On Reforming Science Education In Pakistani Universities[1]

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Modern civilization owes its very existence, as well as its continuing progress and prosperity, to the application of modern science -- science which is founded on the principles of mathematics and physics. Not everyone will concede this willingly. Even the educated sometimes appear doubtful because many find scientific disciplines highly abstract and removed from reality, their specialization labyrinthine, and the language of their aficionados impossible to comprehend. But take away the Newtonian Revolution of 3 centuries ago and there would be no machines more complicated than a pair of shears, no electricity, no vehicles except animal-drawn carts, surgeries would be carried out with butcher's knives without anaesthesia, and so forth. You and I would probably be herding goats, growing wheat or corn, and be dead or dying before reaching the age of 40. The fact is that principles of science, creatively applied by individuals of brilliance, have created the world as we know it today.

It is therefore scarcely surprising that the teaching of science is pursued today with greater vigour than ever before in universities and technical institutes of industrialized countries. The very best students often choose the challenge and excitement of the "pure" sciences, whose fundamental agenda is inquiry into the laws of nature, and whose success is a gauge of civilizational progress. Even though this is without regard to application to problems of technological importance, this sort of work is extremely highly regarded in societies that have learned to appreciate knowledge. At a second level, the discoveries of science can be applied to the engineering of, say, DNA materials or the design of high-density semi-conductors. This is the basis of hi-tech industry. Then there are the more traditional type of applied subjects like electronics and computer sciences, aeronautics and ship-building, industrial engineering and systems dynamics, etc. Without these a modern industrial economy cannot be sustained.

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Whether the ultimate purpose be pure or applied, quality is crucial. A person in possession of a good degree in science is expected to thoroughly understand, and to be able to apply, those physical principles learned at lower rungs of the educational ladder. Internalization of principles is essential, memorization futile. Once armed with a solid understanding of the basics, the real work of research can begin. Research requires application of known principles to new situations and problems, thereby generating new knowledge. This knowledge can range from the highly significant to the fairly trivial; each field of specialization has its own criteria for judging good and bad scientific research. The intensity of specialization is such that no scientist today knows more than a small fraction of the work in his or her broad discipline. Nevertheless there is a fundamental commonality -- irrespective of field, the Ph.D. in science should have learned enough of the basics to read the advanced literature, know where the problems of research lie, and to correctly frame and test hypotheses. Simply put, a science Ph.D. is expected to be a scientist!

The key point that makes a scientist valuable is adaptability. An adaptable scientist manages to find a niche in academia, industry, or elsewhere, because of a broad range of interests and knowledge. For example, a recent survey showed that two-thirds of all US Ph.Ds in physics now work in areas removed from the areas in which they did their theses. Several of my former physics colleagues at MIT now work as computer software designers, some teach in schools, others make toys and science-fiction movies. A couple have become world-class geneticists. Fresh Ph.Ds in theoretical physics from leading US universities are eagerly sought as analysts by firms on Wall Street and offered starting salaries at par with, or better than, those offered to MBAs. Why? The reason is that a good scientist brings attitudes of critical reasoning which have applicability in vastly different situations. These habits, learned in one environment, can be equally valuable in another.

Perhaps the reader is by now convinced that I am advocating a strong swing towards producing more science graduates from Pakistani universities, especially in physics and mathematics. If so, she or he has a surprise coming.

The Poverty Of Pakistani Academia

Where stand the sciences in Pakistan today? Any reasonable analysis must look at both the issue of numbers and the question of quality.

Alarm is often expressed at the small numbers of students enrolled in the science departments of Pakistani universities and the number of degrees awarded. Statistics confirm this.

	Physics	Mathematics	Engineering	Chemistry
M. Sc	939	1070	374	1110
M.Phil	66	53	0	74
Ph.D	30	6	0	52

Student enrollment in 1989-90 in all Pakistani universities.
(University Grants Commission statistics)

To provide a relative measure, around 2500 Ph.D degrees are awarded by Indian universities annually in all scientific disciplines combined. The number for Pakistan is fewer than 25. This correctly reflects the substantially lower level of scientific activity in Pakistan and is an important fact. Pakistan comes out poorer relative to neighbouring Iran as well. The total number of students studying in Pakistani universities is around 90,000. By comparison Iran, which has a population half that of Pakistan, has approximately one million[2]. But these numbers contain no hint of the most important problem.

Even if by some miracle it were possible to double or triple all the numbers in the above table, the impact upon scientific research and teaching, or industrial development, would be imperceptible. On the contrary, much like the case of a government printing currency notes to cover a budget deficit, this "miracle" would simply serve to feed academic inflation without adding any real value. It is a simple mathematical fact that if you add together any number of zeros, the result is still zero.

Of course there always have been, and will continue to be, brilliant individuals who have made it in spite of the odds. Did not Abdus Salam survive Government College Lahore and Punjab University to go on and win a Nobel

[2] This, however, includes both undergraduates and graduates. Pakistani students studying at the under-graduate level at degree colleges (not universities) are not included in the figure of 90,000. Nevertheless, it is clear that Iran has a far greater per-capita student population.

Prize in Physics? He did, and there are perhaps a dozen other Pakistanis who have done creditably well as physicists and mathematicians. But those were arguably better times and the rot had not really set in. The overwhelming majority of those who now emerge from Pakistani universities with degrees in mathematics and physics learn nothing; their degrees are trash. In intellectual terms these students would have lost nothing had they never gone to a university.

Is the situation really that bad? Have Pakistan's state-run universities really collapsed into rubble? Or do we have a bad, but still salvageable, situation? My contention is that after decades of sustained mismanagement the universities have reached the point-of-no-return; without radical and painful surgery they shall remain dysfunctional and dead.

Let me now argue my case. A university comprises of faculty, students, administration, and physical infrastructure. Transmission of existing knowledge, creation of new knowledge, and stimulation of analytical and creative powers, is its purpose in broad terms. The faculty is the single-most important determinant of academic quality, and physical infrastructure is relatively the least important. A strong, competent, well-qualified professor can be a tower of strength for a department for a very long time. Conversely, the appointment of even a single mediocre and incompetent person, who later gains tenure, reduces the pressure for intellectual alertness and scrupulousness in the university as a whole. With time that person rises to positions of administrative authority, depressing standards and reducing the importance of merit as a criterion for progress.

Here, then, is the crux of the problem. With one solitary exception[3], no Pakistani university began with a faculty of acceptable quality in the hard sciences. The number of general universities increased from one in 1947 to 14 in 1996. In response to regional pressures, the government established universities with science departments in the provinces. Most were established during the premiership of Zulfiqar Ali Bhutto in agricultural towns where modern scholarship or learning were unknown and even unheard of. Planning was limited to consideration of building design and physical infrastructure.

[3] The physics department at Quaid-e-Azam University started with an excellent initial momentum and produced world-class research in the area of high energy physics, reaching its peak in the late 1960's and early 1970's. Established by Dr. Riazuddin, a student of Prof. Salam, this continues to be the only physics department in the country where research is still done.

The universities established by government decree were insufficiently imagined. Nobody specified what social purpose these universities were supposed to accomplish. Nobody asked what the multitudes who would sally forth with degrees in hand should be capable of doing. Nobody asked how one should select faculty and students so that the future of the institution could be safeguarded. Instead, the tendency was to appoint whoever came along in the vague belief that somehow "things will improve with time". This was a foolish hope because exactly the opposite happened and the system fell into a catastrophic nose-dive.

The consequences are before us. Today there is no academic community in our universities although there are plenty of academic staff associations that will haggle endlessly on allowances and go on strike at the drop of a hat. Instead of academics, there is only a motley collection of individuals who have been dragged willy-nilly into becoming teachers of subjects which they couldn't care less about, and who are at complete liberty to convey their confusion and ignorance to students. In the process they receive full salaries, and keep doing so until they retire. Most teachers never consult a textbook, choosing to dictate from notes they saved from the time when they were students in the same department. Promotions are time-bound and automatic; incompetence is the most minor of sins. Autistic and mildly retarded individuals do no worse than normal people in this "honourable" profession[4].

It is a significant fact that, in contradistinction to laws governing school teachers, there are no laws that prescribe punishment for the incompetence of a university teacher. There does not exist a single example of a university teacher being reprimanded or removed for not knowing his subject. The overwhelming majority of university teachers, many with Ph.D's in mathematics and physics, would probably fail the "A" level examinations in these subjects. "A" level questions, which are expected to be solved by 17-18 year olds, are conceptual in nature and therefore pose serious difficulties to those used to a system based upon rote learning. Indeed, graduates from Pakistani universities, including those with Ph.Ds, perform miserably when called to teach at elite schools with examinations administered by the Cambridge or London examination boards.

What of research? In principle, the ability to conduct independent research and present the results in a professional journal is the most important qualification of a university faculty member, and is even more important than his ability to

[4] I would not dare to make such an assertion if I did not have several examples as incontrovertible proof.

communicate with students. The grant of tenure at the world's top-notch universities is almost exclusively based upon research output, measured by the impact that that research has had upon the field.

The publication of original research articles is a requirement[5] for being promoted in Pakistani universities. If so, then how can standards be so atrociously poor?

The problem here is the wholesale prevalence of academic fraud, manifest in a large variety of forms. It is not my purpose here to describe this in full gory detail, but enough needs to be said to make the point convincingly. First, there are locally produced science journals where the editor will publish gibberish, either to oblige a friend or for payment, without batting an eye. Often the "journal" will comprise of no more than half a dozen issues before it ceases publication and goes into oblivion, but this may be enough for the contributors and editor to chalk up enough publications for their promotions. Fraud in international journals is done differently: one may choose journals of little repute (mostly Indian and Polish), resubmit one's previous work in some slightly altered form, cook up data without having performed any experiment, hide negative results but state positive ones, plagiarize the work of others and quote without reference, and so on.

How prevalent is academic fraud? Nobody can really know, but even "well-reputed" Pakistani scientists have been caught red-handed by the international community. It has had no effect whatsoever upon their status in the country. Society at large does not understand the fine points, and there is no real academic community in this country that cares. So academic fraud is not thought of as really wrong; it's just life.

While my comments regarding incompetence, lethargy, and academic fraud apply to the bulk of the university teaching community, let me stress that there are still vibrant individual exceptions to be found. If I was to hazard a guess, there are, spread over all of Pakistan's universities, about two dozen individuals who can rightfully be called physicists and mathematicians by virtue of possessing an

[5] At Quaid-e-Azam University, the required number of publications in international journals for the posts of lecturer, assistant professor, associate professor, and full professor are, respectively, zero, zero, 5, and 8. The minimum number of teaching years needed are zero,3,10, and 15 respectively. Other universities have similar requirements but do not require publication in international journals.

adequate understanding of the basics. Small as our blessings are, they have not totally vanished.

Is There A Way Out?

Desperate situations call for desperate remedies, but even desperate remedies may not work in desperate situations. It may well be the case that decades of misplanning and mismanagement of universities have by now created a situation impossible to reverse by any means. In other words, try what you might, but the state-run and owned universities of Pakistan are doomed to remain forever what they are today -- hollow pretences at being institutions of higher learning. Certainly, no Pakistani government has any plans or programmes for reforming the nation's universities[6].

What will it take to make meaningful, substantial, reform? Here is a possible route:

- Recommendation I: *Keep at most one university in every province as a general university offering the usual variety of academic subjects. Upgrade and improve it by infusing large amounts of resources, financial and intellectual. Convert all the other existing universities into "special universities", which would actually mean modern technical training institutes offering programmes of study and courses with direct economic utility. Disband dysfunctional departments.*

The reasons for the above are two-fold. First, as I have emphasized at great length in the previous section, there is simply not enough competent man-power available in Pakistan to teach the sciences at the university level. This is not a temporary difficulty and cannot be fixed by fixing salaries at a higher level or by any other means. The small pool of competent science faculty needs to be concentrated, not diffused. A similar argument can be made for students: the poor quality of incoming students, which is a consequence of quality breakdown at the pre-

[6] The Pakistan government commissioned a World Bank Mission in 1989 to produce a report on higher education reform. While the report was a reasonably comprehensive survey of the problems, it was fundamentally flawed by lack of insider knowledge. Recommendations for action were ill-thought out and, in some cases, self-contradictory. This costly report was shelved as a result of a sudden shift of donor priorities away from higher education towards primary education.

university level, means that the pool of students who can meaningfully take advantage of a high level of instruction is very small.

The second reason is equally, if not more, compelling. Pakistan's economy is severely skill starved. This is evident, for example, from the composition of Pakistani labour in the Middle East. This has increasingly shifted towards the unskilled and semi-skilled; the high-paying skilled jobs have long been taken over by Indians, Filipinos, Malaysians, and others. Industries find it difficult to find skilled persons, and the lack of a well-disciplined and skilled labour force is the principal reason why the multinationals choose other countries in Asia over Pakistan for manufacturing.

Skill starvation is evident in every sector but is particularly glaring in the technical trades -- operation and maintenance of industrial and domestic electronic equipment, computer repair and programming, industrial process and quality control, operation and maintenance of medical and laboratory equipment, refrigeration and airconditioning, precision machining and metal-working, the technology of plastics and special materials, construction of molds and dies, and a host of other areas.

To convert Pakistan's defunct universities into centres of instruction in these trades is far better than to keep breeding generation after generation of parrots who know only how to reproduce mathematical formulae but not how to use them. Individuals are likely to find fulfillment in acquiring real skills which they may successfully barter for a decent wage. At the same time, one will have kept open the doors to higher education -- in the four (or fewer) real universities there would a real chance for the meaningful pursuit of the higher forms of knowledge.

How can such a conversion be successfully organized? Where will the man-power for teaching technical courses come from? Where are the resources to be derived from? This brings me to the remaining recommendations.

- Recommendation II. *The present system of life-long tenure for every university teacher and administrative employee must be terminated. Instead, there must be only 3-5 year contract appointments which should be renewed only after thorough scrutiny of performance. A sizable fraction of the present teaching community, which does not meet minimum quality requirements, should be*

given the golden handshake and asked to move on, as is the practice when a state-owned enterprise is closed down or divested.

Wil this not cause an explosion of resentment in the university teaching community? Of course it will provoke anger and vituperation. But then surgery is sometimes a painful necessity, and it is necessary to remove dysfunctional organs lest they poison the other parts of the body. The people of Pakistan, who ultimately shoulder the burden of all state expenditures, have no obligation to put incompetent and the lazy professors on a permanent dole. They are not bound to support in perpetuity those who receive salary cheques whether they work or not, and those for whom a government job is nice additional income while they pursue their private business. There is simply no moral basis for indefinitely supporting indolence and incompetence; the cost is ultimately born by the taxpayer, or passed on in the form of international debt to generations yet unborn.

Assuming that the terms of service can be redrawn as suggested above, how would one separate the competent from the incompetent? This is a non-trivial issue. On the one hand, most university professors do not have the level of competence in their subjects necessary to make an informed judgement. On the other hand, even if this were not true, impartial assessment by colleagues is next to impossible because of linguistic, sectarian, and personal factors. However, alternatives do exist.

One possible, automatic, way of assessing basic competence is to require that all university teachers, full professors included, take the GRE subject test in their respective disciplines before the renewal of their contracts, and obtain marks above a certain minimum. If a teacher has kept contact with his subject, he or she should have no difficulty doing well[7].

While GRE type examinations are probably a good device to keep mainstream university teachers alert, they are not necessary for teachers of the technical programmes mentioned earlier. Less abstract and more down-to-earth subjects are less intellectually demanding and require fewer years of teaching. Without doubt, the number of individuals who can teach them competently is many times greater

[7] The GRE, or Graduate Record Examination, is a test of international standing which measures understanding of basic subject principles at the US undergraduate (Pakistani M.Sc) level. It is used by many US universities to select candidates for admission into their Ph.D programs, and Pakistan's ministry of science and technology uses it as a criterion for selecting students for overseas scholarships. Because the GREs test real learning in a science subject rather than memorization ability, they are excellent means for enforcing quality standards.

than for the hard sciences, whose proper instruction requires conditions almost unavailable in Pakistan.

- Recommendation III. *Student selection to government universities and vocational institutes be strictly made on the basis of an admissions test. All quotas of every sort and form should be dispensed with. Higher education should be subsidized but not be entirely free. A sufficient number of scholarships should be made available for exceptional students.*

  In a society that still functions in a partly tribal and feudal mode, selection on the basis of merit raises hackles in many parts of Pakistani society. The Government of Sind, for example, fearing that rural Sindhis will be put at a disadvantage relative to urban Karachiites, refuses to recognize the legitimacy of the National Examination Testing Service (NETS) as an instrument for deciding admissions to professional colleges and universities. In the NWFP, recent student demonstrations organized by the Jamaat-i-Islami demanded scrapping of a proposed admissions test for university admission, arguing that students from tribal areas would suffer a disadvantage if they had to compete against students from urban areas.

  Today there are no entrance tests to any government university or college, including Pakistan's so-called premier university in Islamabad, Quaid-e-Azam University. Entrance tests were scrapped in 1990 after the erstwhile vice-chancellor decided that they caused politicization in the student community. An attempt to revive them 5 years later failed, largely because university teachers felt disinclined to put in extra effort, and because of the deep mutual mistrust of each others' integrity. Therefore admissions are today made on the basis of marks obtained at the lower levels of the educational ladder in spite of the clear recognition that many marks sheets are faked, unfair means are regularly employed by prospective students, and the integrity of examinations is highly suspect.

Conclusion and Summary

Orphans of a state which thoughtlessly fathered them, victims of poor governance and bureaucratic intrigue, distrusted and disrespected by the society in which they are imbedded, Pakistan's state universities have been abandoned as

unsalvageable. No government in the last decade has come up even with a token plan to fix them. Only the facade of education remains; the universities are mere outlets for distribution of paper degrees. They contain no community of academics, although here and there an honest academic has managed to survive in some quiet corner. The intellectual discourse in society, including seminars and conferences, does not take place on campus but in city hotels or other public places. While national newspapers and journals remain full of vigour as instruments of debate and discussion, the campuses are silent but for the crackling of automatic weapons. Universities are the prime breeding grounds for various forms of social pestilence, ethnic and religious. Ominous trends are increasingly visible that the sole major asset owned by the public universities, land, will soon be lost to powerful interest groups[8]. Sickness is evident all around.

Bitter pills will have to be swallowed if the system is to be ever reformed. We shall have to give up the pretence that every subject, particularly the hard sciences, can be taught in every university; this implies a reduction in the number of general universities. We shall have to recognize that Pakistan is severely impoverished in technical skills; this demands a partial conversion of universities to vocational institutes with modern facilities. We shall have to disband a parasitic system where everyone is having a free lunch today; this means the discontinuation of automatic tenure and the introduction of a strongly merit oriented contract system for teachers. And, finally, we shall have to recognize that higher education is not a birthright but a privilege; this implies strict selection of students by admission tests and an appropriate level of user fees.

Will it ever happen? It is unlikely that the reform of education, particularly higher education, can occur without a deep restructuring of other social institutions. In particular, the voracious appetite of the military for social resources will have to be curbed if positive change is to be achieved. No such transformation is presently evident. Therefore one scenario is that the present state of misery will drag on indefinitely, or perhaps until the state becomes bankrupt and ungovernable (as in Somalia) and all its institutions collapse with a whimper. But, more optimistically, perhaps we shall collectively come to realize the futility of the

[8] I am referring here to the Quaid-e-Azam University land sale to teachers and employees of the university who manipulated the government into allowing them to purchase prime university land for a song. Since there is no limit to the amount of land which will be turned over for private profit-making, the future expansion of the University and its academic character stand to be compromised.

present system and decide to make a conscious break with the past. Only the future will tell.