**Paper No. 101**

# TRAINING NEEDS OF ENGINEERING PROFESSION

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*The existing pattern of training of engineers is a very old one and does not produce engineers who are immediately useful to the modern society. Owing to very fast advancement in science and technology, an Engineer in the field remains ignorant of the latest developments. The student entering Engineering College/ Polytechnics seeks admission because some one in the family thinks that he should become an engineer. The author has come up with the system that will discourage all such students who have no flair for engineering, from getting into these institutions. His proposals will also enable engineers and technologists to measure up to the expectations of the industries. He has stressed upon the need of Engineers Academy for initiation of young engineers into the profession, for conducting post-graduate research, for conducting research on problems being faced by the engineers on the projects, for solution of difficulties met by practising engineers and for frequent retraining of practising engineers to up-date their knowledge. This Academy will also enable engineers to acquire new skills within their own line and outside. The author believes that these measures are very much necessary if the country is to prosper. Last, but not the least, he has pleaded for proper recognition of engineers' services by the society and the Government.*

The existing pattern of training of engineers in this country is a very old one and runs almost parallel to that followed in the traditional institutions of learning wherein Literature, Logic, and Law were taught as subjects. While polemics suit the study of Law and Logic, only assiduous experimentation and perfection of technique can make a good engineer who is a happy blend of a scientist, an artist and a craftsman ! While the problem of engineering education in particular and that of training of middle level engineering manpower and of vocational level workers in general has changed radically in the countries from which we originally learnt engineering, the old discarded system continues in this country. The obvious result is that our Graduates, Diploma-holders and Certificate-holders from various Engineering and Technical Institutions have become a burden rather than help to a society which is badly starved of the most needed technical manpower. The social values have a greater respect for the Choudhry who wears a clean shirt and sits on high pedestal ordering

people about and living on the spoils of their toils! The example set by the old Indian Civil Service is still being followed as a model by those who get into service. These attitudes need to be corrected immediately if the people of Pakistan are to progress in this age of science and technology that has successfully transported man and his wares to the moon and beyond! If the society is to get rid of Mohenjodaro model of bullock carts and the rickety groaning persian-wheel (which spills more water into the well than delivering it) and the single blade plough driven by two fat voracious bullocks, the engineers and technologists must be trained in a fashion that will enable them to suit the crying needs of the country.

In Russia any one who wants to be an engineer has to work as a labourer or an apprentice to a mechanic or an artisan for nearly two years before he can join any Engineering Institution. The course at the Engineering College/ Institution is not continuous one as practical on-the-job working is sandwiched in between. After an year or two of training at the institute, one has got to go to the field for a year or so and come back to the school for a year and come out again and so on till every one of the students combines within himself the qualities of an artisan, a craftsman, a designer, a planner and an artist. The normal Bachelor's degree is granted to people who are in early thirties or so. Such a system of education is ideal for professional people like engineers and doctors. But only countries like Russia can follow such a system with rigid methodical approach it demands. Russian doctors are trained exactly on similar lines.

The system of training in West Germany is perhaps the best suited to Pakistan. In that country, one who wants to be an engineer has to work for two to three years in an industry or an engineer's office or in a workshop or on an engineering project and after the completion of two to three years of practical on-the-job training in one or more crafts he has to appear before an examining body, jointly constituted by the Chambers of Commerce, Industries and the Education Department, to obtain a certificate of having successfully completed an apprenticeship programme. Only the holders of such certificates are entitled to enter "Ingenieur Schule" in which school, a four year practical-cum-theoretical programme of studies extending to over ten hours a day is followed. No laboratory attendants, no workshop mistries, no firemen for boilers, no linemen or switch operators; not even workshop coolies or sweepers are to be seen in these schools. The workshops are maintained cleaned, dusted and polished by students themselves. Various models for demonstration and experiments, experiment-kits and a good lot of hand-tools are produced by the students themselves. In the city of Bremen, the 'Ingenieur Schule' does not take any power from outside—its huge power-complex is entirely operated

and maintained by the students. Modern steam turbine-driven generators hum all the 24 hours a day and the students under the watchful eye of the teachers attend to power generation in 8-hour shifts. Different types of fuels are used in different seasons and careful scientific analyses of fuels and their performances are carried on. The high tension laboratory of the school would bring to shame the much famed high tension laboratory of the Lahore Government College Physics Department.

For the engineer to be, what is expected of him, he has to be trained the hard way and of course once he is trained he is to be paid well and given a position in society which his training and hard work demands.

More than 70 per cent of the German engineers have to go through this mill. The higher echelons of engineering are manned by university graduates known as "Diplome Ingenieurs". These men are selected from the topmost students who undergo a thirteen years' course of schooling leading to "Abitur". They are the products of the gymnasium schools where they get grounded into gymnastics of higher mathematics, physics and chemistry. Their training at the engineering college is very rigorous and every student has to produce some thing real that matches with the most modern machines or tools or designs produced by the industries. New inventions, new designs and new approaches are developed in the laboratories of these universities and adopted by the industries in the field. These Diplome Ingenieurs are taken by the Industries as well as by the Government in positions that demand great mental skill and are put on applied research design and guidance of major schemes. During their working with the government or with the industries, they are regularly sent out for field training as well as academic training at the university to bring their knowledge up-to-date. No doubt Germany's progress in technology from the smashing defeat of World War II is a testimony to the perfect system of technical training in that country. Of course devotion to duty, their approach to technology and appreciation of the role of the technologist all go hand in hand; but the major credit goes to training itself ! German technology today is leading the world and had it not followed a realistic system of training of its engineers and technologists, Germany could have never come again on the world's map of engineering and technology.

Similar system of training of engineers is reported to be current in Japan. Since the writer of this note has had no chance of studying it in Japan itself, no further mention of the system is made here.

With this introduction to the subject of training of engineers, technologists and vocational workers, a system suitable to needs of this country is outlined very briefly in the following paragraphs.

The training of Engineers should start early in life. At the high school, those who take up Industrial Arts (Smithy, Carpentry, Electricity, Lathe Turning etc.) and pass their matriculation with Physics, Chemistry, Mathematics and Drawing should be given the first preference for admission to Polytechnics. But none should be admitted to a polytechnic unless he has apprenticed himself for 2 years in a recognized trade under recognised workshops, construction firms, construction departments, Government, semi-Government and private institutions. For this purpose the apprenticeship ordinance needs to be rewritten. A subsistence allowance must be paid to these apprentices. At the end of 2-year appranticeship the apprentices should appear before a Joint Board of Examiners set up by Industries and Government and only those who pass the test should become eligible for admission to Polytechnics. The marks obtained at Matric Examination and the score as an apprentice be added up for determining the eligibility for admission and NOTHING ELSE. Those who fail to get admitted to Polyetchnics will easily be absorbed by industries as skilled workers and the law should prohibit recruitment of unapprenticed and untrained people without a certificate in any industry as a skilled worker. These arrangements will ensure that :—

(*i*) only those who have flair for manual work and do not look down on manual workers as "Kameens" will apprentice themselves for a trade for a period of two years.

(*ii*) The Polytechnics will admit people who are already well-versed with elementary workshop practices and therefore the polytechnics will be able to train them in specificated workshop practices.

(*iii*) The rush for admission in the Polytechnics will get reduced because of lily-handed persons will get eliminated during the apprenticeship.

(*iv*) The nation will have much better trained and educated skilled workers for its industries as against illiterate and ill-trained workers (those will be the left-overs after the admissions to the Polytechnics are over, but they will have no regrets because they will find jobs.

At the Polytechnics more emphasis should be placed on manipulation of machinery and equipment and theoretical knowledge should be limited to understanding of mechanisms and no attempt should be made in teaching designs and other things involving mathematical and scientific calculations that go into finalisation of a design or a scheme. The idea being that this set of workers should be fully geared to production without bothering about designs, calculations and experimentations.

At the end of the training at the Polytechnics, every student should be

given a comprehensive test based on the entire learning and he must produce with his own hands with the help of any books or journals that he may like to consult something tangible and for this he may be given a period of two to three days or a week depending upon the job to be produced. The test must recall the use of knowledge and skills imparted to the candidates right from the beginning to the end of his training. Any candidate failing in this final comprehensive test should be asked to repeat no matter how his score is otherwise. It is sincerely believed that if the steps outlined are implemented, the Polytechnic Diploma-holders will be very well-received everywhere and will also not find it difficult to set up their own small manufactories. The intake to the Polytechnics in different branches must be regulated every third year if not every year in accordance with the needs of the country. At present we havs a surfeit of Civil Engineering Diploma-holders, while their need is the least. We need Leather Technologists, Chemical Technologists, Rubber Technologists, and Petro-chemical Technologists but none are available. The whole system of Polytechnic education must be alive to the needs of the country and geared closely to the same.

For those who want to acquire Degree in Engineering they should follow the same curriculum at the school as has been proposed for Polytechnic students. After Matriculation they should join the University for two years' special course which should rigorously train them in Higher Mathematics, Applied Mathematics, Physics, Chemistry and Elementary Biology. In addition to laboratory work in Science, they must also perform experiments in Applied Mechanics so as to understand the combined use of Physics & Mathematics in day to day life and thereby see the wisdom behind teaching these scientific subjects for preparing them to be Engineers of the future. The admission to the Engineering Colleges/Universities should be based on combined performance at Matriculation and at Intermediate Science examinations and nothing else. At the Engineering College the first two years of training must be common for everybody. During these two years Applied Chemistry, Applied Physics, Engineering Mathematics, Applied Mechanics, Engineering Materials, Elementary Hydraulics, Elementary Aero-dynamics, Machine Drawing, Elementary Electric Engines, Elementary Thermo-Dynamics etc. must be taught with emphasis on laboratory and workshop practice based on classroom lectures. At this time very little emphasis is placed on laboratory and workshop practice (the writer has seen a large number of machines and engines covered with plastic sheets after painting and polishing, nicely painted boilers, neatly installed electrical machines, all kept in the labs and workshops as museum pieces and worked once in a blue-moon when the teacher feels need for some manual exercise. Any student failing in laboratory and workshop examina-

tion must be declared to have failed howsoever high his score in the papers be. The next year, that is the third year, should see the students grouped into various specialities which they follow for a Degree in that branch. At the successful completion of a four years programme (the last two years must also expose them to a rigorous laboratory and workshop routines and insist on successful completion of these courses as before) they should only be granted Interim Certificates of having studied up to the Degree level. Before this certificate is granted, a comprehensive Examination covering all that has been learnt must be taken by every candidate. In this comprehensive test, complete designs, models, drawings etc. must be produced. Failure in this test will delay the award of certificate till this test is successfully cleared.

These Engineers should then go into industries and Government service and should remain Apprentice Engineers for a period of two years. During this period of two years they must be trained in professional ethics, learn the business of preparing projects, tenders, specifications, estimates and the like. Be exposed to Public Administration, Accounts, Financial and Budgetary Practices. For this on-the-job and in-the-office training an academy for Engineers is very necessary. The following schedule is proposed :—

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| At General Services Academy | (*i*) 3 months in General Administration, Law and Service matters. |
| At Finance Services Academy | (*ii*) 3 months in Finance and Budget practices. |
| At the Engineers Academy | (*iii*) 6 months in Engineering Practice, specification, designs, estimates, contracts, accounts, fiscal-legal matters and professional ethics. |
| | (*iv*) 6 months on the projects in the field. |
| | (*v*) 6 months in Research Laboratory backing the field operations. |

At the end of 2 years of this practical and professional training a Professional Examination be conducted. On successful completion of this examination, the Degree be formally awarded. What is suggested here is nothing new. In the U.S.A. only a Registered Professional Engineer is entitled to sign any project papers, designs, drawings or specifications. The practical, written and oral examination is conducted by a Government appointed Board only those who clear it are Registered as Professional Engineers—no degrees alone are helpful. The U.S. has long since opened an Academy for Engineers. At the Academy proposed in this country the training and initiation of new Engineers, in-service training of working Engineers, retraining of Engineers of different categories to suit new needs, post-graduate research and research on national

problems like Waterlogging, Salinity, Flood Control, Cyclone Warning and Cyclonic Flood Control, Arid Land Reclamation and the like should receive the attention of all the best brains pooled in one place. We have a National Health Laboratory, an Atomic Energy Commission, Scientific Research Council and a C.S.P. Academy, a Fincance Services Academy, a Police Academy, a National Statistical Office, National Staff Colleges for defence forces and for Administrators, a National Post-Graduate School of Medicine and while 80% of our expenditure goes to development, while a bulk of our National income goes to foreign Engineering Consultants ! While we want to banish poverty by higher production, we want to save the fertile lands from ravages of salinity, waterlogging, flooding and tidal bores, we are yet not thinking on National lines for a National Academy for Engineers. It is time we began not only thinking about it but about giving it a shape if :

(*i*) Poverty is to be banished.
(*ii*) Agriculture is to flourish.
(*iii*) Production is to go up.
(*iv*) Tidal Bores are to be stopped.
(*v*) Heavy Industries are to be established.
(*vi*) The country is to be self-sufficient in military hard-ware.
(*vii*) The transport needs are to be met with Planes/ships/vehicles produced within the country.
(*viii*) Dependence on foreign consultants and technologists is to be minimized.

Similar initiation into the profession is proposed for diploma-holders. But the period should be one year. During this period they should be put on the actual jobs for 80% of time and 20% of time be devoted to class-room lectures and Engineering offices.

Scientific and technical knowledge is increasing at a very fast pace and more than duplicates itself in a decade. Our engineers and technologists are never sent to schools once they get into a service. Like all developed nations the engineers and technologists and also the scientists must go back to school after every 5 years or so to catch up with the uptodate knowledge in the respective fields. This is very much more important in developing countries that are presently trying to bridge the gaps of centuries in years. Graduates of 1946 know nothing about prestressed concrete, plastic design, ultimate load design, satellite communications, space travel, rocketry, colour television, bio-engineering, solid-state, physics, atomic reactors, desalinization of water, electronic control of processes, non-destructive testing, mechanised construction and many other such fields of engineering and technology that have become

so common today. Very naturally, the graduates of 1946 find themselves in a very embarrassing position to-day. But neither the universities nor the Government have provided them means to up-date their knowledge. The Engineers Academy which has been proposed will surely help these active and very experienced engineers to catch up with the latest knowledge and techniques and thereby enable them to prove to be as useful as they are expected to be. This Academy should be opened to engineers in Government services, in private services and to engineers working on their own or for industries. Government departments and Professional Engineers' Bodies should all contribute their share in the shape of money, lectures, equipment and in any other possible way. This is a national problem and should be tackled at the highest possible level.

This brief paper has been kept purposely brief so as to be quickly readable and it is hoped that whatever has been proposed will appeal not only to the engineers but to all administrators and well-meaning citizens of Pakistan who want to see the country prosperous, happy, strong, healthy and self-sufficient.