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Co-operative Education—The Indian Experience

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Co-operative education implies co-operation in the education of engineers between engineering institutions and prospective employers, namely industry. Current Indian efforts draw inspiration from western models, and began with the scheme for Practical Training Stipends in 1949; this scheme has undergone several changes since then. Sandwich courses are offered in several Indian polytechnics in the country, and some of these courses have been very successful. The practice school model of structured industry–institution interaction at the degree level has achieved considerable success, when pursued with commitment and monitored through systematic feedback. In addition, several other strategies, not related to these models of co-operative education, are being pursued in the country in order to promote industry–institute interaction.

INTRODUCTION

CO-OPERATIVE education, implying the need for co-operation between industry and engineering institutions, has its roots in the tradition of linking the place of learning to the place of work. This tradition stems from educational practices of collaboration between learning institutions and the wider community that are characteristic of north-west Europe and from an intense emphasis in North America on post-experience professional education. Thus various models have been tried the world over, most notably the manual labour movement, apprenticeships, internships, extension programmes, co-operative education, the practice school system of education, continuing education (all models coming from the USA) and sandwich programmes (developed in the UK). While these and such other models have been implemented in various disciplines other than engineering, namely science or applied science, medicine, agriculture, business studies and accountancy, tourism, languages, law, architecture, forestry, etc., normally the literature talks about the co-operation between education and the community in terms of the co-operation between engineering institutions and industry, and the structured educational models considered in this context are the co-operative or sandwich programmes (which also include the practice school system of education).

CO-OPERATIVE EDUCATION OR SANDWICH PROGRAMMES IN INDIA—THE NATIONAL EFFORTS

While elements of structured co-operative education in the Indian context were observed even during the pre-independence period, when Mahatma Gandhi came forward with the 'Wardha Scheme of Basic Education', which suggested imparting 'education' through 'productive' activity, organized efforts to foster co-operative education had to wait until independence.

However, since Indian independence, when efforts to link the national system of education with industrial and economic development began in earnest, the subject matter of interaction at the undergraduate level as well as at the post-graduate level between the system of technical education and industry has always been uppermost in the minds of the educational policy-makers, planners and administrators. This is amply demonstrated through various recommendations of different committees, councils, commissions and boards, notable among them being the Scientific Manpower Committee (1947), the All-India Council for Technical Education (AICTE), the Committee for Post-graduate Engineering Education and Research (1961), the Education Commission (1966), the High Power Committee of AICTE on Studying Collaboration between Technical Institutions and Industry (1970), the Chandrakant Committee (1971), the ninth report on Higher Technical Education of the Estimates Committee of the Sixth Parliament (1978), and the Report of the Review Committee on Post-Graduate Education and Research in Engineering and Technology (June 1980).

The various forms for close interaction between engineering institutions and industry recommended from time to time were: schemes for Practical Training Stipends (PTS), sandwich courses, practice schools, collaborative post-graduate programmes, industrial consultancy and sponsored research and continuing education. The earliest of

the initiates to be implemented by central government was the PTS scheme (1949–50).

PRACTICAL TRAINING STIPENDS

Chandrakant terms this scheme as 'a system in transition'. Following the recommendations of the Scientific Manpower Committee (1948), the central government instituted this scheme to enable fresh engineering graduates and diploma-holders to undergo training in industry for two years and thus acquire experience for gainful employment. The government's main purpose, however, was to create a pool of well-trained engineering manpower for the country's economic development.

Under the PTS scheme, stipends of Rs. 75 per month for graduates and Rs. 50 per month for diploma-holders were allotted to individual engineering colleges and polytechnics in proportion to student numbers and institutions were made responsible for locating training places, placement of trainees and administering the scheme.

Growth

With time the scheme was reviewed, and it was found that it suffered from institutions not having training and placement officers on their staff with the responsibility for organizing the training programme; as a result, industry response was not satisfactory. Further, good training places were inequitably distributed. Another problem observed was the large dropout from the training programmes.

As a result, central government assumed direct responsibility for the training by administering the scheme through its four regional offices, which also had the task of developing technical education. Further, the PTS scheme was also made an integral part of the national five-year plans. This change from engineering institutions to the regional offices of the Ministry of Education marked the first transition of the training scheme.

The second transition came when in order to meet the logistic demands of the growing scheme the Government of India decided to give the scheme national status. To this end, the government established four autonomous Regional Boards of Apprenticeship in Madras, Bombay, Kanpur and Calcutta, and entrusted the Boards with the responsibility for administering the scheme by transforming the PTS scheme into a national apprenticeship scheme.

This second transition brought about qualitative changes in objectives, methodology and processes of apprenticeship at the organizational level in industry. Specifically, industries set up training centres with separate training staff to supervise the training programme. As a result, engineer and technician apprentices came to view the training period not just as a stop-gap arrangement before employment, but as a serious part of their professional growth. Because of this planned approach the training period was reduced to one year, which was considered adequate duration.

Another, and perhaps more important, outcome was that, as several industrial organizations started selecting for regular employment from among those trainees who had completed such planned training, an increasing realization started, linking apprenticeship with employment.

Throughout this period the Government of India increased the value of the stipends to attract more engineering graduates and diploma-holders. Further, leading industrial establishments also started sharing the cost of the stipends, with some paying up to 50% of stipend cost, while others gave additional amounts over and above the stipend.

In 1973, central government gave a firm legal position to the apprenticeship scheme by amending the Apprenticeship Act 1961, which had been in force for trade or craftsmen apprentices, to include engineering graduates and diploma-holders. The main provisions of the amendment are that it has made it obligatory for industry to give apprenticeship training to engineering graduates and diploma-holders, including students who are studying for a degree/diploma, and, in the process, it requires that at least 50% of the cost of the stipends paid to apprentices shall be borne by the industrial establishment, the other half being met by the Government of India.

This, then, was the third transition, which has now given the otherwise voluntary scheme a statutory position. The entire responsibility for operating the scheme was given to the Directors of Training who have been designated as the Regional Apprenticeship Advisors by the Act. Understandably, this has brought about tremendous systematization in apprentice training.

More specifically, an apprentice is now required to maintain a daily record of the work done related to the training. This record is to be shown periodically to the supervisors/managers in the establishments, to assess an apprentice's progress. To facilitate this the Boards have formulated training guidelines and hold frequent meetings with the industrial organizations to discuss and improve training programmes. The Boards have identified nearly 71 fields of engineering and technology as apprenticeable fields within the above framework.

Feedback

In spite of above structural growth and in spite of giving the scheme for interaction between engineering institutions and industry a statutory power, a review of this scheme reveals many problems. Briefly, enumerated, the apprenticeship scheme has yet to establish itself firmly in the national ethos. The industrial establishments participating in this scheme give a varied support in that while some have set up their own training departments, some others ask their line managers or their own assistants to conduct the training,

while yet another category of establishments just does not believe in training, thereby bringing in the issue of non-uniform training structures of varied quality; in many situations there is no worthwhile training.

Coming to other problems, the literature reports that in spite of the number of training places being as large as 40,000, utilization ranges from only 40 to 65%. Further, training under this scheme, in some situations, is not related to the regular course work, and the quality of the 'examination' of the progress of apprentices, in spite of the records system mentioned earlier, is inadequate.

It is therefore necessary that all these problems should be given due consideration if the PTS scheme is to play its appointed role in the national framework of human resource development.

SANDWICH COURSES

Sandwich courses are operative in India in several polytechnics. These courses are basically aimed towards linking theory and practice by providing the polytechnic student a defined time-slot in the calendar for industrial training. To facilitate this, the diploma curriculum allows alternate periods of institutional studies and industrial training.

Sandwich course structure

Many different structural patterns of achieving the above curricular objectives are practised in India. To begin with, while a 'normal' diploma takes three years, a diploma programme with a sandwich course is of $3\frac{1}{2}$–4 years duration, depending on the type of 'sandwich'. A course is called a 'thick sandwich' if the diploma has a four-year duration and the period of industrial training is a single one-year stretch; similarly, a course is called a 'medium' sandwich if, in a four-year diploma, the industrial training is implemented in two separate semesters, sandwiched appropriately. In other words, the industrial training is not implemented at a stretch.

As pointed out by Chandrakant, in structuring sandwich courses, co-ordination between polytechnic faculty and academic experts is a must. The objective of industrial training is to give the student practical experience in live situations. To facilitate this, the student should get, during his/her industrial training, an opportunity to work on a 'project'-based activity in actual engineering or organizational problem solving.

This understandably calls for proper examination/evaluation of student progress during industrial periods. Written reports by polytechnic faculty and industrial supervisors are one form of student evaluation. Other methods available are oral examinations and continuous evaluation. Finally, all this evaluation should also provide a means of feedback to improve the training programmes and to redefine course objectives in practical terms.

Another important need of sandwich courses is the requirement of organizational set up to ensure: programme design, programme planning, industrial placement of students, student guidance, student evaluation, day-to-day and overall administration, programme monitoring, teacher training and orientation of industrial supervisors, feedback analysis and research, and programme evaluation.

It is within the above framework that the sandwich courses have taken root in India. A study shows that polytechnics conducting these programmes can be broadly divided into three categories:

1. Polytechnics that have sandwich courses in selected disciplines along with conventional diploma programmes in other disciplines.
2. Polytechnics/institutions that are wholly conducting sandwich courses across their disciplines.
3. Single-faculty or specialized institutions in areas such as leather technology, printing technology, which are conducting their specialized courses under a sandwich pattern.

There are about 50 polytechnics in India conducting sandwich courses and they fall under the above three categories. The bulk of them fall under the first category and these are the state-run polytechnics. Next come polytechnics coming in the second category. These polytechnics are mainly run by private organizations interested in promoting technical education and training. Although they receive grant-in-aid from the government, they are autonomous in their management and administration. Some of these polytechnics have also been given academic freedom by their respective State Boards of Technical Education (SBTE). Finally, a still smaller number of specialized institutions make up the third category. These single-faculty, specialized polytechnics have traditionally had close interaction with industry.

The experience

At this stage, in order to have a more concrete understanding of the operation of sandwich courses, it will be helpful to have a brief account of a successfully run sandwich courses in India. Literature reports the sandwich courses of the Shri Bhagubhai Mafatlal Polytechnic, Vile Parle, Bombay in this context. This polytechnic comes under the second category of institutions mentioned above.

Mafatlal Polytechnic right from the beginning decided to implement the sandwich system to cover all its diploma courses and all students. Thus it offers no other type of courses.

Its sandwich courses are designed on a four-year semester pattern comprising six semesters of institutional studies and 52 weeks of industrial training. The industrial training is sandwiched in the sixth and eighth semesters. Choice of this pattern is guided by two important factors: (i) students are better prepared to absorb the benefit of industrial

training in the latter part of the course after the necessary foundation has been laid in the institutional studies; and (ii) purposeful co-ordination can be established between theory and practice when the students are specializing in their respective fields or disciplines, which are provided in the fifth and seventh semesters of the institutional studies.

One of the most important educational steps the polytechnic takes before students go for industrial training is to orient and prepare them for industrial activity and its educational objectives by familiarizing students with the aims and benefits of sandwich courses, requirements of professional development, structure of the training programme, placement procedure in industry, supervision of training discipline, past experience, etc.

This induction is followed by student placement according to students' choice of industrial establishment, merit and industry's selection methods. Following this, the polytechnic undertakes the planning and arranging of student supervision by faculty.

More specifically, in order to ensure achievement of educational objectives during the phase of industrial training, the polytechnic delegates one faculty member to be in charge of a group of 8–10 students while they are undergoing the industrial training. These faculty/academic tutors plan the training programmes of the students under their charge in consultation with the industrial organizations concerned and ensure that the training is conducted as per the objectives of sandwich courses. The day-to-day supervision of the training programme is the responsibility of the supervisor from industry.

Each student is required to prepare a training diary each week giving information on his/ her job assignment. The diary is examined and certified by both industrial supervisors and academic tutors in terms of students' performance, attendance, discipline, keenness and interest in work.

In the last phase of industrial training, a student is normally required to work on a project and prepare a short project report or dissertation, under the guidance of both his/her industrial supervisor and academic tutor.

To facilitate this and to monitor the overall progress of the student and the programme, the faculty members assigned to the student groups visit the students at regular intervals, discuss and resolve their problems, liaise with the training supervisors in industry and report on the overall progress of the training programme.

In addition to this well-designed system of supervision by industry personnel and polytechnic faculty, the programme also has the following scheme of student evaluation on the training:

(a) Attendance and progress reports	50 marks
(b) Quiz test	50 marks
(c) Project report	50 marks
(d) Oral examination based on (a) or (c)	50 marks

This student evaluation is included in the final examination results.

Thus the entire design, planning, operation and implementation of the sandwich course as undertaken by Mafatlal Polytechnic is to ensure that the 'Industrial training and experience' is an integral part of the academic award of the diploma.

Finally, for the overall monitoring and evaluation of the course, Mafatlal Polytechnic provides for informal and formal feedback from the course. Informal feedback is received from visiting faculty members drawn from industrial organizations associated with the sandwich programme and industrial supervisors, and from heads of department, training and placement officers, and deans of the polytechnic. Against this, formal feedback is received from the student responses to a structured questionnaire administered to them at the end of their training programme.

Feedback

Literature reports that the sandwich courses of Mafatlal Polytechnic stand out in their educational achievements. As can be seen, these courses are well conceived and planned, and efficiently implemented and monitored in collaboration with industry.

The salient aspects of their design and implementation that merit specific mention are:

- Holistic view of the need for polytechnic–industry interaction, by requiring that sandwich courses are implemented across the polytechnic disciplines.
- Pedagogic view in the choice of programme structure.
- Involvement of the entire faculty base in programme implementation.
- Curriculum design and planning of sandwich courses in close collaboration with industry.
- Systematic procedures for orientation of students, industrial placement, selection of academic tutors and industrial supervisors.
- Assigning an academic tutor for each group of 8–10 students undergoing industrial training.
- Day-to-day supervision of student progress by industrial supervisors and periodic supervision by academic tutors.
- Academic tutors responsible for student problems and needs and for ensuring student progress and achievement of educational objectives.
- Rigorous evaluation of student performance under industrial training and its incorporation in final results, thereby making the industrial training an integral part of student education.
- Ensuring a proper organizational set-up from within the polytechnic and also from within the collaborating industries.
- Provision of feedback, analysis and evaluation, mechanisms for programme monitoring and improvement.

As a result, students completing this course readily find employment, industry is very happy

with the programme and offers every possible support, and the polytechnic faculty has new avenues for self-development. This positive collaboration with industry, in turn, has had a regenerative effect on the polytechnic in that it has enabled the polytechnic to adopt a more rational method of admissions which consists not merely of the academic, scholastic merit of students, but also aptitude tests.

Perhaps the most important regenerative input for the polytechnic has been that sandwich courses have provided the basis for further curricular reforms and diversification of courses, while also developing a management information system to facilitate better decision making at the institutional level.

However, the same cannot be said of the sandwich courses run by other polytechnics, the bulk of which are state-run polytechnics and come under the first category of polytechnics offering sandwich courses mentioned earlier. Indeed sandwich courses offered by most of these have no features/considerations as mentioned above. Their response to these aspects of sandwich courses has been negligible and such courses are viewed as 'taxing'. They have looked at sandwich courses as merely an add-on to traditional diploma courses, and, thereby, hope to keep both streams alive without any 'extra' effort. Another indicator is that often just one polytechnic faculty member is designated as training and placement officer and assigned to look after the sandwich course in the polytechnic, without the inputs of planning and organizational support that are intrinsic to the success of Mafatlal Polytechnic.

As a result, in spite of the examples of successful implementation of sandwich courses, the state of sandwich courses in India presents a dismal picture, as is evident from the fact that only about 12% of the total number of 500 polytechnics in the country producing 50,000 diploma technicians each year have sandwich courses; the total admission to various sandwich courses is just over 3% of the total enrolment of students in polytechnics.

Studies reveal that a large proportion of industrial organizations find fault mainly with institutions as the latter are not interested in developing and expanding the sandwich system. They also feel that polytechnic faculty have largely remained theoretical and have not developed an academic view of industrial problems. On the other hand, polytechnics complain of lack of adequate and suitable training facilities in industry and industry's preoccupation with its day-to-day problems.

As for the first argument, it is evident that institutions have not made enough efforts to seek facilities as many industrial placements are remaining unutilized. As for the second argument, examples of planning for sandwich courses, as for example, by Mafatlal Polytechnics, go against it. Indeed, when analysed against this totality of programme implementation, as pointed out by Chandrakant, this limited spread of sandwich courses cannot be attributed to lack of industrial training facilities, but to other factors, notably lack of a total approach to programme development as mentioned above; rigid attitudes at various levels and resistance to change; strait-jacketing of polytechnics; inadequate policy formulation and direction; and lack of motivation and leadership within the polytechnics.

PRACTICE SCHOOLS

This structured form of institution–industry interaction at the degree level was first introduced in 1967 by Harcourt Butler Training Institute (HBTI), Kanpur at postgraduate level in the discipline of chemical engineering. However, Birla Institute of Technology and Science (BITS), Pilani perfected this form of co-operative education in India by implementing it at an undergraduate level, i.e. for first degrees of the institute, across the disciplines of engineering, sciences and humanities.

The theory of education

Just as a medico undergoes internship in a teaching hospital before graduation, similarly the practice school system of education requires first degree students of engineering, science and humanities to practise their respective professions during educational years. In concrete terms, the practice school establishes PS stations—analogues of university classrooms-cum-laboratories—in the professional world.

Student education at PS stations is implemented in terms of their involvement in real-life problems of direct interest to host industries. Thus, the practice school pursues a project method of education. However, the attempt here is not to rediscover the past, but to use contemporary day-to-day industrial activities of direct interest to the professional world as a vehicle to prepare students (equipped with science-based understanding of fundamentals and with the latest systems and analytical tools) to participate in interdisciplinary, goal- and mission-oriented and time-bound problem-solving tasks of production, of design and development and of research. In the process, the performance of the students is graded by the institute's off-campus faculty resident at the locales of PS stations. The grades so obtained by students form part of the degree transcript; and on successful completion of the PS programme and other degree requirements, the students receive degrees in their respective disciplines, which includes the phrase 'with Practice School'. Thus, the PS programme constitutes an integral part of the first degree education at the BITS. Needless to say, in view of the committed nature of PS education, the PS degree stream carries greater academic load and takes more time than for the traditional degree programme without PS.

Programme structure

As mentioned earlier, the BITS implements a PS programme across engineering, science and human-

ities disciplines. In a four-year degree structure, the PS has a total duration of $7\frac{1}{2}$ months, comprising two components, namely PS-I, a course of two months implemented during the summer after the second year, and PS-II, a course of $5\frac{1}{2}$ months conducted during either of the semesters of the final year along with a part of the respective adjoining summers. Thus, while PS-I is operative every summer, PS-II is implemented throughout the year.

In specific terms, exposure-oriented PS-I aims at initiating second-year students, well drilled in science-based foundation courses and accompanying analytical skills, in the art of information seeking, retrieval, documentation, processing and analysis. In the process, the students are introduced to the field-based knowledge of topics such as market study and product specification, plant layouts, process flows and P&I diagrams, capacity utilization, inventory management, in-house R&D organization, management structure, MIS, costing, business communication, etc. Normally, PS-I is implemented at large industrial and scientific complexes.

Against this, PS-II provides an opportunity for a student to work on problem-solving efforts of direct interest to host organizations. Indeed, the choice of PS assignments is central to PS education. Particularly, PS-II assignments are so identified that, firstly, each of them necessarily has at least one professional expert from the host organization interested in it and, secondly, the assignments also form, on a continuous as well as a continual basis, sub-problems in the chain of activities constituting the developmental needs of the host organizations. Normally the PS-II assignments thus cover a large spectrum of industrial activity in terms of further accelerating the pace of on-going production tasks; system improvements *vis-à-vis* production efficiency, maintenance, planning and monitoring methods; system design; modernization; computerization and microprocessor applications; techno-economic analysis; technology development; etc.

In view of the committed nature of a PS programme, the procedure of student allotment to different PS stations closely initiates what the best of the employers do while matching the manpower (to be recruited) to the tasks at hand. Specifically for PS-II the Practice School Division (which on behalf of the Institute is in charge of the entire co-operative education at the Institute), through prior interaction with host organizations, keeps alive a problem bank. Simultaneously, well ahead of students attending PS-II stations, the PS Division prepares complete professional profiles of all PS-II probables. These student profiles along with student preferences are then matched against problem bank and its (manpower) needs so as to arrive at the final student allotment.

Ideally speaking, at PS stations, consistent with the nature of PS assignments, students are divided into interdisciplinary groups, each group being allotted from *a priori* identified PS assignment. One of the members from the group is appointed a leader for that particular assignment and is given total responsibility for planning, scheduling, implementing and defending steps to solution. During the process the professional expert(s) interested in the assignment and the practice school faculty play the role of consultants.

The PS educational process seeks to focus attention on many latent attributes which do not surface in normal classroom situations, such as professional judgement, interdisciplinary approach, ability for written and oral presentation, team work, leadership, etc. These attributes are judged by the faculty through various instruments of evaluation, namely quizzes, vivas, seminars, group discussions, project reports, daily observations of student performance and diary. At the end of PS-II course the practise faculty prepare a rating sheet for each student, describing qualitatively the degree to which the above-mentioned personality traits have been demonstrated by him/her in the course. This rating sheet also incorporates an indication of professional activities in which, in the judgement of the PS-II faculty, the student has achieved proficiency.

Organizational systems for practise schools

From the above it becomes clear that, unlike most educational innovations, practice school is not a mere classroom reform, but involves the essentials of triangular, interactive relationships between the student, teacher and work-in-charge, while fulfilling all the requirements of academic rigour and work discipline. To support such an education requires a functional organizational set-up with investigatory and explanatory skills of planning and research.

All this has led to the BITS establishing a Practice School Division with a responsibility to implement the PS programme across the Institute. Headed by the Dean, this Division has six cells, namely organization and co-ordination; planning and development; instruction; accounts and administration; documentation, publications, liaison and welfare cell; and educational study and research. In addition to decentralization of decision-making authority in respect of various functions, the main characteristic of this organizational system is the responsibility entrusted to it in respect of the future needs of the practice school, continuous monitoring and control of operations in progress, and strengthening of interaction with industrial organizations as well as with the other divisions of the Institute.

Feedback

Studies reveal that, since 1973, BITS, Pilani has implemented, through a practice school, a massive off-campus educational organization accommodating yearly over 900 students, 75 faculty members and 90 industries spread over the length and breadth of the country. The feedback emerging in the process is manifold; the salient points are as follows: (i) the PS owes its success to the unprece-

dented enthusiasm of students, commitment of teachers and to the whole-hearted participation and support by host industries. (ii) Professional challenges inherent in PS assignments conducted at industrial workbenches through PS-I/PS-II courses particularly bring forth what is best in the student, giving a tremendous impetus to career growth opportunities, and in turn demonstrating the congruency of PS educational objectives with student aspirations. (iii) The role of off-campus faculty has been central to the success of the PS as it is through PS faculty resident at participating industries that the PS system of education achieves integration of the rigour and routine of university examinations with the task of PS student performance evaluation at the workbench, making PS education integral to degree requirements. (iv) Integrated programme structures constitute an important prior preparation for implementing the PS system of education as it is the integrated programmes which train students in interdisciplinary and analytical skills so as to be able to participate effectively in PS assignments, which (being drawn from industrial workbenches) are invariably multidisciplinary in character. (v) A study of over 5000 PS assignments implemented through the period 1972–85 reveals that PS-II assignments have particularly emerged as a successful mechanism to institutionalize work-oriented involvements by final-year first-degree students in professional tasks of direct interest to host industries, scanning a wide spectrum of problem-solving areas, namely further accelerating the pace of on-going production tasks, systems improvement, system design and development, instrumentation and control, computerization, modernization, energy and waste management, technology development, etc. (vi) Further, over recent years, there are definite trends that even educationally exposure-oriented PS-I assignments are slowly getting integrated with 'technical documentation' type tasks of direct interest to host industries, as defined in terms of activities such as updating the material and heat balance diagrams, P&I diagram update, sample surveys *vis-à-vis* statistical investigations in terms of manufacturing, production, maintenance and management studies, applications software, inventory documentation, studies in capacity utilization, etc. (vii) Thus, it is now confirmed that while the PS system of education, on the one hand, improves the content of education, on the other, it integrates the university educational process with that of national industrial and economic construction. (viii) The validity of the above abstraction is also to be found in the fact that industries participating in PS, particularly those accommodating the PS-II component, invariably offer (on a work-charge basis) monthly out-of-pocket allowance to students as a token of their appreciation of contributions made by PS students towards the work needs of the concerned industries. Indeed, as researched in 1985, about 60% of yearly inputs (in cash and in kind) as required for the well-being of this co-operative education came from contributions made by the participating industries.

Indeed, in a short span of just over a decade, the Institute has implemented, through PS, a massive off-campus educational organization, linking first-degree level university education with industry. The fact that, in spite of the PS being optional, the entire student population of the institute opts for the PS Degree streams under their respective disciplines and that, particularly during PS-II, host industries invariably pay to students either in cash or in kind as a recognition of students' professional contribution to the overall well-being of these industries, demonstrate the educational, organizational and economic validity of such a PS-based model of higher education characterized by integrated structure and congruency with student aspirations. Understandably the PS programme, which in itself is the product of innovation, has, in turn, given risen to new growth processes, notably M.E. (collaborative) programmes and off-campus doctoral pursuits at industries.

ASSESSMENT

In spite of the success of the PS system of education at BITS, Pilani, as in the case of sandwich courses, this form of co-operative education, has also yet to find large-scale acceptance across the nation's institutions. True, there are institutions like the Thapar Institute, Patiala and IIT, Bombay who have developed their own forms of co-operative education at undergraduate and post-graduate engineering levels, respectively. However, on the whole co-operative education at degree level still remains an elusive reform to national educational planners.

A variety of reasons are forwarded for this, representing views of industry representatives and those of academia and educationalists. The views of industry's representatives range from lack of effort by institutions to know industry's manpower needs; preoccupation of institutions with routine teaching and examinations; lack of industrial experience on the part of teachers, in turn leading to theoretical teaching; inadequate representation of industry on governing bodies of institutions; lack of effort on the part of institutions to shape the attitudes, values, disciplines and work ethic of students to prepare them for work in industry; lack of relevance of courses of study and examinations conducted by institutions to the needs of industry and the absence of work-experience as an integral part of the curriculum; emphasis by institutions on classroom-based courses and lack of effort to extend their perspectives to include the continuing education needs of industrial manpower—to the inability of industry to have confidence in the faculty of institutions to solve its technological problems.

Against this, institutions and academia, on their part, point out the other side of the problem by listing a host of reasons, namely lack of manpower

planning mechanisms in most industries, making industry unable to specify the type of personnel it needs; expectation by industries that institutions produce personnel tailored to suit each industry's specific need, which is impractical; only few industrial organizations carry out apprenticeship training in a rigorous manner and as a result well-organized, purposeful work-experience/practical training is not easily available for the products of institutions; industry too preoccupied with its day-to-day problems and therefore unable to devote time, effort and money to manpower training and development in co-operation with institutions; lack of motivation on the part of industry to invest in research, design and development activities; lack of interest/response from industrial experts to serve as visiting faculty or interact with institutions in educational ways; etc.

However, as one abstracts the experience and salient lessons of the successful experiments in implementing co-operative education, what emerges is that central to the success of these experiments is the ability to answer the question of devising workable mechanisms for integrating teaching–learning processes with work activity in industry.

As a work activity is basically characterized by an interdisciplinary, open-ended, time-bound, and goal- and mission-oriented effort, requiring team involvement, integration to implement co-operative education calls, firstly, for pedagogic input to develop workable teaching mechanisms for 'project'-based learner involvements in 'activity' with the above characteristics. It is obvious that such pedagogic inputs should also include design of a student examination system for 'project-based teaching'.

Secondly, co-operative education requires curricular design which could be eclectic, but should necessarily have 'vicarious' (theory or knowledge) content and 'activity' (practice) content. It is this 'activity' content that would then be designed and implemented with the help of 'project'-based pedagogic input mentioned above.

Thirdly, a teaching–learning organization using co-operative education is needed to be such that a project-based learning involvement in 'activity' should be undertaken by a triangular team of student, teacher, and work-in-charge. The student plays the role of an intern and a contributor to problem-solving effort of interest to industry; the teacher is in charge of student education and is a work activity consultant; and the work-in-charge takes the role of an industrial party with a stake in student–teacher involvement in the industrial work activity.

Fourthly, to facilitate the above, curriculum design for co-operative education requires that the academic calendar provides an appropriate time-slot for an educationally purposive and, from the work point of view, productive group involvement of a student-teacher-work-in-charge team at the workplace. Needless to say, this time-slot should be designed to be mutually convenient to the three team constituents.

Last, but not least, all the above essential requirements would necessitate the institution and industry developing an 'interface organization' for management of linkage between the teaching–learning process in the institution and work activity in industry as above, so that, as can be abstracted from the successful experiments presented here, co-operative education becomes a 'programme of study' in which relevant industrial exposure/training/work experience constitutes one of the courses under the programme and without the satisfactory completion of which the academic award (degree, diploma, etc.) is withheld.

Indeed, all the core requirements identified above for successful implementation of co-operative education, which would establish in an educational sense education–work linkages, are major educational efforts and have normally not been central to pedagogic, examination, curricular, teaching, calendar and management reforms undertaken at various levels of education. There is no denying that different institutions, depending upon their local situations, would and should develop different detailed models to facilitate implementation of co-operative education, but even for such initiatives to begin the educational environment has to consciously encourage, sustain and develop the educational efforts and subsequent reforms as mentioned at all levels of education. More importantly, individual teachers, institutions and industries have to come forward to mingle and synthesize from such an environment. This in turn would call for a more dynamic, interactive and innovative role for peer groups in education at teaching, planning and policy levels.

CONCLUSION

Various forms of institution–industry co-operation—namely industrial visits by students, industry involvement in curriculum design, provision of industrial training to polytechnic teachers, undertaking joint research and consultancy programmes, inviting experts from industry for extension lectures and discussions on typical shopfloor problems, adoption of polytechnics by industry, offering continuing education programmes for industrial personnel by institutions, and co-operative education on patterns like sandwich courses, practice schools, etc.—have been recommended and implemented to various degrees in the country.

However, this reform of institution–industry interaction has yet to acquire a central position in the growth of technical education in India. One of the main reasons for this is co-operative education—wherein a course of study, in which a student undergoes industrial training/internship/problem-solving/work experience as an integral part of the

student programme and without satisfactory completion of which the academic award is withheld—has yet to become a part of the curriculum reform initiatives.

Growth in these initiatives has much to do with understanding of pedagogic processes in the conduct of open-ended 'project'-based learner involvements and development of teaching–learning organizations and of management mechanisms for co-operative interface between institutions and industry. Educational R&D in these areas of development of appropriate educational technologies and for creating a sympathetic and conducive environment should go a long way in implementing this much-desired reform of co-operative education.

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