Emerging modi operandi in institutions for scientific research

Developing research institutions is a resource intensive process with long gestation times. So it is important for such institutions to have guiding principles that help make those necessary changes, but avoid 'popular' prescriptions that are not prudent. Here I layout four common pitfalls that I think are appearing in modern scientific research.

Science without the Scientist: Seeking the palpable instead of germinating scientific competency

One of the more important quests in science is in understanding ‘the’ method involved in scientific discoveries and inventions, if indeed one exists. Relevant to this quest is the veracity of the proposition that a scientist like Einstein or Gauss can indeed be replaced by an army of mediocre scientists (like the author). This also has fundamental relevance to the future of how science is done; can a large computing device replace humans (and their critical role) in the quest for knowledge? This question on the role of human intellect in science is briefly introduced below in the next section, but will be largely ignored in this article.

Meanwhile, economics is also throwing up this fallacy that the ‘quantity’ of science produced in an institution is the most important objective, and the ‘quality’ of scientists produced by these institutions is a distant second. This is indicated by the high throughput models of graduate-student-research where the number of graduate students for a faculty is maximized purely as a consideration of economic affordability. Also, disbursing fewer large-but-competitive grants devoted to specific scientific problems is an apparently efficient economic model; and this encourages universities to operate as research laboratories with low cost labor of undergraduate and postdoctoral students. Note that the quality of students produced may have a marginal impact on the perceived reputation of an institution but not a large direct impact on the academic rankings of an institution. The performance of faculty/students is then simply judged by number of papers written and the time taken for the student to graduate, encouraging fragmentation of scientific research. The intellectual, scientific and emotional growth of the students is becoming unimportant, while the knowledge actually gained by humans is increasingly ambiguous in the large highly fragmented scientific vocabulary and its publications. In fact the mantra for top research universities today is to admit only the excellent and graduate even the reasonable, while the reverse would have been admirable. Einstein was sure that his curiosity and intellect would not have survived formal education; one would propose that higher education today is definitely worse both on informality and the scope for serious exploration.

Danger of esoteric science that is neither applied nor unraveling

'Science is built up with facts, as a house is with stones. But a collection of facts is no more a science than a heap of stones is a house.' – Henri Poincare.

Science that is not clearly evident in its wider use or in its theoretical inevitability is a hurdle to progress in knowledge. Science so far has shown that generality and simplicity are strongly correlated, and indeed both simplicity and rigor are necessary conditions for any durable theory/solution. In fact, Feynman, noticing the inevitability of fragmentation in modern science suggested that every generation (~ 30 yrs), considerable efforts should be expended in compressing/generalizing/weeding-out the organization of our scientific knowledge if further progress is to be made. But the current model of research seriously discourages such efforts by laying disproportionate emphasis on the quantity of literature produced. Worse, it rewards further fragmentation, lexicalization and degrading of our scientific output into a muddle of poor signal to noise ratios. One timely example is how Watson, one of the IBM's supercomputing machines can quickly produce prognosis for cancer treatment options better than the best oncologists could, just by its ability to read faster than a human. Consider that by 2020, medical scientific literature is expected to double every 30 days! The significance of well-thought-through scientific reports can not be overstated. From an engineering perspective, imagine the dreadful situation when 'experts' in dozens of fragmented areas would be required to design a product for our household use.

Science that is applied in wider human use can be produced in industries, product-incubating research centers, national laboratories or research universities. Each plays a different role based on the required training, gestation times and immediacy of use of their scientific results. The effective collaboration among them and more importantly, a clear understanding of their strengths and roles should go a long way in the overall efficiency.

Mercenary science for the markets

One need not be an trained economist to see that the real value of a product might not be closely tied to its price, and that this discrepancy takes significant times to fade away even in the most 'free' of the markets. So quantifying science purely based on the products and immediate economic merits is a sure way to degrade the competency of the scientific workforce. Applied science as alluded to in the previous section, is pursued in different types of research entities including industries in some form or the other. Industries employ large manpower on a few research problems to impact a specific product quickly in the immediate future. Firstly, universities have the mandate to cover wide areas of a science in their academic curriculum to cultivate fundamental skills of its students and minimize product-based retraining that may be otherwise required frequently. Naturally, they are designed to pursue scientific problems that are best addressed by a small high-quality scientific workforce over longer gestation times to result in broad impacts. To bridge these goals with that of the industry, and also to account for the fact that readily useable discoveries can be part of the scientific outcomes in universities, product-incubation centers and research parks are common in a modern university today. Further, faculty of universities can be encouraged to spend a part of their efforts in direct collaboration with the industry on projects that may be relatively long-term investment for industry. But note that the nature of research performed in the industries and a university *have* to be quite different for the maximum overall scientific efficiency, both in the long and near terms.

Hence efforts at homogenizing the research outcomes among very different types of research entities, especially making them market-dependent, are regressive tendencies. Even among universities, a diversity of research goals from technology to the fundamental science is extremely important for enduring scientific capacity. For example, in India the Institutes of Technologies (IITs), Institutes of Information Technologies (IIITs), the Institutes of Science Education and Research (IISERs) and the Institute of Science (IISc) should have independent visions based on the strengths and goals of each institution, for the overall scientific efficiency/capacity of the country to be optimal.

Trading off enduring lessons for the trendy

Finally, the process of reviewing performances and learning lessons from other research institutions has to correspond to the time scales involved. For example, a research university can fully bear the fruits of many of its current policies 15-30 years into the future (i.e.) the time taken by the policy to impact a faculty and accumulate the associated rewards till the end of his/her career at the institution. This need not be the case in an industrial design facility where reviews may be required based on impacts on different products. Reputations and accomplishments of research institutions have to be then seen in light of their policies, performance and relevant factors 10-30 years before the actual review, if the right lessons are to be learnt. One should note that just imitating current practices of a reputed research institution does not guarantee the right directions, and can even turn out to be counterproductive.