The Place of Workshop Practice in Engineering Education

By

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I begin with the proposition that workshop practice is of fundamental importance in engineering education in Pakistan. By "workshop practice" I mean the proper performance of tasks which involve the use of both hand and machine tools, and under conditions which are similar to those we should expect to find in a well managed factory.

Along with engineering drawing, this subject provides the student with the opportunity of using his own hands and personal skills, and it is therefore, an important psychological relief in a programme which consists mainly of listening to lectures, taking notes, solving problems of a mathematical character, and performing routine laboratory experiments.

In the United Kingdom, workshop practice is not included in courses of undergraduate study. It is true that all of our many Universities, and all our Colleges which prepare men for engineering degrees, have extensive and well-equipped workshops. But these workshops are not used for workshop practice; they are used for research projects and for experimental work which is mainly concerned with the metal cutting process, with the effects of that process upon materials, and with the forces which are involved in that process. In no undergraduate course with which I am familiar is the student expected to do carpentry or to learn the elements of house wiring. The workshops are, in fact, laboratories in which the student learns the science rather than the techniques of production.

Workshop practice does, however, form a part of the curriculum of our City and Guilds Courses which are concerned mainly with giving

further education to artisans. These courses are of great variety, covering a wide range of subjects like Instrumentation, Machine Shop Engineering, Foundry Work, Gas Fitting, Carpentry and so on. It is generally admitted both at home and abroad that a man who has gone through one of these courses to the final stage is a craftsman of very high order. Workshop practice also forms an important part of our courses which prepare students for the National and Higher National Certificates in Mechanical and Production Engineering. These courses are concerned with the training of technicians, and like the City and Guilds Courses are generally conducted upon a part time basis,—the student serving a regular period of apprenticeship in industry and getting release from his work on one or more days in the week to attend a Technical College.

Moreover, all our secondary schools, through which every student passes, have some form of handicraft training, which generally includes carpentry and metal work.

In British Education, therefore, the emphasis is placed upon purpose; artisans get much workshop practice, technicians get a highly specialised form of it, whilst applied scientists get none as a regular part of their studies.

I must now add that almost all our graduate engineers do get a a great deal of workshop practice outside their normal courses. As undergraduates they are encouraged to go to work during their long vacations and industry is willing to provide places, *with pay*, for such people. After graduation they are given systematic training before they finally go to their assignments. At Rolls-Royce Ltd., where I worked previously, we used to recruit about fifty graduates every year, and we gave these men two full years of hard training before we expected anything out of them in return for their salaries. Part of this training consisted of from six to nine months of workshop practice in our Training Department—a minimum of 26 weeks of 40 hours of continuous work—a total of 1040 hours. Similar training schemes are in operation everywhere in the United Kingdom and competition is keen both to recruit Graduates and in providing them with training facilities. I may mention in this connection that the average cost of providing such training is in the region of £2,500 per graduate and British industry could not afford to spend this money unless it yielded a dividend.

In this country the same degree of stratification of training facilities, with educational authorities and industry playing their own but completely

integrated parts has yet to be fully developed. As a result, the Engineering Colleges are not only preparing young men for a degree in one of the branches of engineering, but they are being compelled to do some of the work which ought to be done by Technical Colleges. This is partly because the only qualification which has real recognition in the country is a University Degree, and partly because the Government Departments and Industry alike expect the Colleges to undertake work which is more technological in character than it is scientific. The complaint is often made by Government Departments, by Industry and by the Public Service Commission that our young mechanical engineers know nothing of the practical side of their jobs. They are expected to know everything about internal combustion engines, machinery in general, how to run machine shops, to supervise heat treatment procedures, and so on, when all the time their only knowledge of these things is based upon chalk and talk. Until this year the time spent by an under graduate mechanical engineer in actual workshop practice at the Government College of Engineering and Technology, Lahore was 168 hours, and out of this time only 98 hours was devoted to mechanical subjects. This year the time has been increased, and from now on students in this department will get a total of 308 workshop hours with a further 84 of Mechanical Technology. This is an improvement, but no one in his senses will pretend that we can teach everything in approximately 400 hours. I hope that the time is not too far distant when all our Mechanical students will get, in addition, at least two months of continuous work under industrial hours and conditions. Even then they will still need systematic training by industry before they can earn their keep.

Moreover, in this country, the average student arrives at the engineering college with an almost complete mental vacuum as far as machines are concerned. He is the product of a land which is predominantly agricultural in character ; the product of an educational system which lays greater emphasis upon passing examinations than it does upon stirring a healthy curiosity ; and the product of a social heritage which discourages him from getting his hands dirty. Only very rarely do we get a boy who has seen inside an internal combustion engine, still more rarely do we get one who has taken one to pieces with his own hands. If the student's bicycle goes wrong he will take it to the cyclewala rather than attempt to repair it himself ; he is completely bafflled by screw thread systems, by gearboxes and clutches. None of these things are the fault of the student : society has produced him in this way, and his lack of mechanical knowledge is a handicap which he has to overcome. Every teacher of machine drawing in this country is faced with this problem, and will testify that his

difficulty does not lie in teaching the student how to draw, but in getting him to understand what he is drawing. Many students who have "designed" a machine part are completely astonished when they see the actual part itself.

Here, then, are two perfectly valid reasons why the subject of workshop practice should be taught in an undergraduate college. First, it helps to fill up the content of mechanical knowledge ; second because for many years the services of the students will be utilised in jobs where practical "know how" is essential.

There is however, a further reason and I regard this as being sufficiently important to warrant a special paragraph to itself. Workshop practice, again in common with machine drawing, is a subject which plays an important part in the development of personal characteristics. It encourages patient industry ; it helps to develop painstaking care ; it teaches responsibility for materials, machines and tools ; it can be made to foster a love of accuracy for its own sake, and a fine sense of judgment in distinguishing between work which is good and work which is bad ; it helps the student to stand back and view his own work with critical objectivity; it helps to stir the creative ability and gives the student a sense of personal pride in his own achievement when he sees ideas which have only been expressed on paper become realities in fact ; finally, it helps to stimulate a real regard for the dignity of labour, and promotes confidence in his own competence. I believe that all these things are good for young men to learn and to know, and I believe that they have an important part to play in the upbuilding of national character.

I shall turn now to discuss some of the principles which I believe should underlie our teaching of this subject. Let me say at once that I have no use at all for any system of exercises which does not result in some real thing being produced, however simple that thing may be The finding of square holes and plus to fit, in spite of being done in our British Naval Training Depots and in German Industrial Training Schools, is—to my way of thinking—a classical example of a complete waste of material and time. It presents the trainee with a routine task for which no sensible reason can be given ; it ends in two perfectly useless pieces of material which have only scrap value, and it provides no incentive and interest for the student. From these observations, which I have purposely worded in language calculated to be challenging, I draw the following conclusions :—

(1) Every task must be within the capacity of the student to perform with a reasonable degree of accuracy and within the time allowed. At all times it must be remembered that his elearning and the normal rules of

learning apply. With his increase in skill his tasks will obviously increase in complexity, but at each stage the student must be able to meet the challenge with his developing skill.

(2) Each task must result in something which is real. Far better to produce a real simplicity than an elaborate pretence. Use of the finished product must be capable of explanation, and it should preferably be something which the student can use himself either in connection with his work or in his day to day life.

(3) The work must be done from drawings which embody the principles being taguht in the machine drawing classes, and which are similar in character to those which will confront the student when he enters industry. These drawings should, without, exception, contain limits of size to which the student must conform.

(4) The work provided must be related to the student's other work in the College, particularly in his studies of materials, theory of machines, strength of materials, mechanical design and measurement.

(5) The work should be done with tools and equipment which are in good working order, and the methods employed should be similar to those which would be used under conditions of actual production.

(6) Finally the student's work should undergo a critical evaluation which is comparable to industrial inspection, and a policy of no compromise must be adopted so far as dimensional accuracy and finish are concerned.

I now turn to a further and concluding point. In a College where students are being prepared for Civil, Mechanical, Electrical and Mining engineering degrees, should all the workshop practice be the same ? The answer, I belive, can be derived from our work in mechanical drawing and considering this as a parallel case. In this subject we are obliged to begin by teaching everybody how to draw ; we increase the student's knowledge of geometry and teach him how to apply it ; every student learns the principles of projection, and is taught to draw those simple machine elements which are common to all branches of engineering. Once this preliminary work is done, the student branches out into more specialised forms of drawing which belong to the department of his choice. Civil engineers, for example, do Structural Drawing and Design ; Mechanical engineers do more advanced work in mechanism and engines ; Electrical students are concerned with electrical machines, circuits and so on. This is the kind of pattern I would, like to see developing in our teaching of workshop practice. I would, for example, give

Civil Engineers work to do on simple structures, a good deal of joinery, and some brick laying as well. Electrical engineers could strip down generators and motors, diagnose faults, rewind coils, turn up armatures and so on. Similar practical work within their own fields could be provided for mechanical and mining students. The one thing which stands in the way of such developments which might have far reaching effects upon both students and their future jobs, is our painful lack of space, equipment and properly trained teaching personnel. People must be made to realise that in this subject no one can do effective teaching if he has more than 12 students to handle at one time. Beyond this point the teacher's effective span of control is weakened to such an extent that most of his efforts are wasted, and it is this fact more than any thing else which results in poor results.

This paper has been principally concerned with the teaching of workshop practice in the degree conferring colleges of Pakistan. That is because I am engaged in teaching in one of those establishments. I must now close by saying that I think it very necessary that at both the Matriculation and the F. Sc. stages some kind of handicraft training should be introduced This would not only help in developing finer personal characteristics, with a general improvement of skill and discipline, but it would also help in the discovery of special aptitudes. Without such aptitude engineers cannot be effectively trained.