electives, general courses, and the now ubiquitous ‘soft skills’, the latter no doubt to cater to the world of business.

Not all B Sc courses I looked at were this bizarre, but most seemed unrealistic if we really wanted the majority of students to benefit. The fault is not with choice or credit, which have proved their worth. What needs to be defined is the goal of the changes which the new dispensation enables. Globalization, the knowledge society and vocationalization are the common mantras chanted. The degree should ideally help the student through three decades of life and livelihood in the twenty first century. What we now offer, in contrast, is either inflated disciplinary content, or a package of the current fashions and buzzwords.

We can do better. Given that most jobs – including even research – will have their own in-house training programmes, it seems futile to anticipate and imitate them. Such efforts tend to be ineffective and out of date. It makes much more sense to use this special period in the students’ lives to develop broader capabilities which will stand them in good stead in their multiple possible futures as either employees or entrepreneurs, but always as citizens. It is hard to make anyone future proof when one can only guess what the future holds. This is precisely an argument against narrow training. What we can be surer of is that those who graduate today will need to communicate effectively in speech and writing, think logically, practically and quantitatively, and be aware of the larger picture of what is going on in the country. They will need to cope with and harness the deluge of information, and increasingly, cope with/engage with/revel in the digital world. These are not ‘soft skills’. They are not specific to any discipline, but can be nurtured in the context of a given discipline. For example, one of the courses which is part of a science degree could be a seminar, based on the best writings, documents, or books pertaining to how the science developed and the impact it makes on the world. Such a course would naturally encourage reading, writing and speaking, normally considered the province of literature students. It is also important not to take disciplinary boundaries too seriously. A physicist who is only dimly aware of the periodic table, or evolution and genetics, is missing out on something. Options to take courses in other disciplines, at different levels, should be provided. Many graduates go on to become science teachers in schools. Should we not ask what

background we would like to give the teachers of the next generation?

A science degree offering broader options does not presume higher studies, but does not exclude them either. Many students find that their interest in science, dulled by the grind of the 12th standard, comes alive again during a good undergraduate course. Providing multiple paths through electives, project options, and above all some resources and free time to explore and learn on one’s own, will work for all students – those who decide to go on to higher studies as well as for everyone else. A complete and comprehensive disciplinary syllabus for everyone was always a delusion – it can be replaced by a core which is well assimilated, and many choices beyond that, avoiding the pitfall of trying to be all things to everyone. The one area which would seem worth strengthening is the way science has shaped and will shape the world we live in. A physics graduate who has no idea of how a mobile phone complete with GPS functions is again missing something.

The undergraduate science degree which so many will acquire should recognize an even wider concern. This is the need for science being meaningful to a much larger group than the community of professional scientists – not in technical detail but not superficially either. This was expressed eloquently by Carl Sagan, a major public face of science in the United States in the 1980s. His words from an interview in 1996 – the year he died – ring as true today.

‘We’ve arranged a society based on science and technology, in which nobody understands anything about science and technology. And this combustible mixture of ignorance and power, sooner or later, is going to blow up in our faces. Who is running the science and technology in a democracy if the people don’t know anything about it?’

Note the phrase ‘We’ve arranged’. It can be read narrowly in the context of the United States. But surely it applies to all of us who are parties to the current system of science education and for the state of communication of science to the public in our times

This advocacy of broader, more flexible, less loaded science degrees comes from a writer who worked at research institutes for four decades, and moved only recently to undergraduate teaching. It can be questioned as the zeal of the newly converted. To this the answer is – guilty as charged. The broad scenario being suggested is only the view of an individual. However, it draws heavily on the discussions and experience in the Azim Premji University undergraduate programme that I have been part of for the past three years, for which I must thank my colleagues. It is no panacea and calls for harder work than the status quo, but I feel it deserves wider consideration and trial in some form. Status quo is not an option.

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