DESIGN AND DEVELOPMENT OF AN INTERACTIVE TEACHING LEARNING SYSTEM FOR TECHNICAL EDUCATION

THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE

REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

1991

BY

SANJIB KUMAR BHATTACHARYYA

Birla Institute of Technology and Science
Pilani (Rajasthan) India

BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE

PILANI RAJASTHAN

CERTIFICATE

This is to certify that the thesis entitled ***"Design and Development of an Interactive Teaching Learning System for Technical Education"*** *and submitted by Sanjib Kumar Bhattacharyya, ID No.88 PHX F403 for award of* ***Ph.D degree*** *of the Institute, embodies original work done by him under my supervision.*

Signature in full of the Supervisor

Name in capital block letters **DR.VIJAY V. MANDKE**

Designation **PROFESSOR & DIRECTOR**
School of Engineering & Technology
Indira Gandhi
National Open University
New Delhi

Date 16/8/91

ACKNOWLEDGEMENT

The work reported in this thesis has been carried out as a sponsored project of TTTI Chandigarh in active collaboration with a group of polytechnics and a large number of employer organisations under the guidance of Dr. V.V. Mandke, Professor and Director, Indira Gandhi National Open University, New Delhi (Formerly Deputy Director, BITS, Pilani).

This work would not have been possible had it not been for the progressive outlook of my employer, the Technical Teachers' Training Institute, Chandigarh, who granted me permission, encouragement and facilities for undertaking this project. I wish to express my profound gratitude for the same.

I owe my gratitude and indebtedness to my learned guide Dr.V.V. Mandke for the valuable guidance, encouragement, and help extended to me during the tenure of this experimental research study. During my interactions with him, I developed an insight into the problem, was able to analyse the various aspects, develop hypotheses, conceive alternate solutions, test and validate them. Through these experiences, I, as a teacher, developed skills in solving problems related to complex human behaviour and learning.

I would like to record my gratefulness to BITS, Pilani, for providing me this opportunity to work on this research topic as an off-campus Ph.D. student. The educational design conceived and implemented by this premier institution, where professionals are provided an opportunity for improving their qualifications by solving problems related to their own organisations in a scientific manner, is a unique contribution in the field of technical education, training, and development. My grateful thanks are to Dr. C.R. Mitra, former Director, BITS, Pilani for the inspiration provided by him at the initial stage,and to the present Director,Dr.S.Venkateswaran for providing me guidance and support in completing this research study. My sincere thanks and gratefulness are for Dr.L.K.Maheswari, Dean,Research and Consultancy Division of BITS, Pilani,who was also my official mentor during the initial period after my registration as a Ph.D. student,for his valuable guidance and cosntant encouragement in completing the work within the stipulated time. His sympathetic attitude towards me has always been a source of inspiration.

My sincere thanks are also due to all the senior faculty of BITS, Pilani who are connected with the Ph.D. programme,particulary to Professors J.L. Arora, S.Kumar, K.Gopalan, M.Ganesh, A.N. Bhargava, V.P.Goel,and R.P.Vaid for their support in completion of this thesis.

Indeed, words at my command are not adequate to express my sincere and honest gratitude and thanks to Professor K.B. Raina, Principal, T.T.T.I., Chandigarh, who has been a source of inspiration to me in my academic pursuits. I always looked forward to having interactions with him while working on this project.

I would also like to thank all my colleagues at TTTI, Chandigarh who made valuable suggestions from time to time, particularly to Professors B.M.Dhir,S.Krishnamurthy, M.Adithan, and L.N.Mittal.My special thanks are to Mrs.L.mathew, Lecturer for providing assistance, as and when required. Thanks are also due to Shri C.L. Chadha for his administrative support and help.

This note of acknowledgement would remain incomplete without expressing my indebtedness to all the polytechnic managements and their faculty, the employer organisations, and the field experts who collaborated in this project and provided full cooperation in conduct of the experiments. My sincere thanks are also to those young students who participated in the teaching-learning process and also provided me with feedback, which I considered most valuable. Working with these young students, I always found refreshing and a learning experience. It is practically not possible to express personal thanks to all the teachers, students, and professionals who were associated in the experimental studies, as the list is going to be very long.

I must recognise the contribution of my wife, Sumita and my son, Samrat who have been my real source of encouragement in carrying out this research work, which kept me away from my home, most of the time, during the last three years.

I am also thankful to Dr. (Mrs.) Parimal Mandke, who made me feel at home when I had academic discussions regarding this thesis work

At the end, I would like to express my sincere thanks to Shri N.K. Chawla for typing this manuscript with neatness and accuracy.

Sanjib Kumar Bhattacharyya
16/8/91

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CHAPTER-ONE

INTRODUCTION

1.1 Imperatives of modern technology -Training a learner entrepreneur

The sum total of human knowledge was estimated to be doubling every ten years by 1950 and doubling every five years by 1970 (53). Understandably this rate of growth will go on increasing exponentially.

In the area of science and technology the rate of growth of knowledge and its complexity have been tremendous in this century. This unprecedented rate of growth has made things complex at all levels, in turn requiring systems skills of synthesis to face problem solving situations of tomorrow.

The requirement today is for basic skills such as in thinking logically; in problem-solving and in handling of information; and the development of attitudes such as flexibility and willingness to work co-operatively with others . These skills are essentially characterised by an interdisciplinary approach to knowledge and by ability to work in terms of real life, time bound goal oriented tasks of production, of design and development, of research, and ultimately of social action (50,51). Education cannot be taken forward without reference to the needs of society or the needs of individual, if he is to play his full part in society.

Further, the problem solving scenario resulting from development of Technology is fraught with probabilistic elements of uncertainty, thus giving the content and methods of education essentially the task of preparing students to face the unknown. The requirement of a new look at education is not so much from the point of view of what is taught, but from the view of how the learner learns. For, it is the process rather than content which will probably have the most effect on attitudes, and it is attitudes that count. Such education would have to go beyond the traditional codified interpretation of knowledge, requiring knolwedge to be seen, in its holistic and dielectical perception, and will have to achieve much more, in terms of development of cognitive strategies using circumstances where neither the teacher would be know-all nor the answers to the questions would be unique and final, than what the educational system has been able to achieve in the past.

Further, no initial learning or initial occupation will last a single life-time. Wisdom demands that initial learning be reinforced by life-long learning. (69,78,97).

The shift that has to take place is from a mere 'front-end loading' teaching-learning approach to developing 'learning-to-learn' skills or in other words, the need would be to develop learner entrepreneurs. A learner entrepreneur is one who is desirous of learning to learn. Thus, objective of education would be seen not as teaching knowledge or information but method of how to acquire them. One who achieves this ability and in the process introduces 'concept of use' in education is a learner entrepreneur (61,62). Concept of use as shall be explained later, is an activity wherethrough knowledge learned is applied in a specific situation and assessment of the level of this application could be used as statement of the competence of the learner in that specificity.

Further, the impact of new technologies on the curriculum and the map of knowledge, would demand emphasis on powers of synthesis as much as, and perphaps more than powers of intellectual analysis.

In a changing technological society skills required should be flexible and transferable which would demand an education process having transfer of learning objective. Our society would need people who can take skills from one job to another, or from one industry to another, and who can build up on and change their skills in responce to demand(97).

Education need to produce people with such skills who will be capable of designing, using and adapting to physical systems of almost biological complexity. The curriculum for such an education system must be flexible and adaptable menu of varied opportunities.

The new technologies would give fesh impetus to approaches like individualized learning, there would be a need for flexible subject boundaries, leading to a growth of genuine inter-disciplinary studies, involving a problem-solving approach.

This then is the educational imperative, manpower training system world over are continuously seized with.

What is more significant is that the imperative is valid for the developed as also for developing societies, in turn giving it a fundamental character cutting across the state of technology and social development,which can be successfully met only by looking at what more need to be done with the very structure of educational pedagogies(51).

It is the synthesis of these observations that has led to the concept and design of an exploratory teaching-learning system for training a learner entrepreneur which will answer the needs of future educational pedagogy,changing technology and society.

Even at this early stage of research investigation planed through this thesis, the researcher would like to submit that this view of a learner entrepreneur, though gaining ground in educational research, is still a futuristic concept.The much of the educational community engaged in day-to-day teaching-learning tasks is either unconcerned with this issue or even unconvinced, particularly because in many situations educational planners and educationists both alike tend to take short-term view of education and thereby rely more on quick-fire passive learning mechanisms.

Sections to follow argue in brief limitations of these either unconcerned or short-term views of education and the research effort then wholly proposes to direct its investigations in designing alternate teaching-learning mechanisms compatable with long-term educational view.

1.2 Emerging pedagogic considerations

As observed by Husen Torsten,"in a changing society,the school cannot provide an intellectual fare of specific items of knowledge for life long use. The shift that has to take place in the content of teaching is one from emphasis primarily on transmission of specific items of knowledge which may soon become obsolete, to one with emphasis on the intellectual skills that are applicable to a broad and largely unforeseen repertoir of task situations " (70).

Such education should have cognitive outcomes equipping the students with skill of logical thinking,of problem solving, intellectual ability, decision making, creativity, critical analysis, and above all an integrated view of knowledge which have not been fulfilled by the traditional system.

Education cannot, therefore, be limited to the transmission of information or knowledge. The new pupil teacher 'talk-situation' would be much more varied, open-ended,exploratory and flexible than often were now. Further, for achieving transfer of learning objectives the curriculum should provide opportunities to students for open-ended problem solving, the problems being of relevance to the society.

The 'Problem-solving' technique will be the prime essential instructional tool for teaching and learning in the field of engineering subject matter, whether at the degree level or at the diploma level(51). The aim ought to be to develop in the student from the beginning of his technical education and throughout his educational career the ability to think-to reason-to analyse-to synthesize-to visualize-to hypothecate. These are his kit of essential mental tools upon which the graduate's ability in using them will determine very largely the degree of success he may expect to achieve in the engineering field,whether as a Degree holder or as a diploma holder.

For developing problem solving skills, teaching would mean organising student centred learning with student taking more responsibilities and more control of learning situations in terms of content,pace,and style of learning. The new pedagogy would demand from the learner acquiring attitudes of enquiry, self direction in learning, abilities of synthesis and divergent thinking, skills of reading, referencing, selecting and evaluating information,and above all,application of knowledge for open-ended problem solving(50).

Evaluation system needs to be designed so as to encourage this type of education that would sustain change, and development of change.

Evaluation system in the new pedagogy of transfer of learning calls for extensive examination reforms which now need to be oriented towards measuring skills of application of knowledge and problem solving (52).

It would be important for the teachers to know the conditions under which maximum learning takes place as well as other significant variables associated with it viz. ability, motivation, attitude, interest, purpose, rewards and punishment, goals and aspirations of students(98). This will enable the teachers to orient their instructional strategies to help students prepare for the change and face the challenges in the world of work.

With the rapid advancement of technology and the increasing complexity of the industries, technical education cannot remain stagnant. It should meet the challenge by adopting a new system, which is flexible and elastic to meet the aspirations of students vis-a-vis the needs of society.

1.3 Pedagogic Practices in Polytechnic Education

Technical education in India operates at three levels viz. Industrial Training Institutes offering certificate courses, Polytechnics offering diploma courses, Engineering colleges and Technical Universities offering degree and post degree courses.

Polytechnics in India prepare middle level technical manpower for employment in Industry/field.

This middle level technical personnel covers many jobs and bears many positions/titles namely, "Technician, Supervisor, Foreman, Overseer, Section Officer, Technical Assistant, Shift incharge, etc. They are responsible for applying technology to a wide range of field operations ie,in production and construction, testing and development, installing and running engineering plant, drafting and designing products, estimating cost, selling and advising customers on the use of engineering or scientific equipment. Often,these personnel work in between craftsmen and Engineers" (14).

A general observation shows that technicians in engineering and technology find employment in public sector undertakings, private sectors, central and state governments, local bodies and other organisations. The latest position of the percentage distribution of technicians in the above sectors is not available.

The functional employment distribution of technicians in large and medium industry, according to a survey(63)is shown in Table 1.1.

Table 1.1

Functional employment distribution of Technicians

	Production	Quality control	Design & Drawing	Production Planning & control	Research & Development	Repair & Maintenance
Large Industry	65%	10%	5%	5%	5%	10%
Medium Industry	75%	10%	-	-	-	15%

The functional requirements of Technicians in large & small scale industries according to a study(63), are given in table 1.2.

Table 1.2

Functions of Technicians in industries

FUNCTIONS OF TECHNICIANS IN		
LARGE SCALE INDUSTRY	MEDIUM SCALE INDUSTRY	SMALL SCALE INDUSTRY
Work close to Engineer for:	Work on the shop floor for:	Work close to the craftsman for:
.Data Collection/ surveys	.Shop floor planning & management	.Handling precision machines
.Testing of materials	.Supervision of production processes	.Supervising/ guiding craftsmen & workers
.Design of simple components	.Quality control operations	.Repair and Maintenance
.Assistance in planning	.Installation of new machinery	
.Production Supervision & control	.Handling repair and maintenance of precision machines	
.Selection of appropriate equipment & processes	.Ensuring safety	
.Labour management		
.Quality control		

The study further reveals that the present role of Technicians is likely to undergo changes in order to meet the requirements arising out of advancements in technology in the coming decades. The conventional job functions will coalesce into unified jobs, thus calling for a different range of competencies. The technician will be more a knowledge worker and will be required to possess higher order cognitive abilities, a fair amount of managerial capabilities and less of conventional manipulative skills. Some of the essential skills required as foreseen by industry are: understanding of basic concepts and principles; basic skills in reading and interpreting engineering drawings;basic laboratory and workshop skills including importance of accuracy and precision; abilities of applying basic knolwedge and skill for real life problem solving assignments; making effective use of information technologies; and development of positive attitudes and values.

The main objective of polytechnic education is to train various types of technicians needed by industry,through appropriate education processes. About 90% of over 500 polytechnics in India offer full-time 3 years generalised diploma courses. Post diploma, Advanced diploma, Sandwich type diploma, and Part-time diploma courses are run in some limited number of polytechnics (56). The curriculum is broadly structured for each branch of engineering to train a generalist technician in that branch. About 50% of the time is allocated for theoretical instructions while the other 50% is meant for practical work in laboratories and workshops.

In majority of Polytechnics, instructional staff do not have any industrial/field experience. Reference to a study conducted in 50 polytechnics in the Northern region for preparing a profile of polytechnic teachers indicates that 65 percent of the teachers do not have any industrial experience, 12 percent have 1 year experience, 10 percent have 3 to 4 years experience , and the remaining 13 percent have more than 5 years of industrial experience. However, the experience that the 35 percent of teachers have was acquired at the beginning of their teaching career in polytechnics. During the teaching career, they hardly have any interaction with the world of work(74).

As per curriculum, teaching-learning in the polytechnics is required to be carried out through Lecture classes, Tutorial classes, Drawing classes, Practicals in laboratories and Practice in Workshops. In the lecture class, on an average 30 to 60 students are accomodated. In practical class, the average strength varies from 15 to 30. Most states follow semester system of course offering(61). System of student evaluation is divided into two parts viz Internal assessment and External assessment. The weightage of internal and external assessment being in the ratio of 30:70. Internal assessment consists of class tests,home assignments and class work.

After satisfactory completion of the programme of study the students are awarded a diploma by State Board of Technical Education (SBTE).

A study conducted in 1985 on eleven selected polytechnics in five different States (7) indicates the following with respect to status of teaching-learning practices:
"The teaching-learning in the theory class is solely teacher centred where the teacher resort to passing of information

and where the students remain passive listeners. Moreover, majority of the class time is spent in dictating notes by the teachers. Thus, teaching-learning process continues to be a chalk and talk method by the teacher with minimal attention being paid to the acquisition of job related practical skills. In practical classes, in majority of cases, teacher conducts the practical where the students watch. Teachers help the students in recording observations. In some cases, students in a group conduct practicals where only one or two students prepare the set-up, take observations and other members of the group remain unconcerned and copy data. The final report is prepared by copying from report of old students. In the drawing class, it is observed that the students copy drawing from books and blue prints without having clear conception of the drawings being made. For curriculum implementation, the polytechnic system operates more or less in isolation from the world of work, while industry, on the other hand, remains a spectator and not a partner."

A study of the content analysis of examination question papers of State Boards of Technical Education (6,49) reveals that:

"students in general are given an overall choice of about 50 percent in answering questions in a subject. The questions are mainly directed to students' recall of information. Numerical problems are also of such types where students are to put data in some known formulae and make calculations. Discussion with sample students and teachers reveals that students can score fairly good marks even by omitting one third of the course content. Since the type of questions asked in the examination are mainly of recall type, students concentrate memorizing only a few weeks before the final examination."

An analysis of the national curriculum for polytechnics (67) shows that:
the curriculum document, while prescribing course content, study and evaluation scheme, does not provide guidelines on method of course offering and leaves the implementation entirely on the teachers. On the other hand, the rules and regulations do not provide much flexibility in the method of course offering except through institution based class-room oriented lecture method.

An analysis of instructional material, available in the market shows that such materials largely are stereo typed and are, generally, diluted version of material available for degree students.

Student-teacher contact hours in polytechnic is 36 hours per week. There is hardly any time left for the student to think, to learn, to read, and to develop a balanced interest in the real life problem situations, and yet these students are supposedly destined to become supervisors and managers who need to get the best out of people, who need to assess demand for products and who need to be able to cause people to work effectively.

Comparing the present pedagogic practices in polytechnics and the pedagogic requirement as emerged from the modern technological considerations, it can be concluded that the mere teacher centred expository type of teaching will not serve the purpose.

Efforts have been made by the system by way of developing laboratories and workshops, train teachers in use of audio-visual aids, in updating of knowledge of teachers, in revising curriculum and in preparing teaching materials, etc. For providing practical training to students after their diploma course,'Apprenticeship training Act' has been introduced. Both State Governments and the Central Government are allocating more and more resources to polytechnics for removal of obsolescence and for modernisation of laboratories and workshops. In spite of all these efforts the polytechnic product is not matching with the requirements of world of work (14,15,19,20,55,57,58,60,66, 71,72,73,75,76,88).

These disturbing observations have led the researcher to have a fresh look at the vital component of the system i.e. the teaching-learning process, which is considered a central issue of study. The various issues emerging out of the observations described above are presented in the following section.

1.4 Issues

1.4.1 Achievement of quality and excellence

An important indicator of quality and excellence of a technician education system is the self reliance and adaptability of the polytechnic output in the world of work.

Technological developments in the recent years have made the demands of the world of work more complex.

Any measure taken to improve the existing components of the system such as curriculum of courses, instructional materials, teacher training, etc., without bringing in the use of appropriate strategy of technician training, had only marginal effects on the quality and excellence of polytechnic product. Another factor that affects the quality to an extent is the curriculum requirement of passing a prescribed set of subjects which demand primarily acquisition of information, principles and procedures, rather than acquisition of essential related practical skills, basic concepts, problem solving skills, & learning to learn skills. This has made teaching-learning in polytechnics a routine activity, devoid of any challenge to teachers as well as to students.

The present pedagogic practices are not geared towards preparing students for meeting the needs of changing society.

1.4.2 Polytechnic Curriculum

Most of the existing polytechnic courses are in broad disciplines of engineering and the curriculum is science based . The curriculum is developed mostly on the basis of Committee decisions rather than actual need analysis.

The existing polytechnic curriculum does not meet the functional requirement of technicians in industry.

1.4.3 Teacher Preparation

In the context of technological development and preparing students to face the unknown, the role of teacher and pupil are likely to be so changed that education itself would be changed. The teacher need to become a resource manager with democratic attitude which would give impetus to approaches like individualized learning. As a result, emphasis on pupil-indpependence would be strengthened, and impetus given to other affective aspects as well as to cognitive elements. There would be need for arranging experiential learning which has transfer value. There would be a shift towards learner centred approaches to teaching-learning from autocratic teaching. The teacher will have to play the role of a curriculum developer. Developing real life problem solving abilities in students would force the teacher to establish linkage with the environment.Thus, the teacher will have to play a multiple role in performing his tasks. Howe-ever, the change should be 'evolutionary' and not 'revolutionary'. The teaching-learning in the polytechnic should be an innovative experience rather than a routine job. Teacher preparation, for enabling them to take this challenging task assumes importance because it is the teachers who would play the role of Change Agents through use of appropriate pedagogic practices in the polytechnics. There is a need for increased drive to motivate students through guided discovery learning.

These observations lead to the concept of on- the- job teacher-training approach by creating enriching and challenging teaching-learning activities which is missing in the existing system.

1.4.4 Learner Opportunities

For preparing a student to perform, to be able to apply his Knowledge and skill in problem solving, interactive approach would be more demanding than mere exposition type of teaching. Opportunities are to be provided for students to take more responsibilities, there would be need for more self discipline and more freedom to learn from varied possibilities in terms of content, method, pacing,etc.Opportunities are to be created for intellectual development together with the latent qualities of the learner, his communication skill, skill in data collection and interpreting data, creativity, initiative, possitive attitudes,leadership and team work. Teacher centred pedagogic practices have led to passivity in the learners, limiting the opportunities for their self development.

1.4.5 Student Evaluation/Examination

Instruments of student evaluation need to be so designed as to assess all the qualities of a student.Such an evaluation system therefore, should have multiple objectives.

The present evaluation method used by the polytechnics does not necessarily reflect the total personality traits of students.

1.4.6 Instructional Resources

Before giving students a taste of open-ended problem solving experience as an integral part of organising teaching-learning of subjects, it will be necessary to ensure first, learning of basics of the related subjects, activity oriented self study, and enrichment lectures cum group discussion. Use of powerful media like video and computers could play an important role in designing and developing learning material for students.

Such learning materials, either in the form of learning packages, or simply, in illustrative printed form, are not available thus forcing students only to depend on text books which are nothing but diluted version of text books meant for degree students.

1.4.7 Interaction with Employer

The polytechnic product is criticised for its poor quality. The requirements of the employers are therefore to be identified for the design of courses, their development, implementation and evaluation. If the employers are made to participate in the educational processes of the technical institutes, the gap between what is produced and what is expected could considerably be reduced.

Further, the heavy demand of resource requirements of the technical institutes could be rationalised by utilising some of the resources of the world of work through cooperative effort.

Teaching-learning in polytechnics is mainly institutional based having hardly any interaction with the employer.

1.4.8 Management of Teaching-learning

Effective management of Teaching-learning in polytechnics demands innovations in teaching by the teachers, academic leadership from the Heads of departments and Principals of the institutes. Progressive outlook, flexibility in approach, and creating an environment of innovation and challenge are the responsibilities of seniors in the academic world. The Heads of Departments and Principals need to be motivators and facilitators.

The present stereo type management system in the polytechnics does not encourage much innovations in teaching - learning due to rigid rules and regulations. The role of Heads of Departments and Principals and DTEs need to be redefined for bringing improvement in teaching-learning in poly - technics.

1.5 Problem Statement

Before independence, the polytechnic system gave emphasis on training of middle level manpower requirements for manufacturing and operation as also for maintenance tasks . Most of the time engineering education and training was related to requirements of equipment life cycle.

The post-indpendence India obviously had new needs of process and design engineering. This in turn brought in the need for development of middle level manpower which can test and measure ,supervise production processes, do detail engineering particularly vis-a-vis development, inspect & control quality, and do marketing of systems and products.

In order to respond to the new needs of above described manpower requirements, a massive expansion of technical education was undertaken. In 1947 there were only 53 polytechnics conducting diploma courses with an intake of 3670 students each year. In 1989, the number of polytechnics increased to over 500 admitting over 70,000 students.This means,huge inputs in terms of men, material and money have been pumped in to the system. However, the strategies employed in the design, development, and implementation of technician education have mostly been directed towards having 'more of the same'. Further, these inputs have been given visualizing technician education system in isolation of its user resulting in producing diploma holders whose quality is much below the expected requirements of the employers.

Efforts made in the quality improvement of the system by way of providing resource inputs and manpower training have so far not paid much dividend.

The problem therefore is as to how to prepare students to meet the challenge of rapidly changing technological milieu of various levels of industrial,commercial and social developments.

1.6 Hypothesis

From the analysis of the requirements of employers and the strategy used in curriculum implementation in polytechnics, what clearly emerges is that the traditional approaches to manpower planning would not serve the purpose at hand and as a result the corresponding methods of curriculum development & teaching-learning process would need to be seriously questioned.

The central task thus at hand is to develop a technical human resource which has a problem solving ability and an entrepreneural culture. Such culture by definition demands a discipline of mind to see things in a holistic and systems manner where all the aspects of a systems life cycle namely, design , manufacturing, initial production, operation and maintenance and obsolescence are continuously kept in mind for any decision making.

Of course, the type of knowledge and analytical needs for the purpose, in responding to problems such as above, vary depending on which particular stage from those mentioned above the problem solver is centrally concerned, but the discipline of problem solving remains the same; in turn enabling people working at design or manufacturing or operation or maintenance levels to form a hierarchical technical manpower with an ability for interactive dialogue making the total manpower a symbiotic group to enhance the technological development.

If the above were to be possible, one has to then look at curriculum development or the teaching-learning processes within the framework wherein the education incorporates principles of "concepts of use" in education(62).

Concept of use in education is pivotal to complete the innovational process in human resource development. Towards this, teacher (i.e. manager of education), the taught (i.e. the beneficiary) and the employer (i.e. the user) can have an entrepreneural and interactive problem solving effort towards a defined goal measurable in terms of money and time. This in turn calls upon all the above three elements of this process to play a role beyond their traditional images and in the process develop new method of teaching, examination and management.

It may be mentioned that such structuring of education while on the one hand reduces overheads at all levels of education as also industry thereby reducing costs,on the other hand, it introduces new inputs in the domains of teaching-learning as also production so as to ensure elements of synthesis and modernisation,be it a learning or production situation.

This process in terms of 'concept of use' in education is based on using a circumstance as a means for ensuring dynamic elements in defining educational attainments as also requirements of job specifications. 'Use of circumstance' in this manner in fact enables the designer to keep the norms, whether for academic attainments or for employment,variable; in turn allowing the teaching-employer a decision making ability to meet local realities of manpower development or manpower training as also technology modernisation/diffusion.

This need is a basis of the whole problem. The above described circumstance could be achieved through two mechanisms namely,

(i) introducing education-work linkages as an integral part of curricula design;

(ii) Introducing transfer of learning objective in the teaching and learning process.

This thesis intends to experiment on alternative models following both the channels i.e. introducing education - work linkage as an integral part of curriculum design as also introducing transfer of learning objective in the teaching- learning process in the polytechnics.

1.7 Objective of the research study

One of the central lacuna in the traditional teaching methods followed in polytechnic education refers to teacher centred approaches which view student in a passive role in the learning process. These methods have normally based themselves on either mental disciplinarian or apperceptionist view of learning.

Such a passive role for a student in the learning is known not to pay much divided as, firstly, students forget what they learnt, and secondly, they develop no abilities to apply their knowledge in new situations. Such limitations of learning is particularly distressing as one considers the gamut of technical education where main purpose of training manpower is to meet the demand of changing technology which in turn continuously forces new situations in work places.

It is against this diagnosis of the problem the proposed research aims at pursuing the following investigations:

(a) the proposition that will be tested is activity in learning as introduced through curriculum design integrating vicarious learning experience(theory)and direct experience (practice) is a must for training of students with mature outlook, emotional and intellectual development. Towards testing of this proposition an exercise as above would be done where activity takes place at the work-bench, thereby developing teaching-learning pedagogy of a reflective nature.

(b) similar exercises towards testing of the proposition mentioned as (a) above would be done by developing teaching-learning material incorporating class-room based activity oriented learning experiences. These teaching-learning material will be developed for sub - jects particularly from the area of Electrical Engineering. The form of instruction towards this purpose would include guided self study,gap lectures, programmed learning, group discussion,project activity, graded exercises, assignments,etc. as per requirement. Examinations would be so designed as to themselves constitute learning experience of a direct kind. The teachers role will be defined in a participatory manner, thereby requiring teaching methods of group discussion, seminar, viva, project report, etc.

(c) a similar exercise as (a) above will be done using a functional curriculum for learning of basic theory through class-room based learning activities to be followed by direct experience at the work-bench. The learning material developed for the purpose will include self-learning type text covering the basic theory, instructional manual for practical work,and reference study material covering the functional areas.

(d) specific experiments will be conducted by using the material developed as in (a), (b), and (c) above in terms of testing the material developed as well as the methods of teaching-learning followed.

(e) so developed teaching-learning packages including their implementation strategies will be made available to the polytechnics for use.

1.8 Brief outline of the thesis

Chapter II of the thesis is devoted to a brief review of the development of Technical Education in India, studies on status of polytechnic education, a comprehensive study carried out as part of the research work on status of teaching-learning practices in polytechnics, statement of basic deficiency in the polytechnic product, and the types of learning situations needed for achieving long-term objective of education and training.

Chapter III provides details of planning of approach, design, and implementation strategy for interactive teaching-learning systems.

Chapter IV gives the details of an experiment conducted on Open-ended Project-based student-teacher involvement at work-bench.

Chapter V gives an account of an experiment conducted on Open-ended project based student teaching involvement as integral part of class room teaching.

In the second part of this chapter the details of scaled up implementation of the pilot experiment have been reported.

Chapter VI gives details of an experiment on use of teacher made graded exercises with feedback for developing problem solving competence.

Chapter VII describes an experiment on use of functional curriculum in the institutional training followed by students' internship in industry.

Chapter VIII gives an analysis of all the experiments conducted. Also the salient outcomes of all the experiments have been presented. Comparative evaluation of the experimental models have also been made.

Chapter IX is devoted to conclusion of this research work including mention of scope for further research study.

CHAPTER-TWO

TECHNICAL EDUCATION IN INDIA AND NATURE OF EDUCATION AND TRAINING NEEDS

2.1 Introduction

Parallel with the development of technology, there has been a phenomenal growth of technical education facilities in India particularly at the polytechnic level. However, the polytechnic product suffers from continuous criticism from almost all corners for its inferior quality.

There have been enough studies and responses from all concerned on the status of polytechnic education and its output. Central to all the studies and responses, whatever may be their articulation, is that the educational product is lacking ability for 'transfer' which is considered the long term educational objective of any teaching-learning system. Even today, though one accepts such long term need, when it comes to operative stage, all teaching-learning activities become directly aimed at immediate learning outcome. Both parents and teachers seem to support this immediate learning outcome of the system. A learner is however, ambivalent. And the point of disagreement seems to come from the employer, though not in words, in the sense he also seems to say, train students for job needs and thereby suggests immediacy of educational objective. But when it comes to deeds, employer by definition is looking for learner who can move from task to task, as the rate of change of technology at work place is unequivocally demanding ability for flexible application of knowledge i.e. flexible employment.

Training for 'transfer' for achieving the long term educational objective and its concretisation in terms of types of learning situations needed in the curriculum is an important issue under consideration. This Chapter briefly presents the historical development of technical education in India particularly at intermediate level, the present status of teaching-learning in terms of the pedagogic issues stated in Chapter I, the major lacuna in the product, the quality improvement measures already undertaken and the nature of education and training requirement as researched through this thesis, keeping in view the technology development scenario.

2.2 Expansion of Technical Education facilities in India after Independence

2.2.1 Quantitative expansion and qualitative measures

In 1947, India was faced with the great challenge of rapidly industrialising her predominantly agricultural economy. In order to meet this challenge, the country had to build up its technical education system within a short period. All India Council for Technical Education (AICTE) reviewed in 1948, the state of polytechnic education in the country and initiated a comprehensive programme for its reorganisation and development. The Working Group on Technical Education and Vocational Training in 1959, under the Chairmanship of Professor M.S.Thacker, after studying the existing facilities for Technical Education and Training, made far reaching recommendations for its qualitative improvement as well as for quantitative expension. On the qualitative improvement, the Working Group laid emphasis on establishing linkage between technical education and indsutry, offering of sandwich courses, special training courses for teachers, etc. (22).

While assessing the future requirements of industrial development, Kothari Commission, during 1964-66, recommended expansion in diversified fields like metallurgy, chemical engineering, production engineering, etc. The Committee also stressed the need for practical training of students in industries.

By 1966, the number of institutions offering diploma courses rose from 53 institutions in 1947 to about 300 (56).

During 1968, the document on National Policy on Education (NPE) published by Government of India emphasised that there should be continuous review of the agricultural, industrial and other technical manpower needs of the country and efforts should be made to maintain a proper balance between output of the educational institutions and employment opportunities. One of the important recommendations made in the document was the introduction of sandwich/cooperative courses under which a student spends specified periods alternately in educational institution and industry.

Alongwith the expansion of polytechnics, serious criticism was heard about the system of polytechnic education from educationists, industry, professionals,and employers.The common points of criticism were that the diploma courses were mostly theoretical with very little practical bias, that they were a poor imitation of degree courses, and that the diploma courses were not geared towards producing specialist technicians needed by industries (57,60). These and several other factors had been causing concern to planners responsible for the development of technical education.

The 20th meeting of All India Council for Technical education in September,1969 suggested that a high-power committee should examine the entire system of polytechnic education. On the advice of AICTE, Government of India constituted a special committee for Reorgansiation and Development of Polytechnic Education under the Chairmanship of Professor G.R. Damodaran(57).

The main qualities, as identified in the Damodaran report, expected of diploma holders for filling up technician positions in industry are:

(i) Knowledge of basic technology in the chosen field, (ii)Knowledge of engineering practice in industry, (iii) Ability to apply technical knowledge to practical situations, and (iv) personal qualities and leadership ability.

Technical education, according to Damodaran report, should stress not only the acquisition of functional Knowledge and Skills, but also the development of the attitudes and abilities most valued by employers, namely, the practical way of thinking, resourcefulness, an ability to communicate, the correct attitude towards dignity of labour and a sense of disicpline.

Damodaran Committee, on teaching-learning method,observed that:

"The present method of teaching-learning in the polytechnics consists of class-room lectures, set exercises in laboratories, and design & drawing classes. By and large, these have not changed over the years. There is very little evidence of coordination between theory and laboratory practice.....

In short, our system of teaching in the class-room consists only of information-feeding to the students without a provision for feedback at regular intervals. The present examination system disregards the role of assessment and evaluation as a powerful aid to learning. The lecture as a teaching method relies only on the appeal to the sense of hearing and disregards the other senses which are equally important in the learning process. Personal attention to the student is largely lacking. As a result, the present system of instruction is ineffective in developing mental skills and ability in the application and creative use of knowledge. Nor does the approach help the development of indpendent thinking and the spirit of enquiry or the habit of self-study..."

In the late sixties alongwith the expansion of polytechnics, it was realised that it was not enough merely to pass out diploma holders from the polytechnics but that even more important it was to ensure the relevance of their training to the requirements of the world of work. In other words, while it was essential to run an efficient polytechnic system in terms of the number of pass-outs, it was necessary to ensure the effectiveness of the instructional process enabling the polytechnic product to match the requirements of the job situations for which he was trained. This called for the application of scientific approach to the curriculum process which includes the design, development, implementation and evaluation of curriculum.

Four Technical Teachers' Training Institutes (TTTIs) were created as resource systems to provide the needed expertise(54). TTTIs concentrated their activities in training of polytechnic teachers through Long-term and short-term training programmes which included subject matter updating and upgrading, industrial training ,and training in pedagogy. TTTIs also undertook the task of preparing instructional resources in the form of print and non-print material, train teachers in the use of audio-visual aid preparation and use. Audio-visual cells and Learning Rsource Centres were also established in many polytechnics(66).

Meanwhile under Apprentices (Amendment) Act 1973 which came into force in 1974, four Boards of Apprenticeship Training were set up in the country to look after training programmes of degree and diploma course pass outs in industry(3).

TTTIs in early 80s took a fresh look at their efforts towards quality improvement of polytechnic education and subsequently adopted an integrated approach to the development of polytechnic education where simultaneous attention was paid to all the components of the system towards development. The efforts ranged from infrastructure development, removal of obsolescence and modernisation of laboratories and workshops through central assistance, curriculum revision, preparation of comprehensive staff development programme, etc.

Government of India in 1989-90 went for a huge amount of World Bank assistance for quantitative expansion and qualitative improvement of polytechnics. Quality Improvement Schemes under the World Bank assistance programme includes Modernising Existing Polytechnics, Establishing Learning Resource Development Centres and Cells, Setting-up Computer Facilities, Establishing Curriculum Development Centres, Granting Autonomy to polytechnics, Faculty development, Promoting Industry-Institute interactions and Strengthening newly established polytechnics (55). From the above, it is seen that the management system has continuously shown concern over the weaknesses of polytechnics and have been making concerted efforts for improvement. It is only the future will tell whether such huge investment will pay devidend in the form of improvement of teaching-learning practices in polytechnics and thereby turn out better polytechnic product. It may be pointed out here,that the polytechnics have tried to produce quality technicians as per the requirement of industry entirely on their own. Innovations in developing effective linkage with industry at the instructional level have been inadequate. At this juncture where a huge sum of money is being pumped into the system for infrastructure development, it may be worth while to quote the observation made by Kulandaiswamy V.C., "the educational campuses cannot provide within their boundaries the entire infrastructure and institutional facility needed to educate and train an engineering/ technology graduate who would meet atleast broadly the needs of economy...participation of the practioners and the facility of the field situation are needed" (41).

2.2.2 Participation of industry in Technical education and Training

Participation of the industry in the technical education process at various stages have widely been recognised throughout the world as an essential requirement to prepare the right type of technical manpower necessary to sustain and promote industrial growth in keeping with the advancement of technology.

In India efforts have been made through sandwich type programmes for selected courses, provision of industrial training facilities to polytechnic graduates, providing opportunity to polytechnic teachers to have industrial training under Quality Improvement Programme, etc. Sandwich courses were started in selected polytechnics offering specialised courses like Printing Technology, Leather Technology, etc. Some polytechnics conduct sandwich courses in selected fields. A very few polytechnics conduct sandwich courses in all disciplines. In quantative terms the spread of sandwich courses has been less than 19 percent of the total number of polytechnics. In terms of students trained it is only about 4 percent of the student population. This limited spread of sandwich courses cannot be attributed to lack of industrial training facilities, but to other factors like rigid attitudes at various levels and resistance to change, strait-jacketing of polytechnics, inadequate policy formulations and direction and lack of motivation and leadership within institutional settings (15,16).

2.3 Studies on Status of Polytechnic Education

Studies on status of polytechnic education have been conducted from time to time to assess the quality of teaching-learning in polytechnics and its impact on the polytechnic product. Outcome of some of the significant studies are mentioned in this section.

2.3.1 Educational impact of TTTIs on Polytechnics

An inter TTTI research study was conducted in 1981 on the impact of TTTIs on polytechnic education(66). The findings which are relevant to this thesis are summarised as follows: "More than 80% of the polytechnics in various states revised their curriculum of courses. Teachers have been trained in the use of innovative teaching methods and in the use of multiple teaching aids. The teachers have been involved in the curriculum development process in most of the cases. Industries participation also was sought in development of curriculum in most of the cases. Instructional material both for theoretical study and conduct of practicals are available in most of the cases for the conventional courses."

However, the study did not explore the effect of teacher participation in the curriculum development and on its quality. Only 34% of the teachers reported actually innovating in the classroom teaching.

2.3.2 Study on effectiveness of Sandwich programme

A study on sandwich programmes conducted by Chandrakant (15) reveals the following:
"Sandwhich courses have brought some polytechnics and industrial organisations together in a cooperative relationship, but much still remains to be done in this respect. A large proportion of the industrial organisations think that the fault mainly lies within institutions because the latter are not particularly interested in developing and expanding the sandwich system. They also feel that the faculty of institutions are chiefly concerned with theoretical studies and have not developed any perspective about industrial problems. As a sequel, there is

lack of relevance in what the institutions are doing to actual needs of industry.... . Industry has particularly emphasised the role of polytechnic faculty in the sandwich programme and suggested that the faculty should be more closely involved at all stages of design, implementation and evaluation of programmes. It is about the lack of faculty involvement that industry is most critical."

One of the important objectives of the sandwich system is to develop the students' attitude, values, discipline and their character,and personality in general in the right direction through work oriented learning within an industrial setting. How far **this** objective has been achieved by sandwich programmes in operation has not been established by any study.

2.3.3 A Study of Instructional practices in polytechnics

A comprehensive study of instructional practices in polytechnics was conducted by the researcher during 1988-89. The objective of the study was to evaluate the existing instructional methods in polytechnics and to identify the deficiencies in terms of the pedagogic issues as identified in section 1.4 of Chapter I.

2.3.3.1 Methodology of conduct of the study

The study was conducted through collection of feedback from the polytechnics and the employers, analysis of the data, and then arriving at conclusions. Informations were collected through the following:

(i) Feedback Questionnaires,

(ii) Interviews,

(iii) Observations, and

(iv) Group discussions

In addition, study and analysis was made of the existing polytechnic curriculum followed in different States, the teaching-learning material used by polytechnic teachers and students as also those available in the market, method of continuous evaluation of students, and examination question papers used by the State Boards of Technical Education for semester-end student evaluation.

The details of the administration of questionnaire and conduct of interviews for receiving feedback are given in Table 2.1.

Table 2.1

Details of administration of questionnaire and conduct of interviews for receiving feedback on polytechnic teaching-learning system

Feedback from	Feedback received
(i) Polytechnic students	
(a) through questionnaire	527
(b) through personal interview	190
(ii) Polytechnic teachers	
(a) through questionnaire	375
(b) through interview	80
(iii) Polytechnic Principals through questionnaire	26
(iv) Employed diploma holders through questionnaire	195
(v) Employer through interview	40
(vi) Polytechnics through observations	10

2.3.3.2 Analysis of data in terms of pedagogic issues

The data received from all sources were analysed in terms of the issues listed in Chapter I and are summarised as follows. While analysing the data reference has also been made to some relevant studies made by others.

(a) Relevance of Curriculum

63% of the teachers and 65% of the principals have indicated that the existing polytechnic curriculum matches with the functional requirements of technicians in industries.

44.6% of the passed out diploma holders have mentioned that the curriculum they had studied in polytechnics, were relevant to the field requirements.

Feedback from industries on the relevance of the existing curriculum (copies of which were circulated for comments) indicate that the curriculum contained lot of obsolete and unnecessary topics whereas much of the required topics were not included.

Last ten years' data collected from curriculum revision cells indicate that such revision work is being done only with the involvement of polytechnic teachers. Involvement of employer in such review workshops is very rare.

Referring to a study conducted in 1987 on profile of polytechnic institutions (74), it is found that 65% of the polytechnic teachers in position do not have any industrial experience, 10% have only 1 year of experience, 10% have 3 to 5 years of experience and the remaining 13% have more than 5 years of experience.The experience mentioned above were acquired by the teachers before joining the polytechnics.

Further, 85% of the polytechnic teachers have indicated that they organise teaching-learning through lecture method and without any linkage with industry.

While interviewing teachers, most of them expressed that they do not maintain any functional relationship with industry except for taking students on industrial tour by some of the teachers.

Keeping in view the status of industrial experience of polytechnic teachers and also the fact that majority of them do not maintain any professional linkage with industries, the response of 63% of the teachers indicating that the existing curriculum is relevant, can be attributed to their intuition only.

Feedback data indicates that most of the polytechnic principals have risen from the ranks of teachers,and only a very few of them take classes. Those who teach also follow the same traditional method and do not have any functional linkage with industries. Thus, the response of Principals on the relevance of curriculum can also be taken as their guess or imagination only. Feedback from employers and employed diploma holders indicate that curriculum still contains irrelevant and obsolete topics.

Information on curriculum revision work indiciates that the polytechnic curriculum is being revised on a regular basis at an interval of every 3 to 5 years.

How far the participation of teachers in the curriculum development work, who do not have up-to-date knowledge of the requirement of the world of work, enables revision of curriculum to answer the field requirements, is questionable.

From the above observations and analysis, it is concluded that the existing polytechnic curriculum needs revision on the basis of job analysis of diploma holders in industries and such an exercise needs to be taken up jointly by the polytechnics and industries.

(b) Learner Opportunities

85%of the teachers have indicated that they conduct clases by lecture method. Teachers during interviews expressed that due to limited time available, they were normally in a hurry to cover the course content and therefore resorted to simple lectures. Further, innovative teaching calls for extra effort and also management support in terms of flexible rules and regulations as well as encouragement. New teachers entering into the polytechnic system generally follow the seniors and there are very few examples in front of them to influence their teaching methods.

Close observations of teaching-learning in 10 polytechnics revealed that class-room interactions were limited to teachers asking questions to students on what the teachers had just told them. None of the teachers were found using any teaching aids except the chalk board.

In the drawing class, 58% of the students reported that they prepared drawings simply by copying from books or blue-prints supplied by the teacher. Only 20% of the students indicated that they developed the skills of reading and interpreting engineering drawings.

In the laboratories and workshops students were found working in large groups. The researcher in trying to know the initial preparation of students in practical classes, found out that the students came unprepared and depended entirely on the teacher to help them conduct the experiments. In some of the polytechnics, students in practical classes were found spending most of their time writing experimental procedure, etc. copying from old reports.

The response of polytechnic students as also of passed out employed diploma holders indicate that the project work (for final year students) in polytechnics are theoretical in nature and the same projects are repeated every year. Thus , the students are able to prepare project report by copying reports of senior students.

From the above observations and data, it is obvious that the learner has limited opportunities for self develop -

ment in terms of acqiring higher order intellectual as well as personal abilities which are needed by the world of work.

(c) 53.8% of the passed out employed diploma holders indicated that the evaluation system followed in polytechnics assesses the students' real abilities to a limited extent only. 57% of the students of polytechnics indicated that the evaluation system does not assess their real abilities.

While discussing the objective of student evaluation, some polytechnic principals remarked that the purpose should be to determine what a student knows, and not, what he does not know. Regarding draw-backs of the question papers of the examination conducted by the State Boards of Technical Education, the teachers mentioned that because of the overall choice being given, both teachers and students alike omit some portion of the syllabus. This sometimes leads to students not learning many of the important topics. The teachers expressed that instead of over-all choice, some other alternatives could be thought of.

An analysis of question papers was made of 1000 question papers taken on random basis from five State Boards of Technical Education. The analysis is presented in figure 2.1.

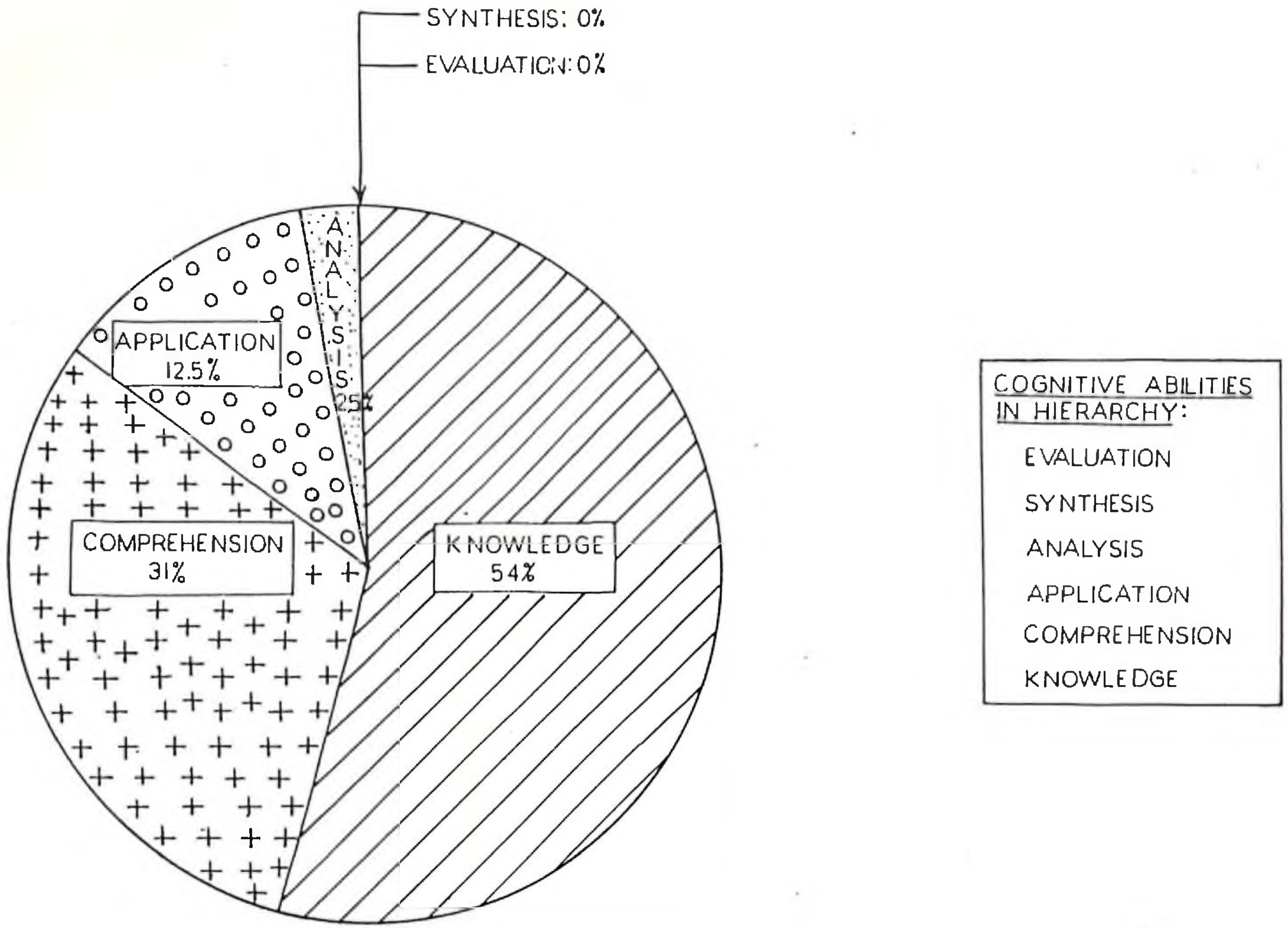


FIGURE 2.1 ANALYSIS OF QUESTION PAPERS OF STATE BOARDS OF TECHNICAL EDUCATION

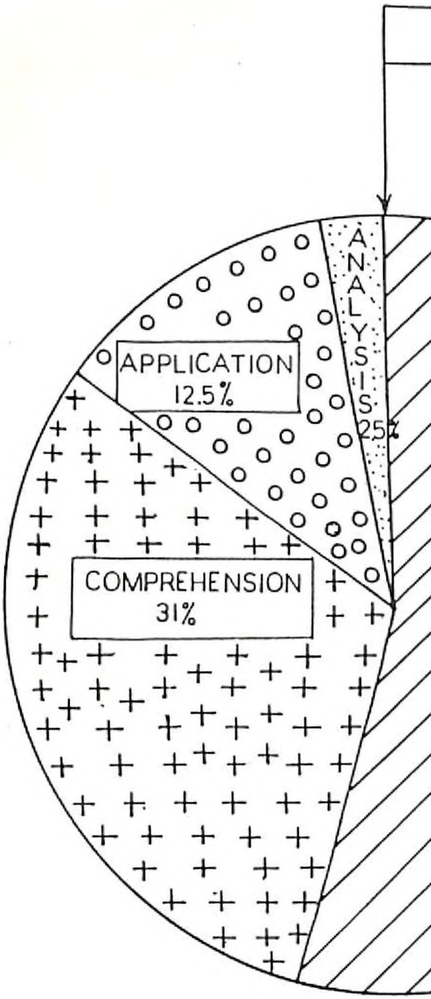
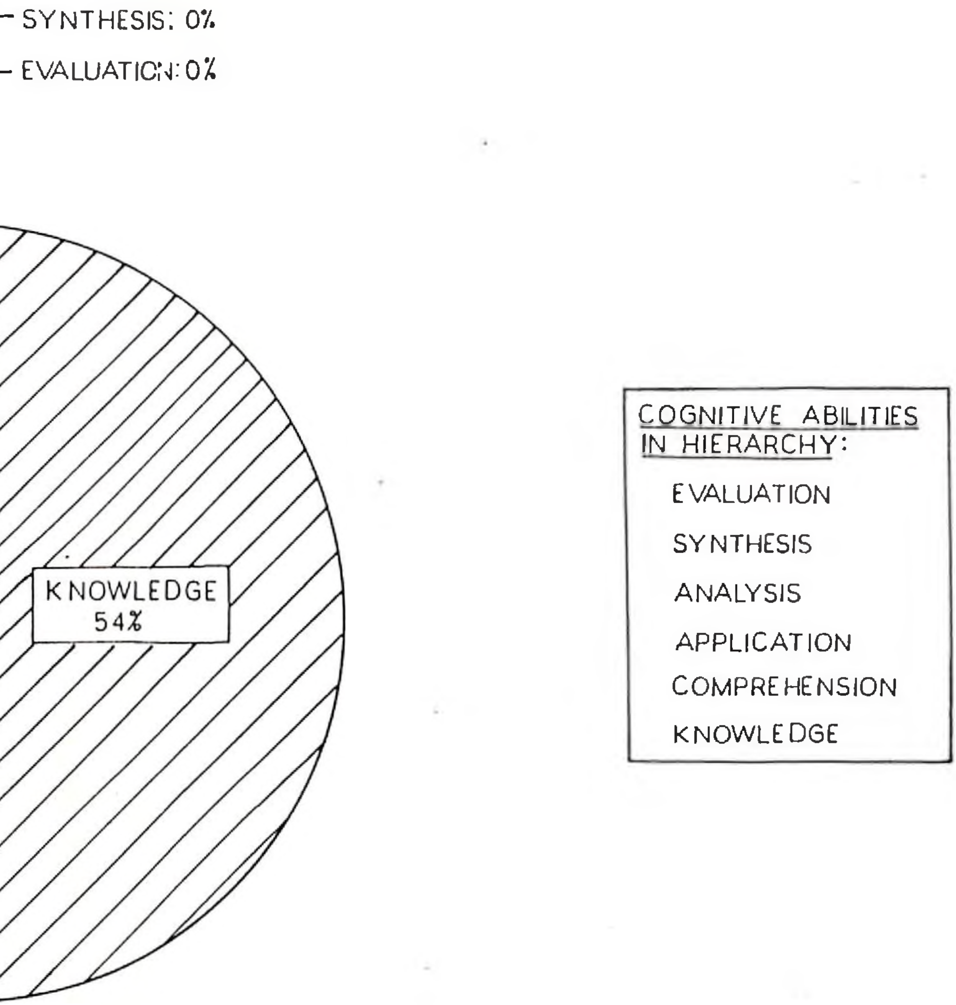


FIGURE 2.1 ANALYSIS OF QUESTION



PAPERS OF STATE BOARDS OF TECHNICAL EDUCATION

From figure 2.1 it is seen that 54% of the questions are of recall type. Only 31% are of application type. However, their level of application is mainly of use of known formulae and related calculations. Further, as there is overall choice to the extent of 60 to 70 percent (to answer any five questions out of given eight or nine questions), evaluation is actually done covering not the whole course content but a part of it. Interview with students reveals that, with this system of examination, they can pass by studying a few weeks before the examination. Teachers say that unless the examination system is improved the method of teaching and learning will continue to be the same as it is existing today. Interview with students further reveals that their participation in the academic activities and their preparation for examination are mainly governed by the prevailing system of examination. The above feedback leads to the vital requirement of evolving a system of examination which will evaluate stduents for their acquiring higher order intellectual abilities i.e. of abilities of application,analysis, synthesis, and evaluation, as also, for their other personality traits so as to influence the methods of teaching and learning in the polytechncis.

(d) Instructional Resources

On the status of instructional resources, 50% of the students expressed that learning material,i.e. good Text books, Manuals, etc. were not available to their requirements.

A survey of the available text books in the market shows that most of them have been written from the point of view of examination only and as such these books are more or less diluted version of degree standard books. In the emrging areas of technology, instructional resources at the level of polytechnics are mostly not available. Feedback from teachers indicate that only 15% of them use audio-visual aids in the class. The researcher investigated the reason for non-use of a-v methods of presentation by the teachers. Interviews with teachers reveal a number of reasons as indicated below:

- -Non-availability of audio-visual material,
- -Lack of class-room facilities for use of projected materials,
- -Non-availability of audio-visual equipment facilities,
- -Time-constraints,
- -Lack of management support for their use,
- -Absence of evaluation of teachers on the basis of improved teacher performance in teaching, and reward system.

However, all students appreciated teachers who taught through multi-media method of presentation. On instructional material requirement, TTTIs have been found to have contributed to a limited extent by producing text books, Laboratory manuals, educational films, experimental kits, demonstration models, charts, etc. However, TTTIs have not been able to develop any suitable strategy to ensure that the materials developed are used in actual field situation for improvement of instruction. Further, it is estimated that the time taken by TTTIs alone to develop the required instructional material will be too long.

From the above, it is clear that there is urgent need for developing instructional material both in print and non-print form as also evolving a teaching-learning strategy where such material developed will actually be used by the target population. Large scale participation of teachers and experts from industry could be arranged so as to meet the demand within a reasonable period.

(e) Interaction with employers

Only 29% of the students have indicated that they got exposure to industry from time to time. This has been substantiated by 28% of teachers who indicated that they occasionally take the students for technical visits.

Only 25% of the polytechnic principals have said that their polytechnics have developed some linkage with industries around for mutual advantage. 72% of passed out diploma holders have indicated that they did not get any exposure to indsutry while studying in polytechnics. 93% of teachers and 87% of Principals have indicated that teaching-learning in polytechnic need to be developed as a joint venture of polytechnics and industry by proper design of the curriculum.

Reference to the proceedings of large number of Seminars and workshops on quality improvement of polytechnic education indicates that ,everywhere, recommendations have been made for developing effective linkage with industry by the technical institutions. As a follow up of these recommendations some effort have been made by the system by way of organising technical visits of students in industry, practical training of students and teachers, inviting industries experts for delivering lectures, etc. But how this linkage could be strengthened for mutual benefit for improvement of teaching-learning in polytechnics seems yet to be explored.

(f) Teacher development

Interviews with teachers of different polytechnics indicate that by and large the teachers do not find the teaching job in polytechnics motivating and a challenging experience. Enthusiasm of newly recruited teachers also vanishes within a few years of working in the system. Some of them leave the system but many of them adjust by compulsion. It is the lack of academic climate, lack of challenge, and inadequate management support for achieving excellence, the teachers mentioned, the system is suffering from. Innovative teaching coupled with research and developmental work, the teachers felt, can only improve the situation. The view expressed by some of the senior teachers is that for development of teachers' competence for such work the management need to plan for both on-the-job and off-the-job faculty development programmes as also create conditions where the teachers could apply their knowledge and skill in polytechnic situation.

The management of the polytechnics maintain the view that faculty development programmes are being organised by the TTTIs and the Indian Society for Technical Education (ISTE) on a regular basis and the willing teachers are sponsored for participation in these courses.

Training programmes organised by TTTIs and ISTE are mostly off-the-job and for many a senior teachers such courses are not so meaningful, motivating, and rewarding. They are able to carry out their teaching,these senior teachers expressed, with their existing repertoire of knowledge and skill.

The need, therefore, appears to be to evolve a system of teaching-learning where teacher development becomes an integral requirement of his enriched job performance. Further, such a system of teaching-learning needs to be planned and implemented through a combination of on-the-job and off-the-job training programmes for teachers.

(g) Management of Teaching-learning

Discussions with teachers, principals and industries revealed the following with regard to management of teaching-learning:

The design of curriculum and its implementation strategy have not changed much, over the years. The management, due to its rigid rules and regulations and its preoccupation in administrative activities has not been able to bring about a climate of change for bringing much improvement in the teaching-learning. There is lack of planning both at the institutional level as well as at the departmental level for organising improved teaching-learning activities. Industry, by and large, responded positively for collaborating with technical institutes in quality improvement aspect of education and training. The polytechnic passouts, employed in various industries, expressed that, their institutes never approached them for any assistance in terms of their participation in curricular activities of the polytechnics. Polytechnic principals expressed the need for autonomy so as to do innovative work. They are bogged down into routine administrative activities so much so that even the departmental Heads are required to spend much of their time in assisting the Principals in their administrative work, leaving little time for innovative academic work.

Academic autonomy and flexible rules and regulations, coupled with Principals and Heads of Departments playing the role of facilitators for innovative teaching-learning, are considered essential for bringing a change for development.

2.3.3.3 **Summary of status of instructional practices in Polytechnics**

The existing teaching-learning practices in polytechnics, studied and as reported above, are summarised as follows:

(i) Instruction in polytechnics is, by and large, teacher centred where teaching is through lectures and is oriented towards passing of informations.

(ii) Students are passive and are merely receiver of informations.

(iii) Examination is more oriented towards judging the students memory.

(iv) Instructional resources appropriate to the level and requirement are not available.

(v) Curriculum does not fully reflect the functional requirements of technicians in industry.

(vi) Polytechnics do not have required level of interaction with industry and work more or less in isolation.

(vii) Teaching-learning in polytechnics is a routine job devoid of much challenge both to the teachers as well as to the students.

(viii) There is less emphasis on basic skill development.

(ix) Emphasis is more towards theoretical study than towards developing such abilities as required by the world of work.

(x) Polytechnic management is stereotyped and does not provide enough motivation and support for innovative teaching-learning.

(xi) Polytechnic system is working towards achievement of quality and excellence entirely on their own without establishing much linkage with the client system i.e. the employers.

2.3.3.4 Suggestions on improvement of teaching-learning

Persons working in the system as also the employer organisations had suggestions to offer for the improvement of the system of technical education. Suggestions were therefore received from employers, teachers, students and employed diploma holders for quality improvement of polytechnic product. The general suggestion received from all concerned was to plan and organise teaching-learning to develop basic skills as well as application of knowledge in practical situations to enable students face the challenge of changing technological scenario of the world of work. Some of the specific suggestions received are mentioned as follows:

(i) Involvement of professional experts in delivering lectures on important topics;

(ii) Organising planned industrial visits for students;

(iii) Involving professionals in student evaluation;

(iv) Supervised practical training of students in industry;

(v) Revision of curriculum based on feedback from employer and employed diploma holders;

(vi) Training of teachers in pedagogy;

(vii) Training of teachers in industry;

(viii) Involvement of students in project work of practical significance;

(ix) Emphasis on development of basic skills;

(x) Development of field oriented practical skills;

(xi) Provision of well equipped laboratories in terms of basic equipment and measurement devices;

(xii) Instructional material development as per the level and requirement of polytechnics;

(xiii) Improving the skills of laboratory and workshop instructors.

Most of the suggestions mentioned above, although relevant and important, are found in the reports and recommendations of various expert committees as also in the proceedings of Seminars and Workshops conducted on the quality improvement of technical education. But what is important in the context of this research work is to design teaching-learning systems where implementation of these important suggestions are purposefully integrated with students' training.

2.4 Fundamental deficiency in the polytechnic product

Studies conducted on polytechnic teaching-learning process, the employers reactions on the polytechnic product, and the desired specifications of the product in view of the requirement of the changing technology in the world of work have been presented in Section 1.3 of Chapter I as also in Section 2.3 of this Chapter. Responses have also been received from students, teachers, employers and planners. What is central to these responses on the present situation is that the polytechnic products are lacking in their 'ability for transfer.' The success or failure of any educational programme must be judged in the long run not only by how well it succeeds in the laboratory or in the class room but also according to how well it prepares the individual for some organised life situations. The acquisition of skill and knowledge will be of limited significance unless the learned behaviours can be adopted to longer-term life process than the learning situation itself. Transfer of learning occurs when learning in one situation influences learning and performance in other situations. If there is no transfer value of learning at all, students ought to be taught specifically every act that they ever would be required to perform in any situation. In its broadest sense, transfer of learning is considered basic to the whole notion of schooling. People who support this view, as well as those who teach, assume that matters being taught today will have some learning value in later times in different situations. This consideration, which underlies the objective of entire education system, is that learning gained in school not only will be available in the future but also will be applied in some degree to the solution of new problems as they arise in life situations.

The effectiveness of any education system depends, to a large extent, upon the amount and quality of transfer potential of the matters that students learn. Thus, transfer of learning is a corner stone upon which education ultimately should rest. However, in actual operation, everyone seem to be more concerned about short-term educational objective i.e. of immediate learning outcome.

The requirement in terms of need for training for transfer towards achieving the long-term educational objective is the issue that this thesis would be dwelling upon.

2.5 Learning theories and the corresponding strategies for achieving transfer

Since the seventeenth century systematic theories of learning have emerged providing sound basis for design of instruction. Earliest among them is the 'Mental discipline' theory. Mental discipline theory considers learning consisting of students' mind being disciplined or trained. Educational practices based on the theory of mental discipline stresses the necessity for developing the 'muscles of the mind' by rigorous exercise.The basis for transfer of learning consists of trained mental faculties and cultivated intellectual powers.However, Thorndike E.L. through his experiments in 1924 destroyed conclusively the notions about the existance of general faculties of learning and memory that can be trained by formal discipline. The fact is that the symbolical learning of the class room rarely is used directly but must be transferred from abstruct formulations to concrete situations in order to be used at all. Thorndike's findings showed that it was the 'common identical elements' between two learning situations which enhanced transfer.

However, the theory of identical elements was questioned by Charles Judd, who contended that transfer was based on an understanding of general principles rather than upon recognition of identical elements.

The second major theory of learning which followed mental discipline theory was 'Apperception' which emphasise implantation in the minds of students a great mass of facts and ideas that have been organised by someone other than the learner. Apperceptive education resembles a process similar to 'filling a storage container'.Promotion of transfer of learning is achieved by building up the apperceptive masses of the students. The formal rigid approach of Apperceptionists, coupled with what seems to be emphasis upon rote learning makes teaching much like the kind of education practiced by mental disciplinarians. Since students completely depend upon the teacher, who provides all the leadership in learning, critical thinking is discouraged and students tend to be docile. Facts are acquired for examination purposes, then rapidly forgotten; their transfer value tends to be too low(8,9,32).

Significant learning theories developed on the basis of experimental studies during the twentieth century are the 'S-R conditioning' theories and 'Cognitive field' theories. Stimulus-response theory views human beings as passive or reactive Learning is viewed as the ability to perform new behaviours which are established as the goals in applied situations. B.F. Skinner, a prominent proponent of S-R theory, views learning as an observable change in behaviour. The structure of internal thinking and learning process is considered irrelevant to the process of instruction, which is seen as the structuring of the environment in such a way as to maximise the probability of the desired new behaviour being learned. Skinner's Operant conditioning theory of learning carries with it definite implications in regards to the nature of transfer and its role in teaching and learning. Since, within operant conditioning, learning simply is a change in the form and probability of a response, transfer likewise is an increased probability of responses of certain class-occuring in future(8).

Emphasis upon creative aspects of learning is traced to the early work of the Gestalt psychologists. Whereas behaviourists treated learner as passive organisms and studied how they could be manipulated by the environment, Gestaltists believed that organisms were innately active in their interactions with the environment. Much behaviour resulted from internal motivation rather than external stimulation.

This work of the early Gestalt psychologists, alongwith their emphasis upon learners as active information processors, was the basis for the development of later cognitive approaches to learning. Cognitive theory views learning as active restructing of perceptions and concepts, not passive response to external stimulation and reinforcement.

Cognitive field psychology is an interpersonal, social psychology that constitutes an effective vehicle for understanding people as interacting persons. In the interactive process a person and his psychological environment are construed as interdependent variables. Learning is defined as an interactional process within which a person attains new insights or cognitive structures or changes old ones.

According to cognitive-field psychology, a child or youth in a learning situation is not unfolding according to nature; neither is he being passively conditioned always to respond in a desired manner. Rather, at his level of maturity and comprehension, an individual is differentiating and restructuring himself and his psychological environment; he is gaining new insights. Learning, then is a dynamic process whereby, through interactive experience,insights or cognitive structures of life spaces are changed so as to become more serviceable for future guidance.

According to Cognitive psychologists when transfer of learning occurs, it is the form of generalizations, concepts, or insights that are developed in one learning situation being employed in others.

A person is in his best frame of mind for transfer to occur when he is aware of acquiring meanings and abilities that are widely applicable in learning and living. Transfer of learning to new tasks is considered better if, in learning, the learner can discover relationships for himself, and if he has opportunities to apply his learning to a variety of tasks(7).

Jerome S. Bruner, a cognitive learning and developmental psychologist, in his study of human beings, considers them as being information processors, thinkers and creators. The first central unifying theme of Bruner is that the acquisition of knowledge, whatever its form, is a dynamic interactive process. The second is that a person constructs his knowledge through his relating incoming information to a previously acquired psychological frame of reference.

Cognitive-field psychologists do not object to having students learn facts and remember them for future use. However, they maintain the view that facts are learned best when they are regarded by learners as instruments for serving purposes that they feel are important.

An educational programme consistent with a cognitive-field psychology focuses on teaching students to think more effectively in a wide variety of situations, it entails problem-centered teaching.

2.6 Cognitive field psychology providing an emergent teaching theory and practice

The primary purpose of referring to learning theories is to critically evaluate these psychological theories and principles from the point of their applicability to class-room practices. However, when this is done, it is seen that whereas certain aspects of respective theories of learning and teaching support one another, some others conflict. Traditionalism is criticised on the ground that it does not permit students enough freedom for intellectual exploration, and progressivism on the ground that it assumes that adequately worthwhile learning will necessarily result if students are given freedom and allowed to plan their own activities. Although cognitive-field psychology is not a compromise between the psychologies underlying traditionalism and permissivism, it does lead to a kind of middle position i.e. a position that permits students considerable amount of freedom, but only within certain confines. Cognitive field psychology appears to be an emergent position that, if widely adopted, might eliminate some of the inadequacies of earlier psychologies. The adoption of cognitive-field psychology as a basis for teaching would lead to greater student participation than is permitted in traditional teaching-learning situations and this participation would be democratic. Widespread acceptance of cognitive-field psychology would restore an intellectual emphasis in education and at the same time provide a psychological basis for eduation free of the criticism validly made of the old 'mind training' or 'Apperception' approach(8,9).

2.7 Types of learning situations needed for achieving long-term learning objective

Each of the learning theories mentioned in Section 2.5 leads to a different level of teaching. Whereas mental discipline theories lead to memory level of teaching-learning, cognitive-field theory leads to reflection or exploratory level of teaching-learning. In exploratory teaching-learning environment the learner is situationally and perceptually interactive, there is purposive involvement of the learner in problem solving,there is perplexity and the learner getting an intelligent 'feel' for a principle, idea, or act, and there is personal involvement of the learner in the learning tasks(8).

The nature of learning include purposively acquired exploratory understandings, insights, principles, relationships, concepts, generalisations, rules, theories, or laws and added to it is an enhanced scientific outlook and instrumental thinking. Such a teaching-learning situation has a perceptual interaction, that is, simultaneously mutual interaction leading to a cognitive experiential process within which a person, psychologically, simultaneously reaches out to his psychological environment, encounters some aspect of it, brings those aspects into relationship with himself, makes something of those aspects, acts in relations to what he makes of them, and realizes the consequences of the entire process. Experience with exploratory or reflective learning would enable the learner gain an incresed store of generalised insights related to the subject studied, and these are incorporated at the personality level so that a permanent change occurs in the learner who would show a greater disposition and ability than before to apply the scientific reflection to problems outside the school subject.

Such reflective teaching and learning would enable students to emerge with an enlarged store of tested insights of a generalised character and an enhanced ability to develop and solve problems on their own. Within problem centred learning, the students learn the very nature and technique of problem solving processes which can be applied in and outside the school. The problem centred reflective teaching-learning therefore requires students participation in open-ended problem solving activities, by open-ended meaning the type of problems whose solutions are not known either to the students or to the teacher. It may be mentioned at this point that often problem centred teaching-learning have failed because what were chosen as problems were, infact, not problems in real psychological sense.

A learning problem is not just an objective issue to be resolved; it must also involve psychological tension in a learner(8).

Problems are either personal or societal in nature. Personal problems hold a dominant place in the life spaces of students. Societal problems, to students, often, seem remote, unless students feel themselves personally involved with them. Thus, to create motivation in students, to arouse psychological tension in them in attempting societal problem solving, it is necessary to bring them near to such problems existing in the environment around and make them feel involved so that they own such problems as their own. Problems chosen from the field and from the area of employment, solving of which puts a challenge to students, and for which there is a taker, is considered motivating to students.

Participation of students in such open-ended problem solving activities by definition, will have to be project oriented. Such projects could form an integral part of the study of subjects by students in the institutions. Working on open-ended projects would require students' initial preparation in terms of basic concepts and principles and also their orientation towards problem solving procedure. While the theory could be taught through explanatory level of teaching, problem solving need to be learned through students' direct involvement into related project activities.

2.8 Implications of project method of teaching-learning

Problem centred or project oriented teaching-learning involves learning in the presence of genuine problems that the students feel the need to solve and for which no ready-made answer is available. Through the study, the students and teacher, working cooperatively, develop what is for them a new or more adequate solution. Such a project oriented learning is essentially based upon, and has much in common with a modern sicnetific outlook and approach. It reflects the conviction that students study and learn best when they are seeking both the intellectual and emotional relevance of their learning to significant aspects of their lives. Education that centers around such exploratory teaching-learning consists of both students and teachers experientially reconstructing their respective life spaces in such a way as to add to their meaning and thereby increase the involved persons' abilities, both individually and collectively, to direct the course and contents of their future life spaces. Identifying and helping students to understand problems, formulating and testing of hypothesis, evaluating students total personality triats, are some of the challenging activities the teacher has to assume if project oriented student-teacher centred teaching-learning is to be made operative. In such a teaching-learning situation formulation and testing of hypothesis is to be conducted in an atmosphere that resembles as far as possible that of a scientific laboratory. The same open-minded and objective attitude that characterise any scientific investigation should prevail. Thus, the teachers' role becomes analogous to that of a head scientist in a laboratory; the teacher need to help students construct hypotheses and then assist them in testing them out. Problem centred study is expected to encompass a variety of evidence-seeking activities. It is likely to include the use of individual and group research, home study, market survey, field trips, gap lectures, etc. It may also include considerable and teacher, working cooperatively, develop what is for them a new or more adequate solution. Such a project oriented learning is essentially based upon, and has much in common with a modern sicnetific outlook and approach. It reflects the conviction that students study and learn best when they are seeking both the intellectual and emotional relevance of their learning to significant aspects of their lives.

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All these involve extra work and cognitive abilities of the highest order on the part of the teacher and, as such, the whole of teacher community, although appreciative of the educational value of the project oriented teaching-learning, seems to be against it. At the same time the parental illeteracy also militates against the project method, as for parents, it means a living exercise in experiencing the evolution of a child in child's own image and consistent with child's own abilities rather than in parents' own image and along the framework of artificial abilities as perceived by them.

The above reactions and feelings ultimately go to suggest that project method of teaching-learning is good but it is too idealistic and also teacher intensive. However, it is argued that what is idealistic is the only 'practical8 edcuation and the most teacher intensive situation is also most interactive, requiring continuous learner participation and effort for learning for transfer. Teacher intensive learning situation like project oriented method of teaching-learning demands more work from the teacher, but it is not the physical or motor work, instead it is the cosntant thought analysis and synthesis, constant decision making in uncertainty, constant management with minimum information,that is involved. This kind of work is interactive where the teacher and the student together working cooperatively are arriving at answers to open-ended problems. The teacher is like a scientist leader and therefore is leading a learner team in a constantly unfolding situation where,every second,fog recedes revealing still wider region of possibilities to choose from, thereby simultaneously presenting the mind with excitment of choosing from the multitude as also the worries of facing too vast a canvas. This is the interactivity that has got to be present in every learning situation, come what may, if training is to be for transfer and this requires constant adaptation in the learning cycle where even accomodation sounds to be a big achievement, with the whole system of education aiming only at assimilation.

2.9 Interactive teaching-learning -a must for achieving transfer of learning objective

Much of the inefficiency in education that research has exposed stems from the way most subjects are organised and taught. Systems of teaching-learning where the teacher tells and the student listens, or the teacher stimulates and the student responds, are basically uncritical and authoritarian systems. In either case, the learner follows directions passively to accept what he is told, and to believe that education consists of those who know telling those who do not. In contrast to this type of education, interactive teaching-learning enables learner to reflect and to see how knowledge changes, grows, and is subject to interpretation and what divergent or lateral thinking is, and how difficult it is to accomplish. Thus, the student learns both to perceive the difference between relevant and irrelevant information and reliable and unreliable sources.

An understanding of how to solve open ended problems and that too in an interactive way, according to principles of scientific reflection is perhaps the most useful intellectual tool a person can possess. In spite of its high educational value, everyone seems to be against the introduction of interactive processes in the teaching-learning system. The only silver lining or ray of hope can come from the technology development scenario running parallel, which is presenting rates of change never known before, thereby making overnight a master of assimilated knowledge, an illiterate of tomorrows' technology. It is this educational anomally which is to be answered and for this purpose the interactive teaching-learning processes have to be made operative and this would intern demand activity oriented learning situations alongwith vicarious inputs in the curriculum.

Open-ended project method is one known channel for activity induction in the curriculum and problems chosen from work place are probabilistically appropriate projects for this learning situation.

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CHAPTER-THREE

PLANNING FOR INTERACTIVE TEACHING-LEARNING SYSTEMS

3.1 Introduction

Achieving long-term educational objective i.e. preparing students to face the challenge of fast changing technology, interactive teaching-learning, which has high transfer value, has been considered most essential.

Further, to make such teaching-learning meaningful and motivating, the learner need to be involved in such tasks which are open-ended, challenging and have direct relevance to real life situations.

Project based learning is one of the known methods where the learner as well as the teacher gets involved in problem solution in an interactive mode.

Various learning theories have shown ways for achieving transfer of learning objective, the latest amongst them being the cognitive field psychology which by implication advocates exploratory level of teaching-learning. Expert Committees, professionals, and educators have made important recommendations and sugestions for creating relevance of the subjects of study, improving teachers competence, and also for incorporating interactivity in the teaching-learning process.

This Chapter discusses in brief the interactive instructional designs implemented in India and elsewhere and also makes summary presentation of the relevant recommendations of expert committees and professionals for quality improvement of the polytechnic education and training.

Taking into consideration the past experience and the recommendations and suggestions as also keeping in view the educational theories of cognitive field psychologists, four alternative conceptual models for interactive teaching-learning have been presented. Details of planning for conduct of specific experiments following each of these models have been described in this chapter.

3.2 Bringing interactivity in teaching-learning system design

3.2.1 Contributions of John Dewey and Kilpatrick

Dewey's lasting contribution to a technology of instruction was his conception of instruction in terms of scientific method, defined in its broadest sense. Dewey's instructional approach, which was basically problem method of teaching, resembled that of a scientific investigation in which hypothesis could be formulated and tested.

While simplifying and clarifying Dewey's complex thinking and writing, as well as adding his own interpretations, Kilpatrick developed the Project Method in 1918. Kilpatrick reorganized the curriculum as a succession of projects suitable to the interests of learners.

Project-based learning systems were developed through questioning of the personal,individual and social purposes of education and the formation of the traditional classroom, where the cultivation of knowledge and character took place by rote-learning. Project-based systems are a close simulation of the research and development process in real life industrial and academic institutions. As such, they have a dual function—the immediate one concerned with the content of the project and a long-term 'learning to learn' function. The problem method and the project method were natural corrolaries of the progmatist philosophy which held that concepts are understood through observable consequences and that learning involved direct contact with the environment.

3.2.2. Project method of instructional designs

Project method of instructional design have been implemented in various forms in higher institutes of learning in many advanced countries like the U.S.A. and the U.K. At Worster Polytechnic, Massachusetts, two projects form an integral part of the degree programme - a qualifying project intended to relate technology and some aspects of social concern. An increasing number of both major and interactive projects are undertaken completely, or partly, off-campus and these usually involve industrial organizations and Government agencies.

The Massachusetts Institute of Technology undergraduate Research Opportunity Programme is a broad based institute-wide programme which seeks to encourage and support undergraduate participation in the research activities of faculty members,through involvement with particular research project.

Other examples of instructional design where project activity forms a course are "a degree by thesis in Chemistry, University of Sussex, U.K.; Independent study scheme of Lancaster University, UK: Inter-disciplinary project-oriented education, Roskilde University, Denmark. In India, project work at both degree and diploma level institutions are included as an integral part of a programme and are implemented towards the end of that particular programme.

3.2.3 Computer-Based interactive instructional systems

Computer-based instructional system designs encompass, a broad spectrum of computer applications in education viz. Computer Managed Instruction, Interactive Instruction, Instructional Simulation and Inquiry.

Interactive instruction which subsumes the concepts of tutorial instruction and drill and practice, presents instructional material to the learner, accepts and judges responses from the learner, provides feedback, and alters the flow of subsequent instructional material based upon learner's responses thus bringing in interactivity in learning. However, even in countries like the U.K., the development and use of computer based interactive learning system packages have been sporadic and have made little impact on the curriculum. While there is activity and opportunity in computer assisted instruction, its achievements and effects seem muted (94).

3.2.4 Project based learning through Sandwich courses

Sandwich courses where part of the time the students spend in industry for practical training have been implemented in U.K. and other advanced countries. Sandwich courses have also been implemented in some selected polytechnics in India. The success of these courses however, lies as observed by Chandrakant, on assigning real life problems to students by the sponsoring industry and also guiding students in problem solving by the teacher in association with the industrial consultants.

3.2.5 Placement in industry for experiential learning

To provide real life experiential learning experience, students during their educational career, are placed in industries for a period ranging from one month to six months. In India, students are sent to industries for such training during vacation periods. At polytechnic level, in most of the cases in India, such industrial attachment is optional. In the absence of any guidance, the effectiveness of such student training appears to be much below the desired level of expectations (15).

3.2.6 Cooperative Education-BITS Pilani experience

The practice school (PS) model of BITS Pilani, implemented at University level of education, has shown considerable success in terms of achieving long-term educational objective. In PS, a group of students and a teacher are involved in real life problem solving assignments where the problems are of direct interest to the professional organisations where the student-teacher team is attached.The concept of practice school model of interactive teaching-learning have been elaborated by Mandke,V.V. in his various writings.To quote Mandke, "Just as a medico serves as an intern in a teaching hospital before his graduation, the Practice school system of education requires students of engineering, sciences and liberal arts to practice their respective professions during the educational years. Thus, the theory of higher education is based on the central theme of the teacher-student participation in the environment. As a process of education, the practice school method substitutes the narrative approach followed within the four walls of a class-room and the two covers of the text-book by experience based cognitive process of learning and teaching, operative in the very way of life, thus making education student centred and environment as well as cirucmstance oriented.

Further, the PS differs in a major and most fundamental sense from the engineering practical training and Sandwich schemes in terms of its requirement of a full-time faculty presence at practice stations. While on the one hand, the PS faculty along with professional experts directly interact on practice assignments, on the other hand, the PS faculty in consultation with professional experts shoulders the entire responsibility for supervising the day to day student performance during their PS involvement..."

The PS system of student training is educationally sound and has successfully been implemented at university level. This model has also been implemented in one of the polytechnics in India with considerable success(88).

3.3 Alternative strategies for interactive teaching-learning system design - recommendations of professionals and expert committees

Professional experts and various committees on development of technical education in India have provided suggestions/recommendations from time to time.(14,15,16,19, 20,33, 57, 58, 59, 60,68,71).These recommendations, directly or indirectly, envisages incorporation of interactiveness in instructional process and, can gainfully be used in the design of alternative interactive instructional systems. These recommendations, in the form they were available, are listed as follows:

(i) Polytechnic courses be offered in sandwich pattern where part of the time the students would spend in industries for gaining job related practical experience.

(ii) Experts from industries be involved in delivering extension lectures in the polytechnics on selected topics as also in student evaluation.

(iii) Project activities should be encouraged and given due importance in polytechnic course offering. Such projects should be of practical significance.

(iv) Learning experience to students be provided at two places, namely the polytechnic and industry.

(v) A close meaningful relationship and spirit of partnership be established between polytechnics and industry for curriculum development.

(vi) Polytechnics should organise teaching-learning through providing opportunities to students on real life problems, learning by practice, learning not only of the subjects but also decision making and learning to exist, live and grow in real life situations.

(vii) Practical in-plant training of students to corelate theory and practice be organised.

(viii) Apprenticeship training scheme be fully implemented.

(ix) Expose students to real life situations, to visualise the applications of knowledge and skills as also invite professionals to participate in curriculum implementation. Exchange of faculty with professionals may be explored.

(x) Make learning tasks meaningful and challenging through use of project activities

(xi) Provide self pacing in learning through activity oriented student centered learning.

(xii) Emphasise development of higher order cognitive abilities rather than loading students' mind with lot of informations.

(xiii) Design vocational courses to promote transferable skills in order to optimise vertical and horizontal mobility and to cope with the demands of rapidly changing technologies

(xiv) Personnel of user agencies may be involved in designing courses, teaching and training. These user institutions/ agencies may be utilised for setting up 'practice schools' and educationally supportive 'work-benches'.

(xv) Create relevance of the subjects of study, to increase student motivation and interest through use of meaningful learning exposure to industrial process and practices, and by emphasising practical work.

(xvi) Industrial practice school to provide opportunities to students and teachers to engage in real life goal oriented problem solving activities be established.

(xvii) Design competency based education for students

(xviii) Emphasise on development of total personality of students rather than only imparting knowledge through teacher based activities.

(xix) Create opportunities for applying knowledge and skill in a variety of real life task situations

3.4 Alternative models of teaching-learning

Keeping in view the objectives of polytechnic education, the experience with the existing methods of teaching-learning, the recommendations of various expert committees, and the theories of learning and instruction, different teaching models can be conceived. Each model will obviously have their advantages and limitations. In this research study four such models have been visualised for experimentation. These models are described as follows.

3.4.1 Institutional training followed by Student-teacher involvement in industry

This model follows the practice-school model where the institutional training is offered through class-room and laboratory experiences for learning of the given course content to be followed by attachment of students and teachers in industries on problem solving assignments, the problems being of interest to the host industries. The industrial experts work as consultants to the team thereby establishing a meaningful interactive relationship between the students, teachers, and industrial experts. Placement of students in industries are done by matching the requirements of the problem with the profile of the student group. Working on such project requires students to prepare themselves with the basic knowledge of concepts, principles and other related informations which are to be provided to students through institutional training. Opportunities are to be provided to students to participate, as far as possible, in the institution based teaching-learning also. In addition, students are to be introduced to the very approach to open-ended problem solving,

Open-ended project activities at the work-bench provide opportunity to each member of the team participate in the learning process and interact purposefully with team members, their teacher, and the consultant. Evaluation of students are done against certain criterion which are considered the requirements in real life situations. A feedback system provides opportunities to students to reflect on their strong and weak areas and thereby help themselves develop.

Figure 3.1 shows in schematic form the model which is based on education-work linkage as an integral part of curriculum.This model is different from the sandwich model in the sense that the teacher is also placed in industries alongwith a group of students to guide them in the project activities. Thus, a part of the institutional

MODEL I :

OPEN ENDED PROJECT BASED
STUDENT TEACHER INVOLVEMENT
AT THE WORK BENCH

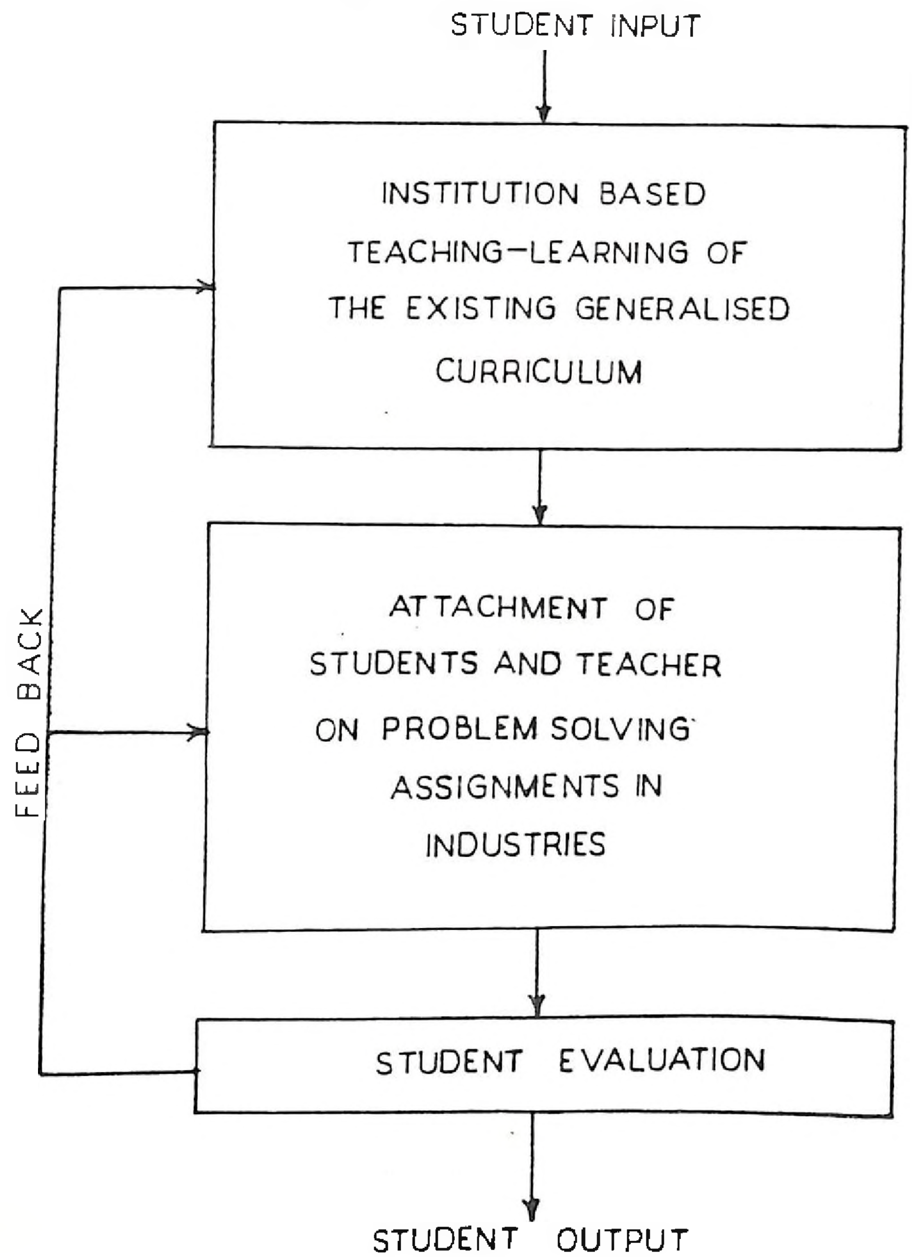

FIGURE 3.1 : MODEL ON PROJECT BASED STUDENT TEACHER INVOLVEMENT AT THE WORK BENCH

training requirement in terms of giving students opportunities for application of knowledge and skill, is now shifted to work - bench based learning situations.

3.4.2 Project activity as an integral part of the institutional training

This model envisages institution based course offering around open-ended project activities. The students study the basic concepts and principles as prerequisite knowledge to project work through class-room interactions with the teacher. This is followed by open-ended project work at the institute but by inter-actions with industries. To increase the efficiency and effective-ness for student learning of basic concepts and principles,instruc-tional material in the form of self learning activity package, demonstration models, reference study material, practicals,periodi-cal tests and feedback, etc. are arranged. To help students work on project work, extension lectures, group discussions,gap lec-tures etc. are organised by involving experts from industries. The teacher and the industrial expert thus form a team of project guide for the students. Evaluation of students is to be done for judging students problem solving abilities through multiple evaluation instruments and for providing feedback.The model has been shown in figure 3.2.

3.4.3 Use of Teacher made graded exercises for developing problem solving competence

In this model, as shown in figure 3.3, the course content is converted into a series of graded exercises for enabling

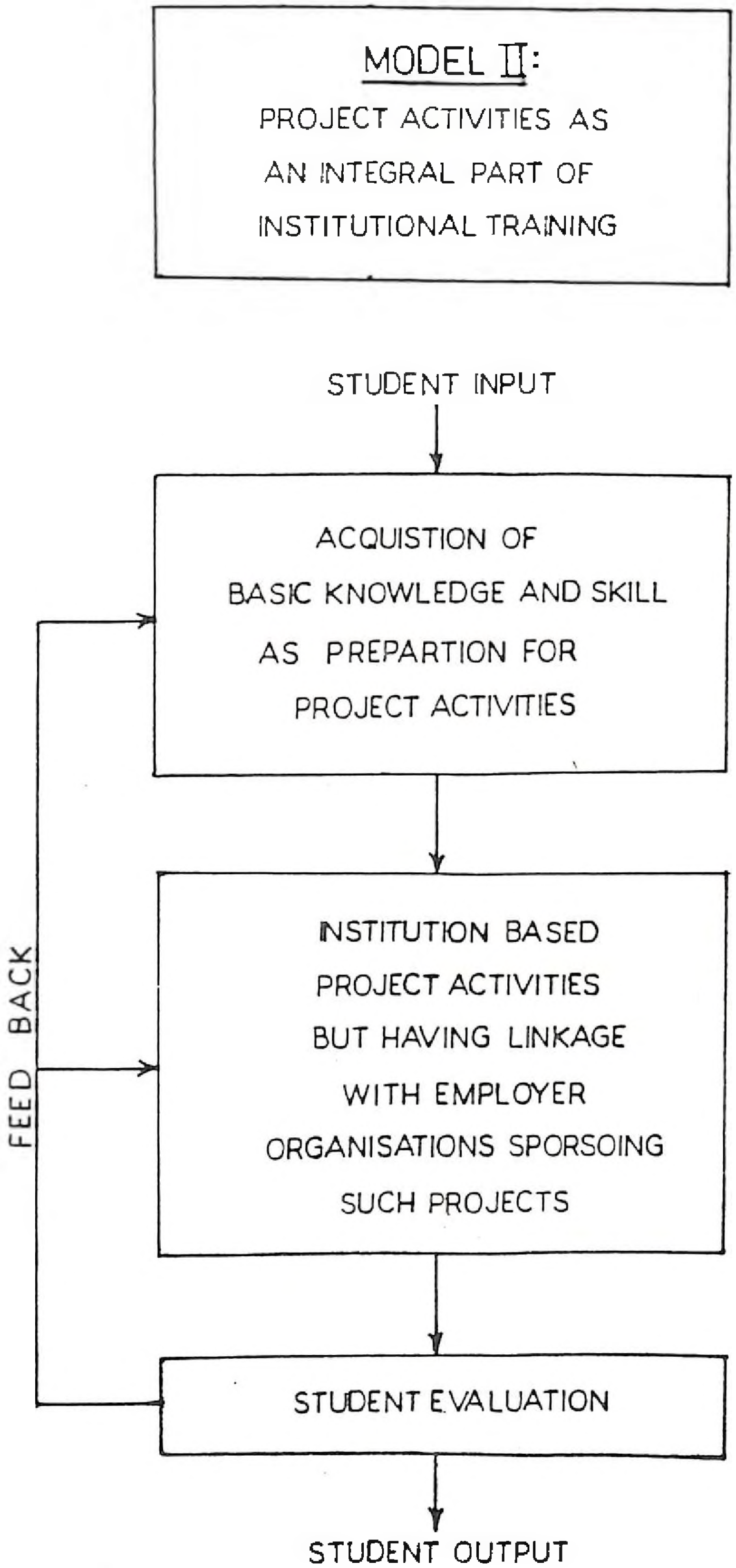

FIGURE 3.2 MODEL ON PROJECT ACTIVITIES AS AN INTEGRAL PART OF INSTITUTION BASED TEACHING – LEARNING

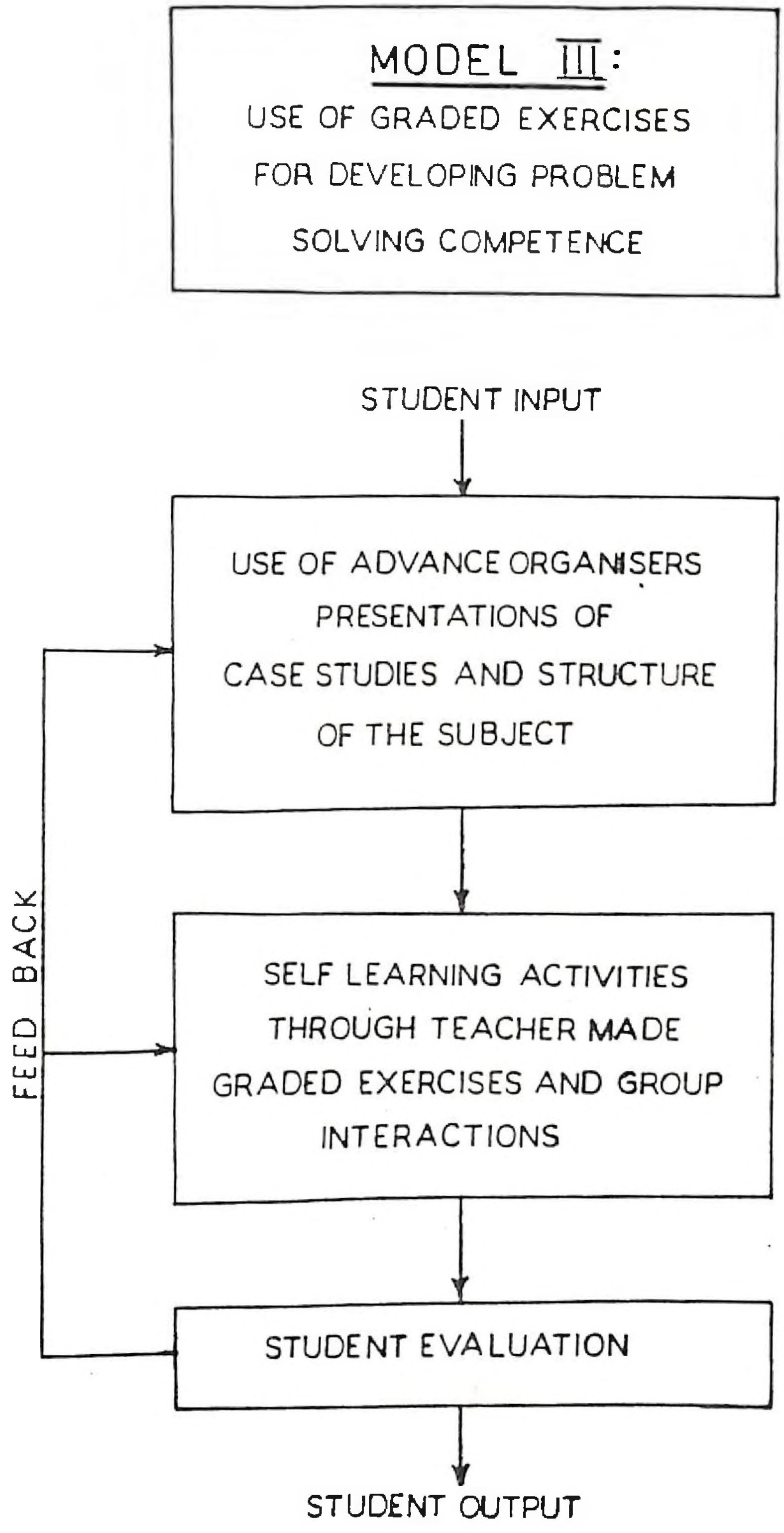

FIGURE 3.3 MODEL ON GRADED EXERCISES FOR DEVELOPING PROBLEM SOLVING COMPETENCE

students to work in the class-room on individual basis. The exercises are made keeping in view the objectives of the course and are organised from simple to complex exercises. Feedback for tasks are inbuilt into each module of exercises. The exercises are prepared by involving experts drawn from the polytechnics. Students while working on the exercises can proceed at their own pace of learning and have the access to the teacher for consultation. At the end of each module of study, group discussions and enrichment lectures are organised by the teacher to clarify doubts and to provide additional informations. Students who do not have the prerequisite knowledge of a module, are given remedial study material to make up their deficiencies. In addition to the graded exercises, the students are given assignments to acquire further experiences. Students are evaluated through periodical tests, viva-voce, assignments, and day-to-day observations. Evaluation of students on their problem solving abilities are done jointly by teacher and industrial experts using multiple evaluation tools as in Model I and II. They are also evaluated through comprehensive written test. Feedback is provided to students after each evaluation.

3.4.4 Study of functional curriculum and internship in industry

This model envisages acquisition of basic knowledge and skills of a functional curriculum through institutional training followed by attachment of students in different functional areas in relevant industries to work as interns under the guidance of industrial supervisors to gain real life problem solving experience. Related learning reference material are provided to students to help them understand the subject of learning while assisting the supervisor in his tasks. Evaluation of students is done using multiple evaluation instruments by the industries in association with the visiting faculty. Students are also evaluated through a comprehensive written test covering the entire course content at the end of their internship in industry.

Teaching-learning material in the form of a total learning package is used to help students learn the basic theory through institutional training as well as learn the functional aspects while working as interns in industry.

It may be useful to clarify the use of the term 'internship' here. In practice school model, which is similar to model I described earlier, the term internship has been used. In this model, the same term is used to convey the idea that the students have 'on-the-job experiential learning' while assisting the supervisors on their day-to-day problem solving tasks.

Figure 3.4 represents the model for use of functional curriculum and students' internship in industry.

MODEL IV :

INSTITUTIONAL TRAINING IN FUNCTIONAL CURRICULUM AND INTERNSHIP IN INDUSTRY

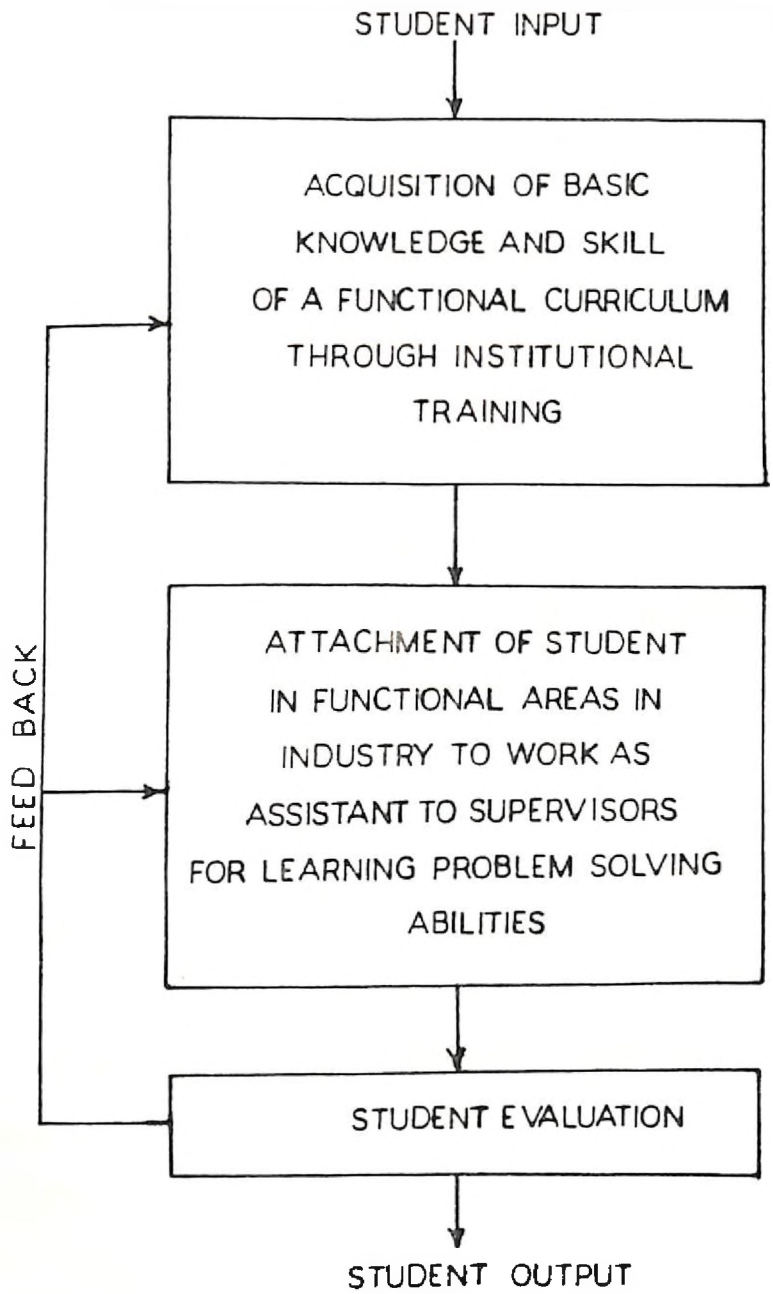

FIGURE 3.4 MODEL ON INSTITUTIONAL TRAINING IN FUNCTIONAL CURRICULUM AND INTERNSHIP IN INDUSTRY

3.5 Comparison of the interactive teaching-learning models

The interactive teaching-learning models described in Section 3.4 has been compared as under. All these models aim at providing students with experiential learning as also need vicarious inputs.

Model I and Model II are basically similar with the exception that in Model I problem solving activities take place at the work-bench with teacher-student working cooperatively in consultation with the industries' experts whereas in Model II similar activities take place as part of institution based class-room activities but with the involvement of experts from industries.

In Model III, the problems on which the students work are formulated by the teacher according to his perceptions of the field requirement and these are assigned by the teacher as graded exercises.

In Model IV students are placed in real life situation to work as assistants to the supervisors where learning of problem solving takes place through direct experience but under the guidance of an expert exactly similar to interns of medical profession. Such learning experience is enriched through self study of related concepts and principles, constant interaction with the supervisor and fellow students, and the visiting faculty. Evaluation of students' performance is done, in all these models, against the criterion of students' attaining all such abilities which are required by the world of work.

3.6 Planning for experiment on student-teacher involvement in industries

3.6.1 Objectives

The objective of this experiment is to enable student to develop problem solving abilities while working on projects assigned by industries under the guidance of teacher and industrial experts. The specific objectives are as follows:

(i) To analyse a given problem and develop hypothesis for its solution;

(ii) To collect relevant informations from various sources;

(iii) To consult literature and understand the related concepts and principles

(iv) To work out alternative solutions to the given problem;

(v) To evaluate such solutions through interactions with the fellow students, teacher and the industrial experts;

(vi) To prepare a technical report on the solutions to the problem;

(vii) To present the solution to industries and receive feedback;

(viii) To make cost-benefit analysis of the suggested solution;

(ix) To develop qualities like discipline,positive attitude, communication abilities, team work, etc.;

(x) To observe discipline followed in industries;

(xi) To appreciate the importance of completion of a given task in a definite time frame.

3.6.2 Present practices of student training and limitations

At present, some of the polytechnics offer summer vacation training to students. The polytechnics after securing indsutries' consent on students' placement, send the to industries and leave the task of planning, supervision, and evaluation totally to the industries. In the absence of the required interactions between the polytechnic and industries, such training in general becomes more like a formality than purposeful involvement of students in learning of any practical skill. The student trainees,in most of the cases,are asked by the industries to only observe the work in various sections of industry. In the absence of any specific task and any guidance, the students take such industrial training lightly and thus much of the valuable time, opportunities ,and possibilities are not utilised. The industries ,because of their preoccupations, consider this task of looking after the students a burden. Many a times, when students do not have commitment to any specific task, resort to wasting time and becoming a source of indiscipline. Students do not find it motivating only to observe and on many occasions they stay in industries for few hours and prefer to leave early. On the other hand ,the polytechnics do not assume the responsibility for planning, supervising and evaluating students through intense involvement. Faculty of polytechnic are more or less kept away from this activity. In some cases the training and placement officer of the polytechnic make occasional visits to meet students in industries, which, in most of the cases, is a formality.

3.6.3 Strategy planned for promoting effectiveness of student involvement at the work-bench.

Here, Education and training of student is organised at the institute as well as at the work-bench. Institutional training is followed by student-teacher attachment in industries on specific problem assignments. Institutional training aims at teaching-learning of the prescribed course content through class-room and laboratory exercises. This is followed by attachment of students in industries for gaining experience in real life open-ended problem solving under the guidance of experts from industry and the teacher. Planning for such an attachment involves interactions with students, industry and the poly-technic faculty. The role of the above three groups are also clearly defined so as to make such interactions meaningful and productive in terms of project output and student learning.

3.6.3.1 Interaction with industry

Interactions with industry involve mutual under-standing of the objective of the student-teacher involvement, identification of nature of tasks to be assigned, guidance to be provided to students, and method of evaluation of students' performance. Since the problems assigned are of relevance and use to the industry, it is envisaged that the industry would take interest in the students' work and would also provide necessary guidance to students, in addition to regular day-to-day guidance provided by the teacher. As a part of planning, the polytechnic faculty under the guidance of the Head of the department would be required to interact with the industries, collect the problems identified by various industries, classify them and make a Problem Bank.

3.6.3.2 Interaction with students

It will be essential for the Head of the department of the polytechnic and the faculty to interact with the students to identify those who would be interested in participation in industrial attachment for a specified period. The aptitude and interest of the students are to be matched with the nature of problems to be assigned to them from the Problem Bank. After matching of students' interest and the problems, the students will be alloted training places. The students then will have to be given introduction about the organisation where they would be placed. Students are to be oriented towards method of problem solving which would involve problem analysis, data collection, literature survey, formulation of hypothesis, working out alternative solutions, evaluating solutions, preparing technical report and its presentation. The students, because of their past experience generally expect their teachers to tell them everything. But, in the proposed situation, it is the students who would be expected to take initiative in the learning tasks. This is a major shift from the conventional teaching-learning strategies employed earlier. The students will have to be prepared for facing this changed situation in their learning effort. In addition, students will have to be given instructions regarding the discipline expected from them in industries. In addition to specific problem solving activities, the students would be expected to study the related practical aspects while in industry which may influence their total perspective about the requirements of the professional world.

Students will also have to be explained the method of evaluation that will be followed to assess their performance.

3.6.3.3 Interaction with teachers

The Heads of Departments would be required to identify faculty to be associated with groups of students being placed in industries. The faculty will be the senior members of the group and will guide the students in gaining problem solving competence and also help achieve the total objectives of the industrial attachment of students. Along with the industrial experts, the faculty would also evaluate students' performance. While in industry, the faculty would also get an opportunity to study the technological developments in industries and would identify areas of curriculum revision. The faculty would help in strengthening the linkage between polytechnics and industry for an on-going collaboration for producing better quality of polytechnic output. Involvement of faculty in student guidance on open-ended problem solving is to be seen as an opportunity created for developing knowledge and skill of the faculty through on-the-job training.

3.6.3.4 Mechanism of placement of students in industry

Placement of students in industry requires initial planning in terms of identification and finalisation of list of eligible candidates, identification of work-benches and the nature of problems assigned by them, matching the stduents' interest and aptitude with the organisational requirements, attachment of faculty, method of evaluation, monitoring and collection of feedback. Factors like accomodation, transport facilities, etc. are also to be considered while placing students in industries. As far as possible, placement be made in large industries a sizeable group of students under the guidance of one faculty on full-time basis. The faculty need to be placed on duty with benefits of TA/DA to avoid any hardship. Industry need to be informed in advance the names of students, their background, and the name of faculty being placed with them. As far as pssible, the students be placed in stations where they do not find difficulties in arranging their own accomodation.

3.6.3.5 Evaluation of students

Evaluation under problem solving based education can be used as a vehicle to develop in students all those abilities which are required by the world of work. Evaluation of students under this condition could also become a learning experience to teachers. Such evaluation would aim at identifying all those latent abilities of students which normally do not surface in the conventional evaluation method of written examinations. The proposed evaluation method would aim at judging students in terms of their intellectual abilities, cognitive strategies, attitudinal development, communication skills, team work, decision making abilities, and of interdisciplinary open-ended problem solving abilities. The entire responsibility of organising student evaluation would rest on the faculty attached with the industries.

3.6.3.6 Evaluation tools

To bring about uniformity in evaluation and to reduce the subjectivity in evaluating students, it is essential to adopt a rationale and unified evaluation procedure.

Multiple evaluation instruments like Quiz, Seminar/Viva,Group Discussion, Observation, and Project report are planned to be used. The percentage weightage of these instruments are:Quiz -10%, Seminar/Viva-20%, Group Discussion-15% , Observation -25%, and Project report -30%. Each of the above instruments would be used to evaluate different attributes. The attributes and their percentage weightages are given as follows:

QUIZ:	(i)	Clarity of concepts,principles	
Total weightage		and processes	5%
=10%	(ii)	Level of practical skills acquired	2%
	(iii)	Ability to solve problems	3%

SEMINARS:	(i)	Clarity of concepts,principles and	6%
Total weightage		processes	
=20%	(ii)	Level of practical skills acquired	6%
	(iii)	Ability to solve problems	5%
	(iv)	Self expression/communication	2%
	(v)	Creativity/conceiving new ideas	1%

GROUP DISCUSSION:	(i)	Level of practical skills acquired	3%
Total	(ii)	Ability to solve problems	3%
weightage=15%	(iii)	Self expression/communication	3%
	(iv)	Maturity and initiative	2%
	(v)	Dealing with workers and/or colleagues	2%
	(vi)	Leadership qualities	2%

OBSERVATION: Total weightage =25%	(i)	Level of practical skills acquired	4%
	(ii)	Ability to solve problems	3%
	(iii)	Punctuality and regularity	5%
	(iv)	Maturity and initiative	4%
	(v)	Sense of responsibility	4%
	(vi)	Leadership qualities	5%
PROJECT REPORT: Total weightage =30%	(i)	Clarity of concepts, principles and processes	4%
	(ii)	Level of practical skills acquired	2%
	(iii)	Ability to solve problems	4%
	(iv)	Skills in data collection and information gathering	4%
	(v)	Self expression/communication	2%
	(vi)	Report writing	6%
	(vii)	Sense of responsibility	6%
	(viii)	Creativity/conceiving new and unusual ideas	2%

The evaluation matrix developed using the above rationale is given in Table 3.1 Depending on whether the student training would be in industries or at the institute or at both places, certain modifications may be incorporated in the matrix.

It may be mentioned here that the attributes of assessing problem solving abilities of students as mentioned above have been evaluated for their validity in a research study conducted by Mandke. Arora, and Ghosh (52).

Table 3.1

EVALUATION MATRIX FOR PROBLEM SOLVING ABILITIES OF STUDENTS

Sr. No.	Characteristics	EVALUATION TOOLS					
		QUIZ (10)	SEMINAR/ VIVA (20)	GROUP DIS- CUSS- ION (15)	OBSER- VATION (25)	PROJ- ECT RE- PORT (30)	TOTAL MARKS (100)
1.	Clarity of conce- pts, principles and processes	5	6			4	15
2.	Level of practical skills acquired	2	6	3	4	2	17
3.	Ability to solve problems	3	5	3	3	4	18
4.	Skill in data collection and information gathering					4	4
5.	Self Expression/ communication		2	3		2	7
6.	Report Writing					6	6
7.	Punctuality and regularity				5		5
8.	Maturity and initiative			2	4		6
9.	Dealing with workers and/or colleagues			2			2
10.	Sense of res- ponsibility				4	6	10
11.	Leadership qualities			2	5		7
12.	Creativity/ conceiving new and unusual ideas		1			2	3
		10	20	15	25	30	100

Operation of evaluation Instruments may be done as follows:

QUIZ: Quiz may be conducted based on the gap lectures delivered to equip students with additional knowledge or skill inputs to pursue their problem solving activities at the work-bench. It may also be conducted on the understanding of basic concepts, principles and applications of the related subject areas. For industry based problem solving activities, as in this case, the quiz may include items related to the knowledge about the organisation also.

OBSERVATION/VIVA: Seminars are to be held on the projects or assignments depending on the type of teaching-learning model followed. The student would be presenting their work in the seminars. In case, more than one student is working on a project, they may be asked to divide the topics for presentation. Each seminar would follow a question answer session for clarification and feedback.

GROUP DISCUSSION: Group discussion may be conducted by taking all the students in one group or dividing the students in more than one group. Students working on similar projects may be grouped together. When a group is having discussion, other groups may be asked to attend as observers. Experts from industries may be invited to participate in such discussions. The topic for group discussion would generally be directly connected to the projects or assignments being done by students. The topic for group discussion may be announced one or two days before the due date or may be decided on the day of the group discussion as suggested by the students. Every member of the group needs to participate in the discussion and see that discussion proceeds in the same direction. Group discussion would give the faculty an opportunity for observing contributions of every member of the group to the progress of the assignment or project.

OBSERVATION: It is one of the best methods of continuous evaluation. The faculty or industrial expert, as the case may be, would evaluate students on the basis of his day-to-day interactions in terms of the attributes mentioned in the evaluation matrix in Table 3.1.

PROJECT REPORT/TRAINING DIARY/ASSIGNMENTS: The report which is presented at the end of project work on completion of assignments, is in fact, a culmination of continuous efforts over the entire period of the learning activities. In case of group work, the leader of the group will have the total responsibility of planning, scheduling, and implementing the work of the group so that a joint report is prepared. Continuous interaction with students would provide opportunities to discriminate between the abilities of individual members of the group. Every member of the group thus would get his due credit in terms of his contribution to the total group work. The training diary, which each student would maintain is to be evaluated for the practical informations gathered by the student.

3.6.3.7 Feedback to students

Feedback is considered essential for helping students know their strong areas as well as their areas of weakness. Feedback to students would be provided through mid-term evaluation and through end of the term evaluation. Results of such evaluation would be communicated to the polytechnic as well as to the sponsoring industries.

3.6.3.8 Monitoring of industry based education and training of students

At the end of industrial attachment of students each institute would evaluate the effectiveness of training by collecting feedback from students, teachers, and industry and prepare a comprehensive report and utilise the same for future development of such linkage between the institutes and industries. The curriculum feedback would be consolidated and sent to the DTE and SBTE for bringing in curriculum revision including revision of strategies for curriculum implementation.

3.6.3.9 Role of faculty

Role of faculty will be that of an academic leader who will be guiding a group of students in developing problem solving abilities by establishing linkage between institutes and industry for mutual advantage. The specific role of such faculty would be to:

(i) ensure students' participation in the task assigned and completion of the work to the level of expectation of industries;

(ii) maintain students' discipline;

(iii) evaluate students and provide feedback;

(iv) arrange assistance to students from industries' experts;

(v) arrange participation of industries in student evaluation;

(vi) diagnose problems of indsutries and include them in the problem bank for future use;

(vii) collect feedback for curriculum revision.

3.6.3.10 Role of industry

The role of industry is very crucial in making the students' training effective. The specific roles as envisaged are as follows:-

(i) the industry need to appoint a supervisor to help students group solve the problems assigned;

(ii) to provide informations required by students when asked for;

(iii) to provide necessary guidance when required;

(iv) to participate in students' evaluation;

(v) to provide facilities to students and faculty;

(vi) to evaluate the students' reports on the problems assigned to them;

(vii) to suggest problems which the next group of students could take up.

3.7 Planning for project activities as an integral part of institutional training

3.7.1 Objective

The objective of this experiment is to develop in students open-ended problem solving abilities through project work.

Such project work would form an integral part of subjects of study. The projects, in this particular case, would be taken from industry, and for project guidance assistance of industrial experts would be taken. The students would have the opportunity to interact with the industries for understanding of the problem assigned, collect data and other relevant informations, and to spend part of the institute time in solving the problems assigned. Participation in group discussion, Seminar,Quiz, and Report Writing would form an integral part of the class-room activities. The students would be evaluated, in addition to their understanding of the subject matter,for their problem solving abilities.

3.7.2 Project work in polytechnics

The polytechnic curriculum envisages project work by students in their final year of studies. The objective is to provide opportunities to students to apply the knowledge and skill gained, through study of various subjects, to a specific problem assigned to them by the teacher or chosen by the students themselves. Such project activities are institution based and are pursued under the guidance of the teacher. Students are also expected to prepare a report on their project work. These are evaluated by the same teachers, who guide the students in their work or by other teachers appointed for the purpose. Certain State Boards of Technical Education prepare a list of projects to be given to students.

3.7.3 Limitations of existing method of project work in Polytechnics

The projects are formulated by the teachers or by the State Board of Technical Education and they are repeated by different batches of students over the years. As reported in Chapter II, Section 2.3.3, the projects are stereo type and do not create much interest in students. Students are found copying reports of project work from the work of previous batch of students' Evaluation of such projects, as done by the teacher, does not necessarily reflect the quality of work needed by the actual user system. Moreover, there is no taker for such project output.

3.7.4 Strategy planned for improving effectiveness of project work by students

In this experiment, project activities are envisaged to form an integral part of subject of study. The curriculum is implemented around open-ended project activities, the projects being sponsored by industries. The students would study the basic concepts and principles involved in a subject for the purpose of acquiring knowledge and skills which are prerequisite to the project work. Study of the course content and cross referencing to other related subjects will be required while working on open-ended projects. Students would be led to interact with the industries for study of the problems assigned, collection of data, analysis of the problems, finding solutions and presentation of solutions in the form of reports. For project guidance in addition to the subject teacher, assistance of industrial experts would be sought by way of organising extension lectures, ensuring participation of professionals in group discussion and student evaluation.

3.7.5 Identification of projects

The polytechnic would be required to identify suitable industrial problems, to be alloted to students as projects, from the industries situated in the neighbourhood. For this purpose the polytechnic faculty need to visit such industries and explain to them the objectives of the students' project work and also help them identify suitable projects through discussion. While identifying problems from industry the following points are to be considered:-

(i) Industry should show interest in the project output;

(ii) Industry should be willing to extend facilities to students to study the problem and collect relevant informations;

(iii) The projects identified should be related to the subjects of study of the students;

(iv) If the project is big,it is to be broken down in to smaller projects;

(v) It should be possible for the students to visit the work places easily;

(vi) Industry should extend cooperation by lending their experts in project guidance to students.

3.7.6 Allotment of projects to students

After identifying problems from the industries,the faculty incharge of the polytechnic would prepare a consolidated list of projects, and circulate the same to the students. The students in groups would be given a choice to select the type of projects they would like to work on. The representatives of relevant industries would be invited to explain the problems to the group of students and also state their expectations. Students would visit each industry, understand the problems,and then the final allotment would be done. The polytechnic faculty would also accompany the students to industries to help them get a grasp of the problems before they decide taking them up as projects.

3.7.7 Preparation for project activities

Acquisition of basic knowledge and skills is necessary before taking up project work. Since the experiments are planned to be conducted on-line, the students need also to learn the course content as per the examination requirements of State Board of Technical Education. Further, the students are to be acquainted with the approaches to problem solving before they actually start working on the projects. In conventional class-room activities, the teachers take up the responsibility of covering the course content through lectures. In this experiment, the learning task of course content will be the responsibility of the students. However, learning material in the form of students' notes, learning packages, demonstration models, experimental boards, charts, transparencies, handouts, assignment sheets, video films, slides, etc. will be made use of. Students' understanding of the subject will be strengthened by use of enrichment lectures, group discussion, and feedback.

3.7.8 Involvement of industry

For guiding students in open-ended projects,it is envisaged that involvement of professional engineers would be very useful. The teacher alone may not be able to provide all the informations,guidance, and help needed to arrive at the problem solutions because of their limitations. Experts from industries would be required to participate in curri-done. The polytechnic faculty would also accompany the students to industries to help them get a grasp of the problems before they decide taking them up as projects.

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3.7.9 Planning for students'involvement in project activities

The type of problems alloted to students for solving need to generate motivation in them to acquire the required basic knolwledge and skills mainly through self effort but having possibility of getting inputs from the teacher. For practical reasons, a part of the sessional marks for the subject may be alloted to project activities. Students should also be awarded certificates for satisfactory completion of their project by the polytechnic and/or industries. Involvement of industries, in explaining the projects to students and students visiting the industries to understand the relevance of the problems to their subjects of study, it is envisaged, would motivate students for undertaking the project work. In addition, case study presentations by invited professionals or through electronic media would be used to enable students understand their future role when employed vis-a-vis the need for acquiring problem solving abilities.

Both faculty and industrial experts would be involved in project guidance to students. The faculty would be coordinator and a regular guide while the professional experts would play the role of consultants who would be invited by the polytechnic for interaction with students in class-room. Also, the students would be visiting the industries and have consultations with the experts.

3.7.9.1 Role of faculty

Faculty would be required to perform the following functions in project activities of students:

(i) Prepare a list of projects by visiting industries and establishing linkage with professional experts;

(ii) Identify experts in industries who would be invited for case study presentations, extension lectures, project guidance, and student evaluation;

(iii) Prepare instructional material to enable students acquire basic knowledge and skill by their own effort and through interactions with colleagues and the teacher;

(iv) Inform the industries regarding allotment of projects to students and their possible dates of visits;

(v) Prepare industrial experts in delivering expert lectures and student evaluation;

(vi) Guide students in project work;

(vii) Facilitate visits to industries for collection of relevant data/informations;

(viii) Keep record of students' progress;

(ix) Encourage students in project activities;

(x) Ensure progress of students as per available time;

(xi) Help students prepare project report;

(xii) Provide industries with the project outputs and receive feedback;

(xiii) Provide feedback to students and receive their reactions.

3.7.9.2 Role of industry

Industry need to view sponsoring of projects to polytechnics as an opportunity for utilising the human resources of polytechnics, as well as assisting these institutions in producing better outputs, which are ultimately going to be employed by them. Thus the industry is to play an an important role in curriculum implementation by way of the following responsibilities:

(i) Identify problems which could be taken up by polytechnics;

(ii) Provide all informations required for arriving at problem solutions;

(iii) Extend facilities of extension lectures, project guidance and student evaluation to polytechnics; and

(iv) Provide feedback regarding the expectations of industry from polytechnic outputs.

3.7.10 Student Evaluation

Evaluation of students would be done by using multiple evaluation instruments of Quiz, Seminar/Viva, Group Discussion, Project Report, and Observations. These evaluation instruments and their method of implementation have been explained in Section 3.6. In addition, the students would be evaluated through a comprehensive written test covering the course content prescribed by the State Board of Technical Education. The evaluation results would help compare students' level of understanding of the subject matter vis-a-vis their problem solving competence.

3.7.11 Feedback to students

Regular feedback would be provided to individual students on the basis of continuous observation and evaluation made during their problem solving activities. Students' abilities, other than cognitive abilities, would also be judged and feedback provided. At the end of the Semester, the subject teacher would provide a comprehensive feedback stating the students' strong and weak areas.

3.7.12 Monitoring and Evaluation

Feedback will be collected from students, teacher and industries and a consolidated report would be prepared. This report would be circulated to other industries for enlarging the scope and increasing the participation of more industries.

3.8 Planning for development of problem solving competence through use of graded exercises

3.8.1 Background

While interacting with polytechnics, an argument was made as to why should it not be possible to produce diploma holders through a well designed institutional training alone. Further, they felt that interactions with industries was a difficult task and the industries might not extend the required cooperation. Many of the polytechnics expressed that because of non existence of industries in the neighbourhood of the polytechnics, it would be difficult to interact with industries situated at far away places. In such circumstances also, it should be possible to design teaching-learning,keeping in view the objectives of developing higher order cognitive abilities required for problem solving, as also the learners motivational aspects.

Graded exercises have been used in designing self learning activity packages, and also, as an appendage to lecture based teaching-learning. Such exercises when well designed have shown their usefulness in individualised learning situations. Self learning modules with feedback have also been used in Kellar's Plan and the experience had been rewarding in terms of students' motivation, and learning of subject matter (38,70).

Considering the need expressed by many polytechnics and taking a cue from the inharent strength of the use of self learning type graded exercises with feedback, a suitable teaching-learning model has been envisaged where students' learning would mainly be revolving round graded exercises with additional inputs from the teacher as and when required.

3.8.2 Objective

In the previous two experimental design plans, open-ended project activities were used to develop problem solving competence of students in association with industries. The objective of this experiment is also develop problem solving competence but through use of teacher made graded exercises and tasks.

3.8.3 Subject Analysis and Development of Graded exercises

Analysis of the existing curriculum of a polytechnic subject would be made to identify the concepts and principles, and their interrelationship as also their applications showing total structure of the subject. The course content will then be divided into modules. Each module will be independent on each other but will be heirarchical in nature. Instructional objectives for each module will be written. For each of the objectives, the knowledge, skill and attitudinal requirements will be identified. On the basis of this content analysis, exercises with feedback will be developed by a group of teachers. These exercises will then be graded in terms of simple to complex and from concrete to abstruct. The exercises would be of completion type and also of open-ended type. For each module, remedial study/ reference material would also be identified. Assignment sheets covering the course content of each module would be prepared for students to work on. For evaluating students after completion of each module of study, tests would be constructed. In addition, a comprehensive written test paper would be constructed through a teacher other than those who would be involved in the design of exercises and tasks.

All such teaching-learning material would be got reviewed by teachers teaching the subject in different polytechnics. The reviewed material would be got multiplied for use by each student.

3.8.4 Planning for implementation

3.8.4.1 Orienting the faculty

The subject teacher of the polytechnic would be involved in preparing a plan of action for a Semester of study of the subject by students. The evaluation procedure would be discussed and finalised during preparatory phase. The Head of Department of the polytechnic and the Principal would also be apprised of the experimentation. Since, the experiment would not disturb the academic schedule, it is envisaged that the polytechnic would provide full support.

3.8.4.2 Orienting the students

Before the semester starts, a meeting would be held with the students to explain to them the changed method of teaching-learning that would be adopted for offering the subject. The students normally expect lectures by teachers because of their past experience. It is envisaged that learner based activity oriented students involvement in graded exercises would motivate students to learn by their own effort. Since help from teachers would also be available in case of need, it is expected that the students would welcome this approach to teaching and learning.

3.8.4.3 Implementation

For providing an overview of the subject, use of 'advance organisers'(4), in the form of presentation of objectives and structure of the subject would be made. The students would also be explained the importance of study of the subject and its significance in the world of work. This would be followed by self learning activities of students through graded exercises. Individual guidance would be provided by teachers as per students need. The teacher would keep record of progress of each student and award credits for it. Formal lectures and group discussion would be organised for topics of importance and of high difficulty level. Remedial/additional study and reference material would be provided to students whose level of understanding or initial preparation is comparatively low. Record of progress of each student would be maintained by the teacher and feedback provided on a continuous basis.

3.8.5 Evaluation and Feedback

Students would be evaluated on their learning of the course content on a continuous basis through class work, assignments, and periodical tests; and through a comprehensive written test at the end of the course. Students would also be evaluated for their problem solving abilities by experts drawn from industry. Feedback to students would be provided, indicating their strong and weak areas, based on the evaluation made by industrial experts. Feedback from students and teacher would be collected on all aspects of teaching-learning. Reactions of representatives of industry would also be obtained.

3.9 Planning for functional curriculum and students' internship in industry

3.9.1 Introduction

The existing polytechnic curriculum and the method of course offering mainly emphasise generalised descriptive study of course content through institutional training. The students' training is oriented towards transmission of informations. This type of curriculum and method of course offering in polytechnics are being followed over the ages. Technological developments of the present day demand training of technicians in functional areas like manufacture, installation, operation and maintenance, repair, etc. This would require study of functional curriculum and development of problem solving abilities in functional areas.

Teaching-learning of the descriptive type of generalised curriculum through lecture based institutional training is perhaps not the best method of producing the type of technicians needed by modern industries. The requirement, therefore, is to develop functional curriculum, related teaching-learning material, and an implementation strategy to train students to occupy functional positions in modern industries. The following sections explain the planning of an experiment on the use of functional curriculum for institutional training to be followed by on-the-job experiential learning through internship in functional areas in industries.

3.9.2 Objective of the experiment

The objective of the experiment is to study the effectiveness of use of functional curriculum for institutional training to be followed by students' attachment as interns in functional areas in industries for the development of real life problem solving abilities. The specific objectives are:

(i) To train students in acquiring basic knowledge and skills of a subject/part of a subject through institutional training but mainly through student centred learning activities;

(ii) To enable students learn problem-solving abilities by working as interns in related industries in functional areas;

(iii) To enable students learn to use reference material, supervisors' manuals, etc., while working in functional areas as interns;

(iv) To provide opportunities to students to develop personal and social qualities required for working in any functional area.

3.9.3 Development of functional curriculum

Functional curriculum will be developed for a part of the subject of the existing polytechnic curriculum. While choosing the topic, the relevance of such a topic would be verified through expert opinion and then the task of curriculum development work will be taken up.

For curriculum development, functional areas in which diploma holders of the discipline are expected to be employed would be identified. Such functional areas could be Design, Manufacture/Assembly/Production, Installation, Operation, Maintenance and Repair, etc.

After identifying the functional areas, a list of industries would be prepared for the purpose of studying the activities of diploma holders in various functional areas. On the basis of such activity analysis, a curriculum which would respond to the functional requirements of diploma holders would be developed. The curriculum so developed would be used for training of students following the teaching-learning model IV.

3.9.4 Development of instructional material

Instructional material relevant to the basic concepts and principles as well as covering the functional aspects would be developed for use by the students and the teacher. Such material would take the form of a complete teaching-learning package which would include the following:

(i) Teaching plan;

(ii) Self study type print material on basic concepts and principles;

(iii) Demonstration models, charts, etc.;

(iv) Assignment sheets;

(v) Laboratory instructional manual;

(vi) Reference study material in the form of Supervisors' Guides in functional areas; and

(vii) Evaluation tools.

3.9.5 Instructional Plan

To implement a functional curriculum through institutional training alone, it is envisaged, would call for huge infrastructure development within the institute, as also developing competencies of faculty in training students in functional areas. As an alternative, as envisaged in this experiment, the resources of the industries will be utilised for training of students in functional areas. The total teaching-learning activities are divided between institutional training and attachment of students in industries to work as interns under the guidance of industrial supervisors. Planning for such a teaching-learning system would call for identifying a polytechnic and orientating the faculty in offering learner-based instruction for learning of basic theory, establishing contacts with industries for finding places for internship of students, orienting the industrial supervisors, orienting the students and arranging their placement, monitoring, evaluation and feedback.

3.9.6 Contacting Polytechnic

One of the nearby polytechnics would be contacted and the total philosphy explained to the principal and the concerned Head of Department. As an on-line experiment it may not be possible for the polytechnic to implement the instructional plan with different student groups studying diffe - rent curriculum during the academic session. In such a case, alternative strategies would be worked out. One of the alterna- tive possibilities could be to conduct of the experiment during vacation period with a small group of students.

After deciding the period of conduct of the experiment, its duration would also be worked out in association with the subject teacher and Head of Department of Polytechnic by analysing the content coverage and the learning experience to be provided . The subject teacher would be provided with the functional curri - culum and the related teaching-learning material for study.

The total instructional plan would be discussed with the teacher and the Head of Department. The method of course offering in the institute, for learning of the basic theory , would also be worked out.The teaching-learning activities,as envisaged would involve lectures,demonstration,self activity through assign- ments,practical work,independent study,evaluation and feedback.

3.9.7 Identification of places of internship

Industries, relevant to the subject of study, would be contacted through letters explaining the total philosophy of student training. Such industries, who respond favourably, would personally be contacted in association with the polytechnic faculty.

The supervisors in functional areas would be identified and through the management support they would be made incharge of student training in industries. The students would be placed to work under such supervisors to learn problem solving activities being performed by them. The supervisors would also be explained the method of student evaluation. They would also be provided with a copy of the functional curriculum and a register to maintain the progress of each student.

3.9.8 Orientation of students.

Allotment of students to different functional areas would be done on the basis of their convenience in reaching the industries from their normal place of stay. Such allotment will be communicated to the industries as also to the supervisors. Before the students are placed in functional areas, they would be explained the total objectives of their attachment to industries, given brief information about the industries, and the expectations of the industries from the interns. The role of students vis-a-vis the industrial supervisors would be clearly explained to the students. They would be provided with a diary to maintain record of their day-to-day activities. They will also be given all the instructional material developed covering the functional aspects of the curriculum for use during their internship in industries.

3.9.9 Planning for conduct of the institutional training

Copies of the curriculum,the instructional material, and the teaching-learning plan would be discussed and given to the polytechnic faculty who would conduct the institutional training. The researcher will attend all the classes and observe the teaching-learning process.He would also have discussions with the teacher about various aspects of the teaching-learning and provide feedback as needed.

3.9.10 Students' internship in industries

Efforts would be made, as far as possible, to place students in industries so that they can travel easily from their normal place of stay. The students would be required to assist the industrial supervisor in planning and implementing his work.The students would be expected to consult the related literature,including the literature provided to them,to learn the details of the underlying concepts and principles related to the activities performed. Interactions with the supervisors, fellow interns, and the visiting faculty for strengthening their understanding would form an essential component of internship. Students would be required to participate in group discussions organised regularly where the visiting faculty and representatives of industry would take part.

3.9.11 Evaluation of Students

Students would be evaluated on continuous basis by the supervisor as well as by the polytechnic faculty who is expected to visit students in industries atleast once a weak. The evaluation of students would be through use of multiple evaluation instruments used in the previous experiments. In addition, the students would be given a comprehensive written test covering two parts i.e. the basic theory, and the functional aspects of the curriculum. For the purpose of comparison, a group of students who have studied the same subject/topic following the existing curriculum and through institutional training alone, would also be tested similarly.

All the students would be interviewed by a panel of experts drawn from different functional areas in industries to judge their suitability for employment.

3.9.12 Monitoring and feedback

The total teaching-learning plan will be monitored by the Head of Department in association with the researcher. They would visit the industries and ensure that the students work to the satisfaction of industries. For collecting feedback from students, teachers and industries, a seminar would be organised in the polytechnic where the whole programme of student training would be presented by the polytechnic faculty and the stduents. Feedback would also be collected through use of questionnaires. Students' evaluation record would be analysed and a comprehensive report prepared for circulation to all concerned.

CHAPTER-FOUR

OPEN-ENDED PROJECT-BASED STUDENT-TEACHER INVOLVEMENT AT WORK-BENCH.

4.1 Introduction

The gaps between the requirements of the world of work and the quality of diploma holders being turned out by polytechnics were discussed in Chapter I and in the later part of Chapter II. Development of open-ended problem solving abilities in students were envisaged as the long term objective of technical education system. Four conceptual models of teaching learning were discussed in Chapter III. Involvement of students in Project activities at the work-bench was considered one of the strategies for giving problem solving experience to students. This Chapter presents details of an experiment conducted on open-ended project-based student teacher involvement at work-bench ,based on the conceptual model I,as discussed in Chapter III. This experiment was conducted with students of four polytechnics situated respectively at Chandigarh, Ambala, Patiala and Jalandhar. Thirty-five neighbouring industries collaborated in this experiment.

The polytechnics at Patiala and Jalandhar are privately managed institutions whereas the other two polytechnics i.e. at Ambala and Chandigarh are Government Polytechnics. Good number of industries, both large scale and medium scale exist in the areas where the polytechnics are situated. Students in these polytechnics are admitted on the basis of their performance in school leaving examination, recently these polytechnics have started admitting students on the basis of entrance examination). The teachers in these polytechnics are mainly of three categories i.e. degree holding teachers, diploma holding teachers, and teachers with degree or diploma plus TTTI diploma in Technical Teaching. These polytechnics run generalised diploma courses only through institutional training. Although students may opt for vacation training on voluntary basis, the past record shows negligible participation of students in vacation training in industries.

The following sections present the experiment, starting from how the polytechnics were involved and motivated, to the outcome of the experiment.

4.2 Involving the polytechnics

For sharing of ideas and receiving comments from polytechnics, industries, and experts, it was planned to conduct a meeting of the selected representatives and thus develop a final design and implementation strategy. A workshop was therefore organised in April 1989 to consider concrete educational methods and programmes for orienting polytechnic education to industrial needs by inviting representatives from leading industries and a few polytechnic principals.

Representatives from four industries, five polytechnics, and senior faculty of TTTI Chandigarh including an eminent expert from an institution of higher learning participated in the workshop. The criteria for selection of polytechnics was the reputation of their principals in the field of polytechnic education having leadership qualities. The four local industries invited were also known for their reputation. Seventeen representatives participated in the workshop.

The participants from industries and polytechnics exchanged views on various aspects of industrial training of students. The two salient observations made were:

(i) Polytechnics do not have purposeful linkage with the world of work in training of their students. Certain polytechnics organise industrial training of students during vacation periods. Institutional training should be followed by clinical experience of students in industry.

(ii) The major lacuna of current industrial training of polytechnic students was that of absence of involvement of their teachers in the training of students in industry thereby vesting all responsibilities of guiding students to the officers of industry who are too occupied with their day-to-day work.

(iii) The students receiving practical training could be seen as additional human resources available to the industries and their training period could be better utilised by enabling them work on problems of interest to industry and thereby making the training a meaningful activity for both industry and the students.

The participants studied the practice-school model of BITS Pilani(10) which is operating successfully with the engineering degree students. The workshop made the following recommendations:-

The industry-institute interface model of BITs Pilani (which is also one of the four models described in

Chapter III of the thesis) should be experimented in polytechnic situation by making available appropriate time slot in the curriculum. The participants viewed that the main strength of the practice school (PS) was in its requirement for teacher to be incharge of total student training in industry.This fundamentally varies from Sandwich concept where teachers role is limited to occcasional visits.Further, the workshop observed that the teachers' presence allows PS to be incorporated in the curriculum without requiring duration of total polytechnic curriculum being increased, unlike as in the case of sandwich courses.In PS the stake of industry exists because the student under the guidance of the teacher work on assignment of direct interest to the industry. In the process,the professional from industry with interest in the assignment , works as a consultant. The stake of the institution comes as it now has access to the resources of indsutry while imparting problem solving based education which is intense in its academic regour, while giving students advantage of facilitating employment opportunities as a bye-product. Finally, the stake of the teacher comes as he now has an opportunity to directly relate professional requirement of technicians and teaching-learning activities in the polytechnic while at the same time providing him an opportunity to undertake his own training as a future consultant to the industry.

Keeping in view the advantages of PS School of BITS

Pilani and a similar model envisaged for polytechnics,the workshop recommended the proposed model to be tried out for two months industrial attachment of their students. The polytechnics would identify ,on voluntary basis, students of final year who would like to take advantage from the training mentioned as above.

It was decided that the researcher would be guiding the polytechnics in organising this industrial training programme by way of suggesting potential industries, identifying problems from industry,assisting teachers in the organisation and supervision of training, developing student evaluation instruments,and gathering overall feedback.

The participating polytechnics were then asked to send their acceptance of undertaking this task of training of their students in industry indicating the dates and duration of training, prepare the list of students and also of the teachers.

On the basis of the Orientation workshop, the final design of the experiment was made. This was sent to all the participating polytechnic principals immediately after the orientation workshop. The final design as circulated to the polytechnics is as follows:

EXPERIMENTAL GROUP: A group of polytechnic students and teachers taken from three to four institutions who would be undergoing practical training in industries for acquiring problem solving abilities.

DURATION OF CONDUCT OF THE EXPERIMENT: Eight weeks for the final year students who would be assigned problems as projects during their attachment in industries.

TEACHING-LEARNING METHOD: The students would gain problem solving abilities in real life situation through their self effort and by having interactions with industry, their teacher, and among the peers. Evaluation of problem solving ability will be done by the industrial supervisor and also by the teacher and feedback provided. The emphasis of training on open-ended problem solving will be to develop in students all such related abilities which are required by the world of work.

INSTRUCTIONAL MATERIALS: Following Instructional material will be developed and used during the conduct of the experiment:

(i) Guidelines to students being sent on industrial attachment;

(ii) Problem-Bank for students, developed in consultation with the collaborating industries;

(iii) Guidelines for participating teachers;

(iv) Schedule of follow up of training by the polytechnics;

(v) Evaluation tool for assessing students on their abilities of problem solving;

(vi) Questionnaire for collection of feedback from teachers, students and industry.

METHOD OF EVALUATION: Students will be evaluated against standard criteria laid down in the evaluation instruments. Achievement of students and feedback from students, teachers, and the collaborating industries will be used for the overall evaluation of the experimental model and arriving at conclusions.

4.3 Selection of polytechnic students and teachers

Out of the five polytechnics who participated in the workshop, 4 polytechnics sent their acceptance. Seventeen teachers and 85 students were identified by these polytechnics. The distribution of students and teachers of these four polytechnics is shown in Table 4.1. Because of extension of academic session during that year, the vacation period of first and second year students were reduced to only three weeks in place of normal summer vacation of about 6 to 8 weeks. Since, such a small period was not adequate for the students to take up open-ended problem solving assignments, it was decided to send only the final year students who, after their terminal Board examination, wait for about 8 to 10 weeks for the declaration of results.

Table 4.1

List of polytechnics and number of students and teachers who participated in the experimental study

Name of Polytechnic	No.of Third year students	No. of teachers
1.Central Polytechnic,Chandigarh	22	4
2.Government Polytechnic,Ambala City,Haryana	22	7
3.Thapar Polytechnic,Patiala,Punjab	26	4
4.Mehr Chand Polytechnic,Jalandhar, Punjab	15	2
Total	85	17

As mentioned earlier, the selection of polytechnics were made on the basis of reputation of their principals as dynamic academic leaders. The principals of polytechnics held meetings with students and teachers explaining the proposed training programme. The students were asked to indicate their willingness to their respective Heads of Departments. Thus, the selection of students were made on voluntary basis. The students identified, belonged to the discipline of Civil Engineering, Electrical Engineering, Mechanical Engineering and Architectural Assistantship. Teachers were selected on the basis of interest shown by them to gain experience in guiding students in practical situations and also to develop linkage with the potential employers of their students.

4.4 Identification of time for industrial attachment

In India polytechnics offer three-year generalised diploma courses. Before seventies, most of the polytechnics used to offer courses on annual pattern, but later, when curriculum revision work was taken up, many of the states recommended semester pattern of course offering. Now, most of the states have adopted semester pattern. In the States of Punjab, Haryana and Chandigarh, where the experiment was conducted, the polytechnics follow semester pattern. A three year programme is divided into six semesters. During this period, students are given winter breaks of $1\frac{1}{2}$ weeks duration after first, Third, and fifth semesters. The students also get summer vacations of about 6 weeks duration after second and fourth semester. The students wait for a period of about 10 weeks after sixth semester of studies for the declaration of result and award of diploma by the State Boards of Technical Education. Figure 4.1 shows the polytechnic semester scheme of course offering alongwith breaks, vacations, etc.

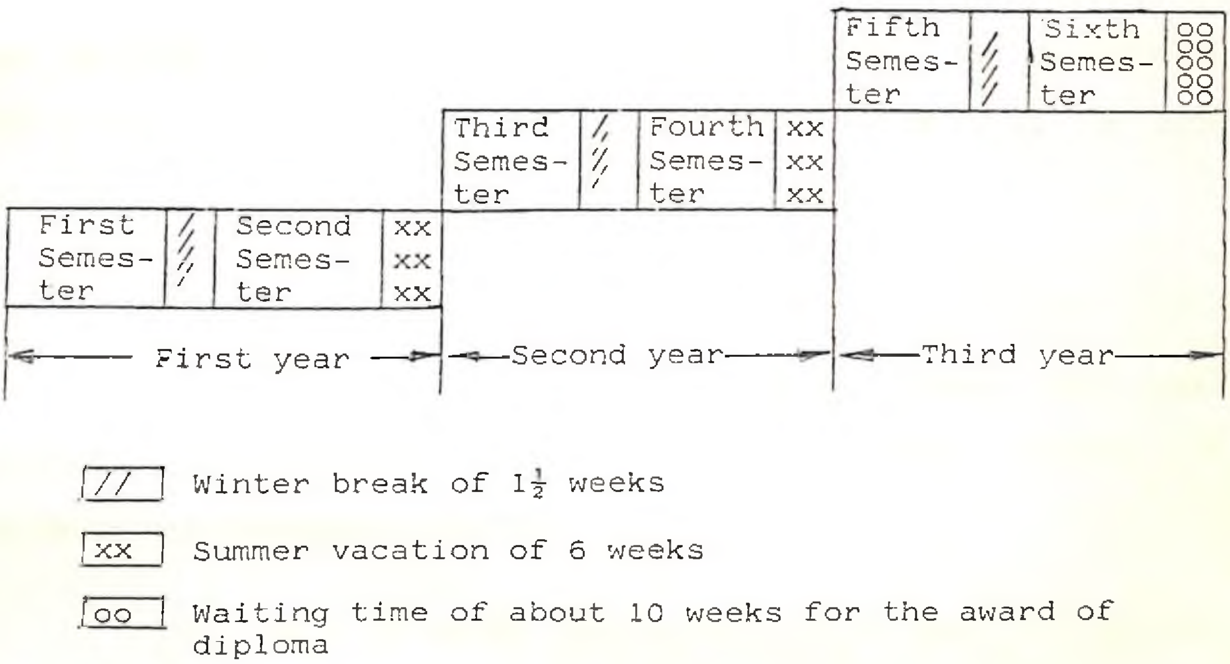


Figure 4.1 Semester pattern of polytechnic course offering with winter breaks and summer vacations

A common academic calender is prepared for all the polytechnics under the State Board of Technical Education. This experiment was to be conducted in few polytechnics and that too for a selected group of students. It was, therefore, feasible to disturb the common academic calender. The alternative was to utilise the winter breaks or the summer vacations. Winter breaks were only of short duration and therefore, could be utilised only for exposure type of training rather than for problem solving assignments. Since the summer vacation during the year of the experiment was reduced to about 4 weeks, it was decided to send only the third year students after their diploma examination conducted by the State Boards of Technical Education.

In consultation with the polytechnic principals, it was decided to place the third year students in industries for a period of nearly 8 weeks i.e. from 15th July to 15th Septemebr,1989.

4.5 Selection of Industries

A list of large and medium scale industries were prepared by consulting Punjab, Haryana, Delhi Chamber of Commerce and Industry(PHDCCI).

Polytechnics selected industries out of this list,considering their locations and wrote to them for training places for third year students. In their communication to the industries, the objective and methodology of conduct of the experiment were explained in detail. Out of a total of 75 industries to whom letters were sent by the four polytechnics, 50 industries responded positively. The polytechnics then selected a total of 40 industries on the basis of the following criteria:

(i) Willingness of industry to assign specific problems/ assignments to the students;

(ii) Agreeing to provide basic facilities to students and teachers;

(iii) Safe working conditions and reputation of industry;

(iv) Suitability of students' placement keeping in view their places of stay, and reporting easily to industries.

The list of selected industries was then circulated to each participating teacher for them to take up further follow-up activities. The researcher also collected this list from the polytechnics for visiting industries in association with the polytechnic teachers.

4.6 Identification of problems in industries

Some of the industries indicated in their letters the type of problems which they were likely to assign to students when placed with them. However, majority of them sent their acceptance only. It was, therefore, necessary to visit all the industries to identify suitable problems and also to discuss the total training programme as also to identify the consultants who would be associated in the training of students. Polytechnics with the help of their teachers contacted the indsutries and had detailed discussions with them. The employed diploma holders in the industries working on shop floors or at the site were in a position to propose suitable problems for polytechnic students. With their assistance, it was possible to identify problems and prepare statements and thus make a problem bank. The problems taken were such that the industries had a waiting time for 2 to 3 months for their solution. Problems were identified for students of Mechanical, Civil, Electrial Engineering, and Architectural Assistantship disciplines separately. Problems identified were in supervision of work, quality control, estimating and costing, site investigation, measurement, preparation of working drawings, survey, preparation of bill of materials, data collection, preparation of lay out plans, fault finding in existing installation, conduct of market surveys, supervision of fabrication, testing of materials and equipment, maintenance and repair, inspection and quality assurance, design of control circuits,productivity surveys, inventory control, reduction of wastage, process planning, study of pollution and environmental problems, etc.

The problems thus identified (Annexure 4.1) were classified and made available to students and all teachers. Together with the problems, a brief description of each of collaborating industries were also supplied to the teachers and students.

4.7 Development of Evaluation tools and related instructional material

For achieving the stated objectives of the experiment, in addition to developing a problem bank, role of all the three parties i.e. the industry, the teachers, and the students were clearly identified. A common evaluation scheme was prepared and the required evaluation tools were identified for use in all the industries for assessing students problem solving abilities. Schedule of visits by polytechnic principals/ Heads of departments , separately, as also with the researcher, was prepared. For receiving feedback from industries,teachers and students, separate questionnaires were developed. All these instructional and informational material were developed in association with the polytechnics.

4.7.1 Development of evaluation tools

A simple paper and pencil test alone, does not necessarily evaluate students' all such abilities required by the world of work. Students when trained in problem solving in an exploratory and interactive learning situation, need to be evaluated using multiple evaluation instruments like Quiz, Seminar, Group discussion, Observation, Project Report, Viva-Voce, etc. An evaluation matrix already in use in the Practice School division of BITS Pilani for student evaluation on problem solving abilities was studied.

In the evaluation matrix the characteristics of students to be judged were identified and weightage for each was alloted. For each characteristic the instruments for evaluation were identified and the total weightage was distributed against each. Following this procedure the evaluation matrix was prepared for use by industrial supervisors and the teachers as has been shown in Table 3.1.

As the evaluation matrix was a validated one(27,52). it was decided to use the same for student evaluation in the experiment without going for its validation once again.

4.7.2 Guidelines for industries

Since attachment of students with their teacher in industries on problem solving assignments was different than the conventional method of practical training of students, it was necessary to develop guidelines for industries and make it available to the industrial supervisors well in advance. The guideline informations included the following:

(i) Objectives of industrial attachment of students;

(ii) Brief outline of the strategy;

(iii) Evaluation Scheme;

(iv) Evaluation tools;

(v) Role of industry;

(vi) Statement of problem assigned by the industry;

(vii) Dates and duration of Training;

(viii) Number of students reporting.

In addition, the industry was requested to issue instructions to the expert who would be guiding the students as consultant during the period of their attachment in industry. Industry was also requested to provide all the necessary information to students, as and when required, for finding solution to the problem assigned.

The industrial expert, in addition to providing guidance to the student-teacher team, was required to participate in Seminar and Group discussion organised in the industry from time to time and extend the benefit of his experience to facilitate better learning by the students. Industry had also to discuss with the student-teacher group the suggested solution to the problem to see their applicability and provide further inputs for modifications, if required. For avoiding interference with the day to day work of the expert, it was suggested that some specific time could be allocated to the student-teacher group for interaction. It was also suggested that the industry could identify more problems to be assigned to the next group of students. The industries were requested to provide feedback for curriculum revision on the basis of requirements of the world of work.

4.7.3 Guidelines for Teachers

Guiding students in open-ended problem solving and evaluating their performance was going to be different than what was being practiced by the teachers in the polytechnics. Teachers' role, now would be that of a guide and a manager than a conventional class-room teacher. Teachers' involvement in practical training of students in industries, earlier, was limited to occasional visits to see what students were doing and to evaluate progress through viva-voce. Providing guidance to students by associating oneself as one of the senior partners of the project team was not experienced earlier by any of the teachers.

To clarify the role of teachers,guidelines and information sheets were provided which included the following:

(i) Objectives of attachment of students in industry;
(ii) Proforma for maintenance of records;
(iii) Student evaluation scheme and evaluation instruments;
(iv) Role of teachers;
(v) Role of students;
(vi) Method of conduct of Quiz,Seminar and Group discussion and Viva-voce.

4.7.4 Guidelines for Students

Before sending the students to the industries, they had to be provided with relevant information and support material. The following material were developed for this purpose:

(i) Objectives of industrial attachment;
(ii) A training diary to maintain a record of information collected;

(iii) Guidelines regarding conduct and discipline;

(iv) Guidelines regarding general approach to problem solving;

(v) Method of writing of technical report;

(vi) Role of students; and

(vii) Evaluation procedure.

4.7.5 Questionnaires for feedback

Feedback about the experiment had to be collected through actual observation and through questionnaires from students, teachers, and industries. Three sets of questionnaire were developed for this purpose.

4.7.5.1 Questionnaire for students

This questionnaire (Annexure 4.3) included twenty-four qeustions to receive reactions of students on the following:

(i) Students' understanding of the objectives of the industrial attachment;

(ii) Guidance received from teachers;

(iii) Incentives received from industry;

(iv) Attitude of industry;

(v) Opportunities for learning, and the abilities developed;

(vi) Difficulties faced during industrial training; and

(vii) Overall assessment of the industrial attachment.

4.7.5.2 Questionnaire for teachers

The questionnaire for teachers included fourteen items covering the following feedback areas:

(i) Adequacy of informational material provided;

(ii) Adequacy of period of industrial attachment;

(iii) Completion of assignments by students within the available time;

(iv) Attitude of industry;

(v) Attitude of students;

(vi) Quality of learning by students;

(vii) Advantages derived by the teacher;

(viii) Overall rating;

(ix) Suggestions for improvement.

The questionnaire is given in Annexure 4.4.

4.7.5.3 Questionnaire for Industries

This included thirteen questions covering areas like usefulness of project output to industries incentives to students, requirement of the presence of teacher, general performance and behaviour of students, willingness of indsutry to establish a long-term linkage with polytechnics following similar students' attachment, etc. In addition, the industry was asked to indicate the abilities they found lacking in the students when they joined industry and also to make general suggestions for improvement (Annexure 4.5).

4.8 Orientation of students prior to placement in industries

Polytechnics prepared a placement schedule of their students in various industries keeping in view the students' interest in the problems assigned by the industries. Other factors like the students' place of stay during the attachment phase and the time required for them to report to industries were also considered. Orientation workshops were organised in each of the polytechnics one week before the beginning of the industrial attachment where the students,teachers,Heads of departments,the principal,and the researcher participated. All the instructional material developed were made available to teachers and students during these workshops.Expectations of the industry,the training schedule,nature of problems to be solved, maintenance of training diary,report writing, and method of student evaluation were discussed in these workshops.

Guidelines regarding conduct and discipline expected in the industry and the training schedule were discussed and given to the students.

Teachers were supplied with teachers'register which included objectives of industrial attachment,record keeping details,method and tools for student evaluation.

The methodology of conduct of Quiz, Seminar, and Group discussion were discussed with the teachers. A schedule was decided for evaluation of students' performance during the period of their industrial attachment as in Table 4.2.

Table 4.2

Frequency of use of evaluation instruments

Evaluation through	Suggested frequency
1) Quiz	Twice
2) Seminar/Viva	Twice
3) Group discussion	Twice
4) Project report and diary	Twice
5) Observation	Continuous

Principals of the polytechncis decided to place the teachers on duty in the respective industries for the entire period of training. Students were asked to make their own arrangement for reaching the industry daily.

The instructional material developed for implementing the teaching-learning model I, formed a complete package which has been illustrated in Figure 4.2. Photographic view of the material developed has also been shown to provide a feel of the material developed.

4.9 Placement of students

A total of 85 final year students (22 Electrical, 25 Mechanical, 31 Civil, and 7 Architectural Assistantship) joined 36 industries on the scheduled date and sent copy of their joining report to the respective polytechnics. The distribution of students in various industries is shown in Table 4.3. Since there were only 17 teachers participating in the experiment, and there were 36 industries where students were placed, one teacher had to be alloted 2 or 3 nearby industries to attend to. Thus, a teacher had to divide his time between the industries alloted to him.

4.10 Monitoring

Monitoring of the students work in various industries was done by the Heads of Departments/Training and Placement Officers. Principal of Polytechnics made surprise visits and had interactions with students, teachers, and the management of the industries. The researcher alongwith polytechnic HOD/TPO/Principal visited all the industries once in very two weeks to have an overall idea of the progress and to sort out problems,if any. During the attachment period,it was observed that 7 students dropped out because of their personal reasons. The progress made by other students in general,was found to be satisfactory. The Principals,during their interactions with the management of industry,sought suggestions for strengthening linkage between industry and polytechnics on a long-term basis.

TEACHING-LEARNING PACKAGE- I

(Package I illustrated for student-teacher involvement at the work bench for problem solving assignments)

Learning Experiences	Nature of instructional material	Specific material developed
*1. Abstract learning experience through lectures for learning of theory	Text books as available in the market and lecture notes	-
*2. Direct purposeful experience through laboratory and workshop exercises for verification of theory and development of skills	Experimental set ups, lecture notes, etc.	-
3. Simulated experience for understanding the method of problem solving and working in industry	Text material for self study	(i) Booklet on guidelines for open-ended problem solving in industry by student trainees
4. Abstract learning experience of nature of problems to be solved	Problem Bank	(ii) Sample of open-ended problems collected from 40 industries in the area of civil, electrical, mechanical and architectural assistant-ship course.
5. Interactive learning of open-ended problem solving through group discussion, seminar, report writing and presentation of techncial reports.	Instructional Manual	(iii) Instructional Manual on methods of conduct of group discussion, seminar, report writing and its presentation.

*No specific instructional material could be developed, as this involves huge inputs in terms of resource requirements for catering to the total needs of students. The students used the instructional material as available in the market for these learning experiences. A standard list of available books and reference material for one engineering discipline was prepared for use by the polytechnics.

Figure 4.2 :Schematic of the interactive teaching-learning package for Model I.

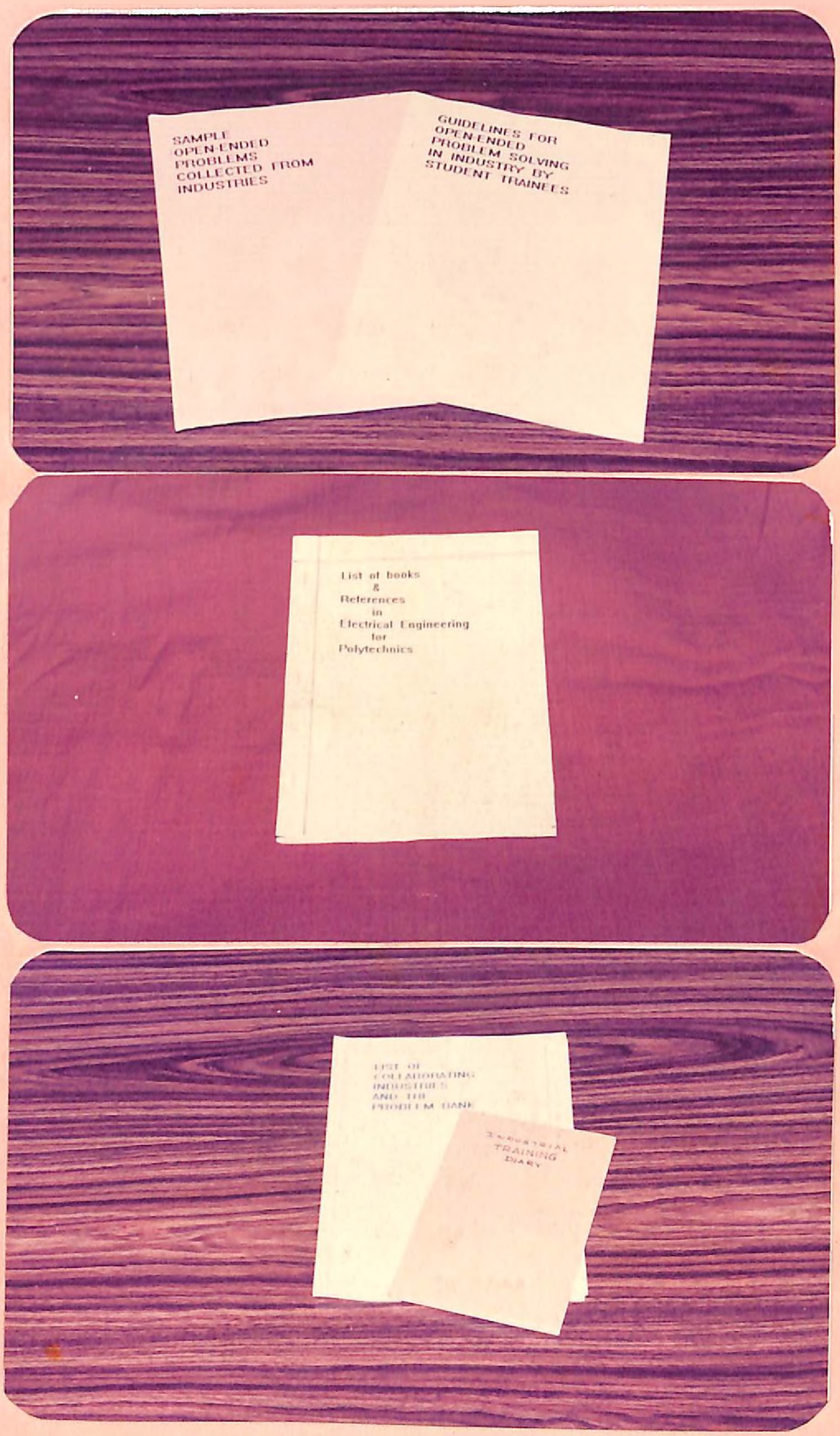


Figure 4.2 Photographic view of interactive teaching-learning material developed.(Sample open-ended problems collected from industries,guidelines for open-ended problem solving,list of books and references,list of collaborating industries and problem bank,and industrial training diary).

Table 4.3

Placement of Students in various industries

S.No.	Name of Industry	No. of students
1.	CEC Limited, Site of PSEB, Mohali	2
2.	M/s Om Parkash Baldev Krishan Engrs, Contractors, Chandigarh	2
3.	Chief Engineer, UT, Chandigarh	2
4.	Mrs.Renuka Khanna, Architect & Engineers, Panchkula	2
5.	HMT Ltd, Pinjore	5
6.	Steel Strips Private Limited, Chandigarh	1
7.	Khandelia Oil & General Mills, Chandigarh	2
8.	PTL, SAS Nagar, Mohali	2
9.	IDMA Laboratories, Chandigarh	3
10.	Astra Construction Co., Chandgiarh	4
11.	CPWD, Chandigarh	2
12.	PGI, Workshop, Chandigarh	2
13.	Electrotech Engineers, SAS Nagar, Mohali	2
14.	Jai Parabolic, SAS Nagar, Mohali	1
15.	Alpesco Industries, Chandigarh	2
16.	Gilco Industries, Chandigarh	2
17.	OSAW, Ambala	2
18.	Samrat Forgings Limited, Derabassi	2
19.	Yamuna Auto Industries, Yamunanagar	2
20.	Punjab Small Scale Industrial Export Corporation, Chandigarh	2
21.	PWD, B&R, Kaithal, Haryana	1
22.	Super Auto Manufacturer, Patiala	1
23.	DCW, Patiala	10
24.	Didar Steel Complex, Patiala	2
25.	CPWD, Patiala	4
26.	CCPL, Rajpura,	1
27.	Deptt.of Arch.Pb,.Patiala	7
28.	Khalsa Engg. Works, Jalandhar	1
29.	Zoloto Industries, Jalandhar	2
30.	Kalsi Metal Works, Jalandhar	2
31.	JMP Industries, Jalandhar	2
32.	Indo Asia Switchgear, Jalandhar	1
33.	Gosain & Sharma, Engineers & Architects, Jalandhar	3
34.	Navin Construction Company, Bulton Park, Jalandhar	1
35.	Bharat Spring pipes, Jalandhar	2
36.	Escorts Ltd., Patiala	1

4.11 Evaluation of students

Students were evaluated by the industrial supervisors and the teachers on a continuous basis using the evaluation instruments i.e. Quiz, Seminar/Viva-Voce, Group Discussion, Technical Report and Observation. In industries where there were only one or two students, evaluation on Group Discussion was based on the students' interactions with teachers and industrial supervisors. Seminars were conducted by the students on their return to the polytechnics where all the teachers of the polytechnics and invited representatives of industries, and the researcher participated. Students were evaluated on the basis of the quality of seminar conducted by students. Students reports on the problem solving exercise were evaluated by industries representatives as also by the teachers. Annexure 4.5 lists the problems/assignments on which the students worked during their industrial attachment period.

4.12 Collection of feedback

Feedback was collected from students, teachers and industries through questionnaires. During the conduct of the experiment and immediately after the experiment, the researcher collected feedback from industries and polytechnic management on points directly related to the experiment. Reactions of students and teachers were also collected at the time when students organised seminars in their polytechnics. In addition, after the conduct of the experiment, the principals of the polytechnics called separate meetings of those faculty who participated in the experiment. The principals invited the researcher to be present during the faculty meetings. This opportunity was availed by the researcher to collect feedback from the teachers through open discussions.

4.13 Experimental Results

Results of the experiment is presented under three main sub-headings, namely, evaluation of students, salient outcome, reactions of students, teachers, and industry.

4.13.1 Evaluation of students

Evaluation of students was done by the teachers and the supervisors of industries as per schedule and by using the evaluation matrix developed for the purpose.

Seven students of one of the polytechnics discontinued their training due to personal reasons and as such total evaluation data of 78 students were available.

To study the relationship between students performance evaluation through different evaluation instruments for various abilities, correlation coefficients were calculated. Annexure 4.8 provides the computer programme, the computational values, and the correlation coefficients as calculated. Further, to study the relationship between the performance of students of different polytechnics, correlation coefficients of students scores (as evaluated by industries) were also calculated. The results are shown in Table 4.4 and 4.5 .

Table 4.4

Correlation coefficients of Students' achievements evaluated through various evaluation instruments

	Evaluation by teacher	Evaluation by industry
(a) Quiz and Seminar	0.59	0.57
(b) Quiz and Group Discussion	0.56	0.46
(c) Quiz and Report Writing	0.61	0.60
(d) Quiz and Observation	0.51	0.45
(e) Seminar and Group Discussion	0.63	0.55
(f) Seminar & Report Writing	0.74	0.73
(g) Seminar & Observation	0.70	0.71
(h) Group Discussion & Report Writing	0.62	0.57
(i) Group Discussion and Observation	0.70	0.61
(j) Report Writing and Observation	0.73	0.64

Table 4.5

Correlation coefficients of scores of students' of different polytechnics as evaluated by industries (calculated by considering the score of 10 students from each polytechnic).

(a) Ambala & Chandigarh	0.89
(b) Ambala & Patiala	0.97
(c) Ambala & Jalandhar	0.92
(d) Chandigarh & Patiala	0.87
(e) Chandigarh & Jalandhar	0.89
(f) Patiala & Jalandhar	0.90

The results show that there has been fairly high correlation of scores of Quiz, Seminar, Group Discussion, Report Writing and Observation.

The correlation coefficients of scores of students of different polytechnics also were high indicating that the students of all the polytechnics performed similarly.

4.13.2 Salient outcome of the experiment

(i) 60 percent of the students carried out the assignments which helped the industries. The rest of the students could not complete the assignments within the available time. However, in the process they learnt the methods which developed confidence in them for problem solving in future.

(ii) 29 students i.e. 37 percent of the students got out of pocket allowance of Rs.300/- to Rs. 800/- per month during the period of their training from industry for the problem solving activities carried out by them.

(iii) 48 percent of the students got employment in the industries where they were placed on problem solving assignments.

(iv) 96 percent of the students could attend the training places by staying either with their parents/relatives or in the college hostels.

(v) 7 percent of the students travelled by the transport vehicles of the industries, the remaining students travelled either by public bus or by their own conveyance.

(vi) Average time taken by students to reach the industries was about half an hour.

(vii) An analysis of Training diaries maintained by students indicated that they recorded informations on organisa - tional structure, plant layout, types of machines and equipment, processes and practices, specification of materials, safety regulations,pollution control, emplo- yees welfare measures, etc. Thus, in addition to problem solving exercise, the students studied other job related subjects during their industrial attachment period.

4.13.3 Feedback from Students, Teachers, and Industries

4.13.3.1 Feedback from students

(i) All the students expressed that they learnt how to communicate effectively through verbal as well as in written form.

(ii) The training totally changed their attitude towards learning and as such they felt they understood the meaning and relevance of subjects taught in polyte- chnics better.

(iii) Students expressed their interests in learning modern technologies like use of computers,electronic instrumen- tation and control, etc.

(iv) Students expressed that the presence of teachers in industry on a full time basis was a must to derive maximum benefit and develop problem solving abilities through mutual interaction.

(v) 95 percent of the students expressed that the attitude of industries was favourable towards their learning and completing assignments.

(vi) Students placed in medium scale industries could take up specific assignments after 2 to 3 weeks of their stay in those industries. However, in large industries, take off time was long and in some cases, the students could only study the problems assigned to them and collect relevant informations but could not solve the problems as the period of attachment was small.

(vii) All students expressed that this type of industrial attachment should be made an integral part of the polytechnic curriculum.

(viii) All students expressed that they realised the importance of team work and completion of a given task within a given time frame.

(ix) The duration of industrial attachment of students was considered less by all the students.

(x) The students expressed that for the first time, they realised the importance of acquiring knowledge of reading and interpreting working drawings.

(xi) All the students expressed that the learning tasks assigned to them were challenging and motivating.

(xii) The problem assignments and the comprehensive evaluation procedure, the students expressed, provided them with real feedback about their areas of weakness and also helped them develop their total personality through their own effort.

(xiii) 91% of the students expressed that for the first time they got opportunity to speak in a seminar which developed their self confidence.

(xiv) Group discussions with professional experts and teachers held in industries on important and relevant topics, all the students expressed, were helpful in clarifying doubts and in enriching knowledge.

4.13.3.2 Feedback from teachers

16 out of 17 teachers found this industrial attachment a unique learning experience. One of the teachers asked why such problem solving experience could not be provided through institution based training. Guiding students in industrial problem solving was, the teachers experienced, a challenging task. Asistance of industries' experts was very useful in making satisfactory progress in the project work. All the teachers expressed that while in industries they could observe the recent developments in industrial processes and practices. They , after their industrial attachment, found themselves in a more competent position to provide feedback for curriculum revision. The teachers expressed that there was a need for having a fresh look at the present teaching-learning methods in the polytechnics and suggesting an appropriate technology of teaching for developing problem solving abilities in students. The polytechnics, the teachers expressed, need to establish direct linkage with the world of work for the above mentioned purpose.

The participating teachers expressed that contacting industries and identifying problems for students were time consuming and therefore suggested involvement of all the faculty so that the work could be shared by all under the guidance of the Heads of Departments.

Teachers expressed that institutional rules and regulations could be made flexible in terms of providing TA/DA so as to enable teachers contact large number of industries. They suggested official transport facilities for the purpose.

All the teachers found attitude of industries, by and large, very favourable.

For identifying problems in industries, the employed diploma holders provided help as they had the expereince as well as polytechnic background. The teachers suggested that the polytechnics could maintain a record of their own diploma holders in various industries and with their help the problem bank could be easily strengthened. Teachers found stduents in industries putting more effort in learning tasks as compared to when they studied at the institutes. There was overall improvement in the motivation of students for learning, the teachers observed.

The quality of interactions with students was superior as students asked higher order questions, and many a times, answer to these questions were even not known them and they had to consult literature for satisfying the students. The other advantages the teachers derived from this experience,as expressed by them, are as follows:

(i) They could identify the areas of weakness of each student and provide feedback for improvement;

(ii) They could enrich their knowledge and skill for better teaching in the polytechnics;

(iii) The teachers were now in a better position to formulate assignments and projects for students to be used during institutional training;

(iv) Because of the contact established with industries, extension lectures and technical visits to industries could be better planned now;

(v) For nearly 70 percent of the teachers, it was also their first industrial attachment as these teachers joined polytechnics immediately after acquiring their degrees/diplomas.

94 percent of the teachers emphasised that industrial attachment of students, alongwith teacher supervisors, should be made an integral part of the polytechnic curriculum.

4.13.3.3 Feedback from industries

Industries appreciated this concept of student-teacher attachment with specific tasks worked out in advance. This approach, they found, was quite different from the conventional approach in which students were sent by different technical institutes for industrial training without proper planning and supervision from their side, resulting in students spending most of their time without any assignment, and in many cases, creating an atmosphere of indiscipline in the work environment of the industry.

Diploma holders working in industries expressed that polytechnic curriculum and teaching-learning strategy required a change, and this could be achieved by establishing an effective linkage between technical institutes and industreis for mutual benefit.

Sixty percent of the industries expressed that the solutions to the problems were of direct use to them.

All the industries were prepared to pay honorarium to the students for their work but only 37 percent did actually pay. The remaining could not do so because they belonged to public sector and their existing rules did not provide for such payment. They issued letters of appreciation to the students.

All the industries expressed that they would extend such training facilities to students on a long-term basis, and the polytechnics ought to make such training programmes an essential component of their curriculum offering.

4.13.4 General observations

Following are some critical observations made by the researcher during the experiment by having constant interactions with teachers, students, industries and polytechnic management:

(i) Students secured employment in industry by demonstrating their abilities. Industry could choose the right person for employment from the student trainees after a period of observation.

(ii) Teachers ,for the first time,observed that many of the topics they teach were irrelevant and required to be replaced by topics of new technological practices.

(iii) Both students and teachers found open-ended problem solving activities a difficult task because neither the students nor the teachers ever faced such open-ended technological problem solving tasks.

(iv) Identifying problems in industry required special skill. Many of the industries could not identify and frame the problem although the problems existed. Extended discussions, particularly with shop-floor supervisors, were necessary for identification of problems.

(v) All the principals said that they would like to continue sending students in industry in more numbers every year during summer vacations without waiting for the changes to come in the revised curriculum, or waiting for instructions from higher authorities. They would also like to induct more teachers in this activity. In the process they would ask for transport facility, provision for payment of TA/DA to faculty, etc. for this purpose. The attitude of industry, the principals of polytechnics found, was very favourable, about which they earlier were somewhat apprehensive.

(vi) Duration of 8 weeks of attachment was considered less for undertaking problem solving activities by the students (only 60 percent could complete the problem solving tasks, as has been reported in Section 4.13.2).

4.14 Difficulties experienced in conduct of the Experiment

4.14.1 Motivating the faculty

Involvement of faculty right from the planning stage was essential for implementation of the model. A faculty meeting was organised at the polytechnic where the conceptual model and its objectives were explained to all faculty. The faculty in general appreciated the idea but only a few showed willingness to participate. Others thought that this was an additional task and questioned as to who would pay their TA/DA and other facilities. They said that their normal duty was to teach in the class the number of periods as per norms. However, a few teachers volunteered to participate perhaps because of personal influence of the principals. Principals, however, said that they would place these teachers on duty during the period of training. For local transportation, they could only be paid as per rules. Transport facilities of the institute was not available in most of the cases.

All the required instructional material were developed by the researcher and made available to students, as this was not a normal activity of the institute and faculty.

4.14.2 Involving Industry and identification of projects

Letters were written by the principals to industries for allocation of training places to students and identification of problems. Industry, because of their past experience, in most of the cases, while agreeing for training places did not mention about the projects they would be giving to students.

It was therefore necessary to visit such industries to identify suitable projects which were considered problems by the industries. Visits were made by the polytechnic faculty and the researcher to the industries who responded to the written request. The concept was also new to the industries. Many of the industries, particularly the modern large scale industries, told that they had their own persons to solve their problems and showed apprehensions about the capabilities of polytechnic students as well as the teachers. However,they were requested to consider the idea and a second visit was made after a few days.The researcher than thought of interacting with the shop floor supervisors and lower management staff rather than with the top management alone. In the next visit, with the permission of the management, the researcher and the polytechnic faculty had detailed discussions with each departmental or sectional head ,who had the polytechnic background. It was possible through them to identify number of problems which, although did not look like a problem of any one but, had significance from the managements' point of view. For example, the officer incharge of transport vehicles of a large industry mentioned,while discussing his activities, that he was facing a shortage of transport vehicles and had asked for 5 more, and was waiting for the sanction of the management. The researcher when met the General Manager,mentioned about the discussions he had with the various departments for identification of projects. Incidently, mention was made about the need of more transport vehicle. The General Manager knew about it and said, "I am not sure whether more vehicles are required". The researcher made a suggestion to the management if it would like students to investigate the actual needs and give recommendation. The General Manager accepted the suggestion and agreed to take students on attachment with this specific assignment. This problem was taken as one of the projects for a group of Mechanical Engineering students. The students while working on the project collected data regarding movement of vehicles,their timings,frequency of breakdown,etc. and made net-work analysis and provided feedback. This example is cited only to emphasise that many a times industry is not able to identify problems by herself all of a sudden, and many a times does not see her own problems. Better managerial decisions could be made if data was made available.

In some industries the problem identified had to be broken down into small problems and given to groups of students. This was possible because the teachers and industries could work these out together. In this context, involvement of teachers in project identification, their allotment to students, in project guidance, and in student evaluation, was essential.

4.14.3 Allotment of work-benches to students

Allotment of seats to students for industrial attachment had to be on the basis of nearness of students' places of residence from the industries. This restricted the spread of students to a variety of industries, although such industries responded favourably. As there was no financial commitment by the industries to their agreeing to take the students on trainng, and the fact that the polytechnic students generally came from lower middle class families, it was essential not to cause hardship to students on account of their stay arrangements.However,many of the industries granted out of pocket allowance at the end of the training due to the good work done by the students. Some industries under the public sector could not pay stipend to students due to their rules and regulations. Due to this initial limitation, only a small number of student groups could be placed together in a particular industry. Further, one teacher had to guide students in a cluster of industries as adequate number of teachers were not available for the purpose (17 teachers were alloted 36 industries). Continuous dialogue by polytechnic management with industries and also effort to extend the facility of receiving stipend by students from the Apprenticeship Board for Training, it is envisaged, would help all students receive stipends during their industrial attachment period.

4.14.4 Guiding students in industries

Guiding students in open-ended problems was a new experience to teachers. Consultations with industrial experts helped students and teachers proceed in the tasks assigned. Because of presence of teachers, the students could get the required informations without much loss of time. It was observed, in some cases, that students , because of their past habit, waited for their teachers to help them in their problem solving tasks. But slowly the students realised their responsibilities and learned to help themselves. Further, in each group, it was necessary to make certain, equal participation of all students in the project work. Thus, the role of teacher was crucial in ensuring students' participation, maintaining student motivation, and also to keep to the given time schedule.

4.14.5 Evaluating students on problem solving abilities

Because of the non-availability of adequate number of students in some of the work-benches, evaluation on group discussions was done on the basis of students' interactions with teacher and industries' expert. Student evaluation through seminars was done in the polytechnics immediately after the industrial attachment period, as facilities for conduct of seminars were not available in some of the work sites. Reactions of students and teachers on various aspects of the training were also collected on these occasions.

4.14.6 Monitoring of students' progress by polytechnic management

Although a tentative schedule was made for the Principal/H.O.D./Training and Placement Officer to visit the students and teachers in industries to see the work progress and to interact with the industrial experts,the researcher had to send reminders and take follow up actions,as polytechnics were seen sliding towards their past practice of conventional industrial training of students where all responsibilities were given to the industries.

4.15 Conclusion

Education work linkage as explained in this experiment has given a number of benefits to students,teachers,polytechnics, and indsutries.However,such training of students in indsutries needs to be included as a part of the curriculum implementation process. The duration of industrial attachment for problem solving needs to be increased to say 4 to 6 months, as this would give sufficient time to the student trainees to learn problem solving. The indsutries should be ensured regular supply of students every year so that they know in advance the additional resources they would be getting every year, and could keep some of their problems to be given to students.

During this experiment, the researcher found some reservations on the part of teachers to be in industry, as there were no facilities provided to them either by the industry or by the institutions. On the other hand, both the students and industry found the presence of teacher very useful. It, therefore, becomes essential that the teachers be placed in industries alongwith the students with all the required facilities and legitimate benefits.

Looking into the advantages of the industrial attachment of students, one tempts to suggest it's incorporation in the curriculum, immediately. However, for achieving better results, the following points may be considered:

(i) should the duration of diploma course be increased from 3 years to $3\frac{1}{2}$ years as has been done in the case of sandwich programmes?

(ii) is it possible to reduce the institutional course content thereby reducing institutional training to say $2\frac{1}{2}$ years and thus find 6 months for industrial attachment?

(iii) what should be the role of teachers, Heads of Departments, Principals, Directors of Technical Education in the new context of education work linkage?

(iv) what should be the Management Information System to establish effective linkage between the world of work and the award of Diplomas?

(vi) are there any alternative approach to development of problem solving abilities in students?

These are some of the basic points which may be considered while the scheme is adopted by the system at the state level.

Chapter V presents details of an experiment conducted following the second conceptual model as explained in Chapter III.

CHAPTER-FIVE

OPEN-ENDED PROJECT BASED STUDENT TEACHER INVOLVEMENT AS AN INTEGRAL PART OF CLASS ROOM INSTRUCTION - A PILOT STUDY AND A STUDY ON SCALED UP IMPLEMENTATION

5.1 Introduction

In the experiment presented in Chapter IV,students were placed in industries on problem solving assignments and they worked under the guidance of teachers and industrial experts. In this experiment open-ended projects taken from industries were assigned to students as an integral part of their studies in the institute. The students worked in groups under the guidance of teacher and industrial experts in the institute.

This experiment was first conducted on pilot basis with a polytechnic class for a period of 9 weeks i.e. for about half a semester. Feedback was collected to examine the effectiveness of the model and to make changes, if required, for its scaled up implementation,which followed this pilot study.

In the scaled up implementation,experiments were conducted with two polytechnic classes and for a full semester. The evaluation of the model was done in terms of students' achievements,feedback from students, teachers, industries and polytechnic management.

5.2 Selection of polytechnic

For convenience the researcher decided to experiment on a nearby polytechnic where he could interact with the teachers and the management on a regular basis.Central Polytechnic,Chandigarh (CPC) is situated very near to the place of work of the researcher. The principal of the polytechnic had shown his interest in improvement of instruction in various seminars and workshops where he participated. Letters were, therefore written to the Principal of Central Polytechnic, Chandigarh and also to the Director Technical Education (DTE), Chandigarh, explaining the objective of the experiment. The researcher also contacted the Principal at the Polytechnic and had detailed discussions regarding the various aspects of the experiment. Response received from the DTE and the Polytechnic Principal were encouraging. Written approval of the Director of Technical Education and the Principal of polytechnic were taken for the conduct of experiment at the Central Polytechnic, Chandigarh. Academic schedule including the timings etc. were not to be disturbed. The Director of Technical Education while approving the experimentation asked the Principal to provide all cooperation and also to follow up progress of the experiment.

5.3 Selection of subject and orientation of the subject teacher

It was decided to choose teaching of an applied engineering subject for this experimental study. Being a student of electrical engineering, the researcher prefered to take up subjects from Electrical Engineering discipline. Interaction with industries on the activities of electrical diploma holders , revealed that abilities of reading and interpreting drawing and the skill in design, estimating and costing of electrical installations were some of the essential areas in which the polytechnic students be given a thorough training. While going through the Electrical Engineering diploma curriculum, it was observed that "Electrical Design and Drawing" was included as an applied engineering subject in the curriculum . The curriculum envisages teaching of the subject in three consecutive semesters in parts in the form of a spiral curriculum. Part I of the subject is taught in Third Semester, Part II in Fourth Semester, and Part III in Fifth Semester. During the time this experiment was planned, the Fifth Semester stduents were studying "Electrical Design and Drawing III" and it was decided to take this subject for this experiment. Since development of instructional material as well as orientation of teachers including involvement of industries required time, it was considered appropriate to conduct this experiment during the second half of the semester.

The subject teacher was contacted for the purpose of explaining to him the total teaching-learning strategy to be employed and also getting his consent for the experiment. The teacher showed interest on experimenting with the new method of teaching-learning and also to assist in the preparation of teaching-learning material as appropriate. The part of the course content as identified by the teacher for use during the experiment is given in Annexure 5.1. The course content included design and drawing of motor control centres for various kinds of drives used in industries. The first part of the subject which the student would study before the conduct of the experiment includes design, drawing, estimating and costing of Electrical installations for commercial buildings and small industry.

5.4 Development of instructional material

Interactive Teaching-learning, built around open-ended project activities by students, as envisaged in this conceptual model,required initial preparation in terms of acquisition of basic knowledge and skills related to the course content. Further, as this was an 'on-line' experiment, the students would also be required to study the course content from the point of view of examination conducted by State Board of Technical Education. To facilitate learning of basic knowledge and skill, it was decided to develop certain teaching-learning material which would provide students with a variety of learning experiences.

5.4.1 Criteria for selection of nature of instructional material

Basic to the design of instructional material,as set of assumptions was made about learning.They are stated as:

(i) Learners acquire skills and understandings best when they can predict ahead of time what they will learn during a learning experience;

(ii) Learners will respond more positively where learning experiences are reinforced;

(iii) Learners will learn more efficiently if materials and experiences are arranged into small steps and from simple to complex and concrete to abstruct form;

(iv) Learners will retain learnings if there are adequate opportunities for practice of new learnings; transfer of learning will more likely occur; and

(v) Learners will integrate small steps of learnings into complex skills and understandings if provided an opportunity in context of an evaluation activity.

Organising learning experiences would form a combination of expository and discovery strategies depending on the nature of knowledge to be acquired by the learner. Further, 'group learning' and 'individual learning' activities would also depend on the nature of knowledge to be learnt. Decision about the strategies mentioned above and subsequent development of instructional material, were made as indicated diagrametically in figure 5.1.

Reference was also made to the 'Dale's Cone of learning experiences' which indicates the nature of learning experiences and their relative effectiveness. The most effective learning experience, according to 'Dale', is the 'direct purposeful' one and the least effective being the 'abstract verbal' one. The decreasing effectiveness travels through indirect, contrived or simulated, etc.

While deciding about the nature of learning experiences and the required teaching-learning material, the content and the objectives of the subject of study as also the constraints of the system were kept in view.

The course content for the subject of study in terms of its scope, objectives, its knowledge components in terms of Facts, Concepts, Procedures and Principles , and the required instructional material for development,were identified on the basis of the following factors:

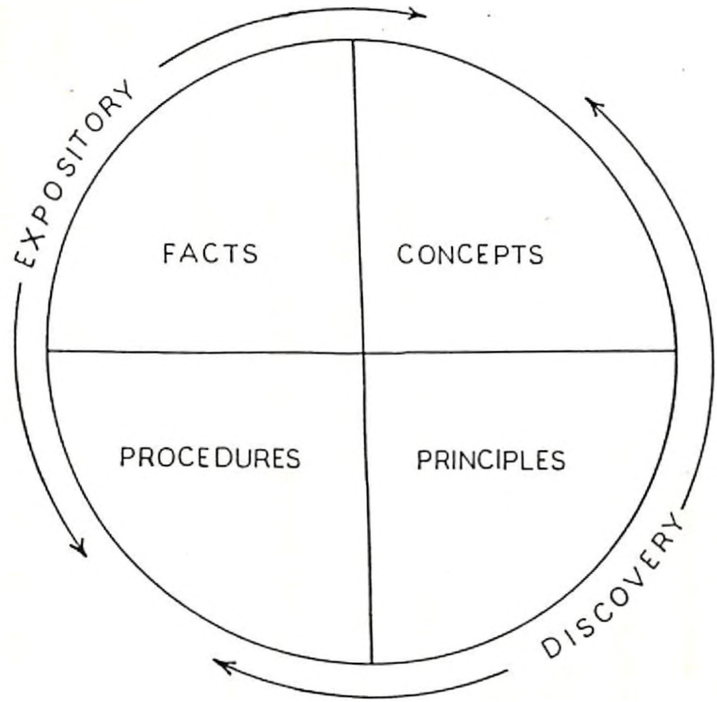
(i) To create opportunities for the students to see the relevance of the subject/topics of study;

(ii) To provide students,practice on a variety of exercises;

(iii) To correlate theoretical study with experimentations;

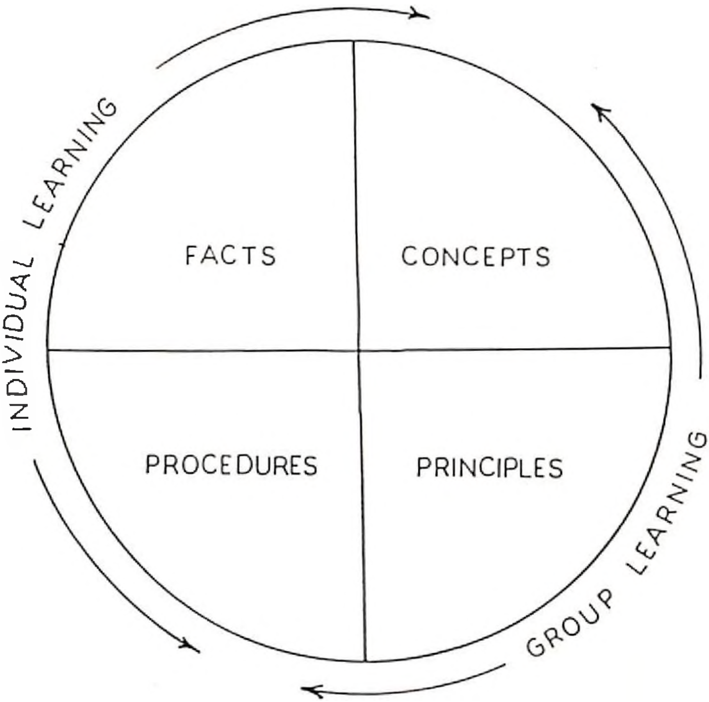
(iv) To make available to students reading material in the form of notes,reference materials,etc;

(v) To enable teacher demonstrate the basic principles & use audio-visual presentations while teaching;



STRATEGIES FOR TEACHING-LEARNING OF KNOWLEDGE

FIGURE 5.1 KNOWLEDGE COMPONENTS AND STRATEGIES ADOPTED FROM ROMISZOWSKI (7)



AREAS OF USE OF GROUP AND INDIVIDUAL LEARNING METHODS

FOR ORGANISING TEACHING—LEARNING ,

(vi) To enable students to evaluate their learning through feedback.

The following basic principles were followed in preparing instructional materials in various forms:

(i) Preparing narrative materials:

Narrative materials are preceded by an exercise to make reading purposeful. Materials are organised so that an active response is frequently required and feedback immediately provided. The language used is appropriate to the level of the students. Narrative materials are amply supported by visuals, examples, etc.

(ii) Preparing audio-visual and activity oriented learning material:

For concept learning, in addition to reading materials, audio-visual kinesthetic experiences are considered very useful and motivating. Such materials are carefully prepared particularly to facilitate complex concept learning ,matching the learning styles of the student population. Models, charts, demonstrations, etc. are used to strengthen the understandings of the learner of the various concepts and principles. To bring in activity in learning and to correlate theory with practice, opportunities are provided for varifying the learning experience through experimentation and receiving feedback. For this purpose, facilities are created for simulated as well as direct experiences through use of carefully designed experimental boards , Laboratory set ups, etc.

Fundamental to the design of the total learning package material, as indicated above, the emphasis is to be in the active involvement of the learners in the learning tasks. Unless the learners are involved with material they believe to be realistic and worthwhile, they forget 90 percent of what they hear within 72 hours after they hear it, forget 80 percent of what they see within 72 hours after they see it, and forget 35 percent of what they are shown and told after 72 hours have passed. Maximum retention of learning occurs when learners do something they believe to be productive and important, that is related to what they are supposed to learn (95).

Involvement cannot be taken as granted, it must be designed. For involvement of the learner in learning, it is necesary to:

(a) orient him to the purposes and nature of the learning event;

(b) display to the learner the relevance and to attempt to convince that the learning material/task is valuable to him for tangible purposes;

(c) bring the readiness of the learner to the peak and pitch necessary to engage in learning.

The above, aims at involving the learner at the preparing level and to be achieved through design of instructional material in the form of case study presentations by professional experts, video film presentations involving the employer organisations, presentation of total structure of the subject etc.

Further, involvement in the specific learning tasks may be achieved by providing experiences and practices (direct and if required, simulated) designed to develop behaviours as specified in the objectives of the course. This may be achieved through use of opportunities for practice, doing completion tasks, questioning, discussion, exercises, problem solving tasks, etc.

Instructional material for the above requirements may include activity packages, work-books, self study materials, demonstration boards, experimental kits, assignment sheets, visual materials, graded problems, etc.

5.4.2 Development of specific teaching-learning material

The following student-teacher material based on the given course content were identified and developed for use during the experiment:

(i) Video film showing the various application industries including interview with practicing engineers;

(ii) Universal type training board for performing experiments, & for fabricating and testing of designed circuits;

(iii) Work-book on design and drawing of contactor control circuits;

(iv) Self study type student reading material;

(v) Video films on principles of motor control circuit design;

(vi) Audio-visual aids in the form of charts, models, demonstration boards, and OHP transparencies;

(vii) Home assignment sheets;

(viii) Graded problems formulated from different industrial applications;

Brief description of the Teaching-Learning material developed is given as follows:

(a) Creating relevance of the subject of study - a video film on motor controls.

Before teaching a subject, it is expected that the students would be shown the applications of the subject content. For this purpose, the students may have to be taken to relevant industries, or alternatively, they may be provided audio-visual experiences. In an effort to bring industry into the class-room through use of electronic media, and to cover a large number of industries which are located at distant places, it was decided to plan for a video film. A video film was produced on motor controls with the assitance of nine industries/institutions, namely Bhartia Cutler Hammer, Faridabad; Hindustan Machine Tools Limited, Pinjore; Panjab Breweries Limited, Industrial Area, Chandigarh; Modella Woollens Limited, Chandigarh; Verka Milk Plant, Mohali, Punjab; YMCA Institute of Engineering, Faridabad: Mechanical Engineering Workshop, TTTI, Chandigarh; Control and Switchgears, Okhla, New Delhi; Electro Tech.Engineers, Industrial Area, Chandigarh.

The video film aimed at giving a general exposure of both manufacturing and application industries and to show the job requirements of diploma holders in such industries.

In addition to showing the applications, presentations by senior managers and diploma holding engineers working in industry were also included in the film. An entrepreneur who is a diploma holder, and has set up a motor control unit, also made presentation in this film. All these were made with a view to increase the motivation of students in learning the subject. It was possible to cover a large number of industries in a film of 35 minutes duration.

(b) Understanding of basic principles through multimedia presentations.

(i) Video film presentation

To explain the basic principles of design of motor control circuits, three video films were produced which included explanations through use of actual objects, demonstrations, charts, etc.

These were produced to help students get a grasp of the basic principles through a variety of applications. Students who could not understand well, might view these films again at a time suitable to them.

(ii) Demonstration Kit

The demonstration kit included all available motor control circuit components which could be dismentaled to show their basic construction. These were placed in a box for taking to the class room to enable students study these components.

(iii) Over-Head Projector Transparencies

OHP transparencies of a large number of motor control circuits were prepared for use during explanations. Prints of these circuits were taken on paper for giving to students. The objective was that the teacher and students might not spend time in drawing these circuits but use the time in clarifying ideas and developing understanding of the design considerations for a variety of situations, and thus make saving in the time required for teaching-learning.

(iv) Print material with illustrations

A market survey revealed that student learning material appropriate to their level of understanding were not available. Print material in the form of students' notes was developed which incorporated an overview, objectives, explanations of concepts, principles, and procedures, practice exercises, and feedback.

(c) Creating opportunities for practice

For providing opportunities for design, fabrication and testing of motor control circuits, a 'contactor control circuit trainer' was designed and developed. The trainer has two components viz. a Universal type training board and a work-book. The work-book contains a large number of control circuit problems. The problems have been arranged such that a student starts with simple problems and gradually attempts to solve complex problems. The student after designing a circuit may wire the same on the board and test the working of the circuit. The working or non-working of the circuit provides him immediate feedback. Wiring of circuits on the trainer is quicker as there is saving in time in mounting the components and making actual connections. Once the student has designed and tested one circuit he can move to the next problem on the work-book. The student need not have to wait for the rest of the students. In the work-book are included 20 experiments. All these experiments can be wired on the universal board. The advantages of the training boards as envisaged in the design, are:

(i) Theory and practice are highly correlated;

(ii) A student may proceed at his own pace of learning;

(iii) Students would learn by doing;

(iv) Immediate feedback on work done by the students;

(v) Stress on indpendent thinking and learning;

d) Creating opportunities for problem solving experience through graded problems formulated from different industrial situations.

Problems on design of motor control circuits were taken from field situations and were worked out. These were collected from actual control circuits existing in different industries viz. DCM Engineering Products, Ropar, Panjab; Ordnance Cable Factory, Chandigarh; Sports King

Industry, Ludhiana, Panjab; HMT, Pinjore;OTIS India Limited, Chandigarh.

These problems were prepared for giving to students during the course of study of the subject, but prior to undertaking real life projects of industries. The students were to be provided with sample solutions as feedback. The idea of giving these problems, whose answers are already known i.e. the problems which have already been worked out, was to give students with simulated exercise as a preparation for taking up actual open-ended problem solving tasks.

All these teaching-learning material together with additional material developed for the scaled up implementation of the model formed a complete instructional package. Figure 5.2 shows schematic of the interactive teaching-learning system for model II along with photographic view of the component teaching-learning material developed.

TEACHING-LEARNING PACKAGE-II

(Package II ilustrated for a course in 'Electrical Design Estimating and Costing taught to Third and Fifth semester electrical engineering students)

Learning Experiences	Nature of instructional material	Specific material developed
1. Multi-sensory vicarious experience for perceiving the relevance of subject of study	Video film + Print Material	(i) One video film on 'Introduction to Motor control circuits' showing the application industries, the role of diploma holders in these industries, and the scope of employment. (ii) Advance organiser for the subject
2. Abstract learning of concepts, principles, and related theory	Experimental kit + Self study modules	(i) Experimental kit on Design and fabrication of alarm/signal circutis and light and fan circuits. (ii) Self study print materials in the form of modules on 'Electrical Design, Estimating & Costing'.
3. Simulated learning through self study and practical activity	Work-book + Trainer	(i) A work-book on "Motor Control Circuit Design". (ii) Universal type Trainer on Motor Controls which facilitates for wiring of large number of control circuits designed, as given as exercises in the work-book.

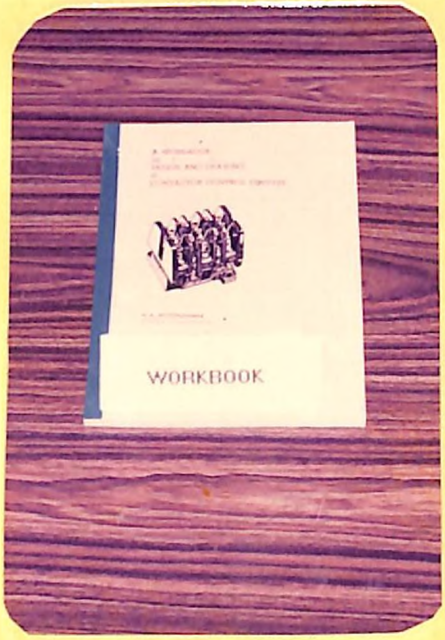
TEACHING-LEARNING PACKAGE-II (Continued)

Learning Experiences	Nature of instructional material	Specific material developed
4. Multi-sensory and kinesthetic experiences	Video films + Print Material Demonstration boards (working type)	(i) Three video films on 'Design of Motor Control Circuits'. These films form a set covering the design principles and common examples of motor controls (ii) Print material on 'Design of Motor Control Circuits' (iii) Demonstration Boards for showing the working of circuits as well as for fault finding exercises.
5. Interactive learning of open-ended problem solving through self study group discussions, seminars, report writing etc.	Instructional Manual + Problem Bank	(i) Instructional Manual and problem bank, problems related to the area of electrical control circuit design, estimating and costing.

*The work-book may be used in association with the trainer where vicarious learning could be reinforced with practical activities or, the work-book may be used independently.

Figure 5.2: Schematic of the interactive teaching-learning system for model II.

Figure 5.2 Photographic view of interactive teaching-learning material developed(video films,structure of the subject,learning objectives & experimental kit).



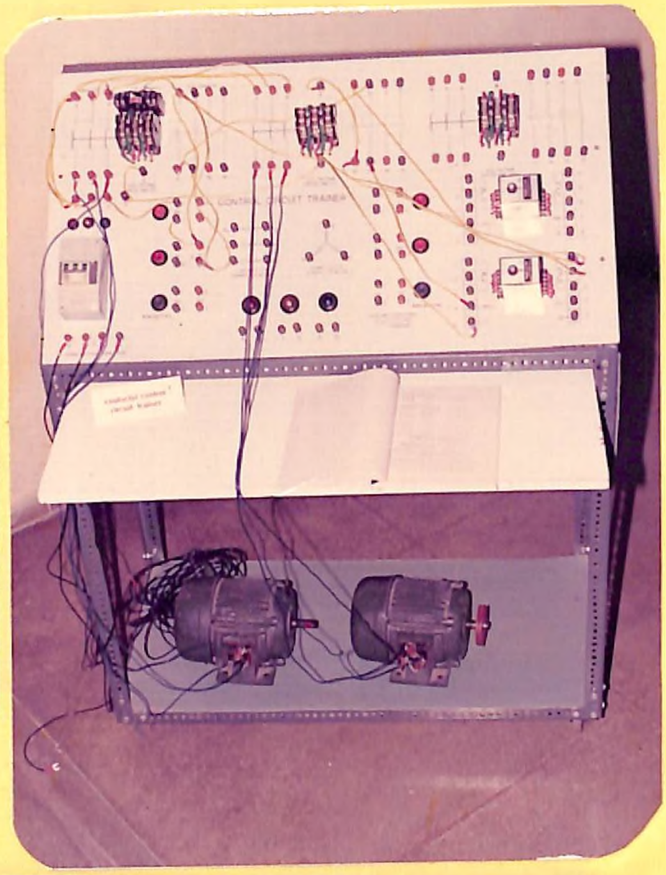


Figure 5.2(Contd): Photographic view of interactive teaching-learning material developed(work-book, universal type trainer,self study print material in the subject).

Figure 5.2(contd.) Photographic view of interactive teaching-learning material developed.(Demonstration boards,teaching aids,students study material,guidelines for problem solving, problem bank and selected industrial problems with typical solutions).

5.5 Development of evaluation tools

The following evaluation tools were developed for assessment of students:

5.5.1 Evaluation matrix for problem solving abilities

The evaluation matrix as used in experiment I, explained in Chapter IV. was chosen for this experiment also.

The evaluation matrix included criterion for judgement of students' abilities in terms of knowledge of concepts, principles, and applications; intellectual abilities in problem solving, communication skill, drawing skill, professional judgement, creativity, self reliance, documentation, initiative, leadership, punctuality and regularity. The evaluation of such abilities is to be done using multiple evaluation tools like Quiz, Seminar/Viva, Group discussion, Report/Assignment, Class work, and Observation.

5.5.2 Evaluation through written test

For evaluation of students through a written test, a question paper covering the course content was developed. This was prepared keeping in view the objectives of the course. The question paper was developed with the help of a teacher not involved in the experiment and was got validated by expert opinion on the course coverage and difficulty level. The question paper included multiple choice test items as well as descriptive type questions. No overall choice was given as is normally provided in question papers used by the State Boards of Technical Education.

5.5.3 Continuous evaluation

Criterion for continuous evaluation of students was made on the basis of the following:

(i) Student's work;

(ii) Home Assignments -their number and quality; and

(iii) Weekly tests.

5.5.4 Feedback on students' perceptions

A questionnaire on five point scale including seven items (Annexure 5.2) was developed for receiving feedback through self assessment by students. The questionnaire included the following:

(i) Understanding the·purpose;

(ii) Interest in Learning;

(iii) Opportunities to observe and understand practical applications;

(iv) Understanding problems of industry;

(v) Opportunities for demonstration of abilities;

(vi) Opportunities for development of abilities; and

(vii) Confidence gained in problem solving.

5.5.5 Questionnaires for receiving feedback

Three questionnaires were developed for receiving feedback from students, teachers, and collaborating industries.The contents of the individual questionnaire are mentioned in the following sub sections.

5.5.5.1 Questionnaire for students

The questionnaire included ten items to receive students' reactions on the following:

(i) Understanding of the subject matter;

(ii) Completion of project activity and its difficulty level;

(iii) Quality and usefulness of instructional material;

(iv) Attitude of industries;

(v) Quality and usefulness of extension lectures by industrial experts;

(vi) Interactions with industry;

(vii) Guidance provided by industrial experts in problem solving;

(viii) Any specific comments or suggestions.

5.5.5.2 Questionnaire for teachers

This questionnaire included ten items on the following aspects of Teaching-learning:

(i) Reactions on quality of experience gained in guiding students in project activities;

(ii) Attitude of industries;

(iii) Level of interest of students in learning;

(iv) Evaluation of students;

(v) Time tabling;

(vi) Curriculum;

(vii) Quality of interactions with students;

(viii) Attitude of polytechnic management;

(ix) Any specific comments or suggestions.

5.5.5.3 Questionnaire for Industries

The questionnaire for industries included seven items covering the following:

(i) Quality of students' work;

(ii) Students' evaluation system;

(iii) Curriculum;

(iv) Quality of interactions with students;

(v) Methods of strengthening industry-institute linkage;

(vi) Any other specific suggestions.

5.6 Identification of Problems of Industries

Before approaching industries for identifying problems, the researcher contacted the president of the association of local industries who assisted in identifying the relevant industries.

Ten local industries were contacted through written communication followed by personal visits to explain to the industries the philosophy and the mutual advantage of the collaboration. Out of ten industries, six industries responded favourably. Although problems existed in all industries, the remaining four industries showed apprehensions on the capabilities of polytechnic students in solving their problems.

5.6.1 Identification of industries

The following six local industries agreed to assign one or two problems relevant to their industries for solving by the students:

(i) Sunhome Cable Industries, 137, Industrial Area-Phase II, Chandigarh;

(ii) Khandelia Oil and General Mills Limited, 23, Industrial Area, Chandigarh;

(iii) Electro Tech Engineers, 383, Industrial Area, Phase II, Chandigarh;

(iv) Jai Parabolic Springs Limited, Phase VII, Mohali, Near Chandigarh;

(v) Hanson Enterprises, 11, MW Industrial Area, Chandigarh.

(vi) International Switchgears, Industrial Area, Chandigarh.

Industries chosen were such that they were not far away from the polytechnic and the students could visit these industries using their own conveyance. Except the industry at serial number 4, others are medium scale industries and are located within a distance of 4kms from the polytechnic.

5.6.2 Statements of Problems identified by the Industries

Identification of problems in specific terms was a difficult task. The researcher along with the subject teacher of the polytechnic had to study the processes and practices in the industries, have detailed discussions with the engineers, and help them identify suitable problems out of many problems facing the industries. Only the problems relevant to the subject of study were taken up and the industries communicated in writing their assigning the problems. A total of seven problems were assigned by the six collaborating industries (Annexure 5.2).

The problems chosen were such that the industries had a waiting time of atleast 3 to 4 months. These problems existed in the industries but they either did not find time for their solution or did not have the requried expertise.

5.7 Orientation of industrial experts for participation in institutional training

Industries had to take part in the implementation of teaching-learning system to provide guidance to students, provide opportunities for collection of relevant informations, and to evaluate students' performance in problem solving. Experts were identified from the sponsoring industries as well as from some other related local industries. These experts were contacted and the total teaching-learning strategy including the student evaluation scheme were explained to them. Some of the experts identified were to deliver extension lectures to students in the polytechnic for enrichment of students' understanding of the subject as well as to guide them in problem solving.

It was felt necessary to prepare the technical experts from industry to make their extension/enrichment lectures useful to students. Discussions were held with these experts prior to their delivering lectures, and the following areas were identified for inclusion in the lectures. These points had to be discussed by the experts on the basis of their long practical experience:

(i) Optimisation in design, considering various practical aspects;

(ii) Availability of material from various sources, their cost and quality;

(iii) Time Scheduling, Supervision, and Quality Control;

(iv) Testing, Installation and after sales service requirements.

It was also suggested that the experts might mention about the general qualities for which an employer looks forward, while selecting diploma holders.

The experts were also explained the evaluation matrix chosen, for the purpose of assessment of students' abilities on problem solving.

5.8 Implementation through a pilot experiment

During the first half of the semester, as decided, the teacher taught a part of the subject following his own method of teaching as he had been practicing over the years. The researcher with the consent of the teacher, observed the teaching-learning activities by attending his classes. Feedback from students were collected to know the students' own perceptions on certain aspects of teaching-learning using the feedback proforma as in Annexure 5.3. A pre-test was conducted to evaluate students on their problem solving abilities by assigning them a problem related to the subject and then evaluating, using the evaluation tools for problem solving. Thus the main indicators i.e. the students' initial preparation in terms of problem solving abilities as a result of existing method of teaching-learning, as also students' own perceptions on the development of their abilities, were available, which could, at a later stage, be used for making a comparative analysis of students achievements in these two cases.

One week before the beginning of the experiment, the teacher was provided with sufficient copies of all the teaching-learning material. Facilities for use of projection equipment like VCR, OHP, etc., and arrangements for conduct of practicals were ensured. For the purpose of the experiment the teaching-learning material developed had to be got duplicated in required numbers by the researcher. However, in due course of time after their velidation and revision, the researcher was able to get most of the material published through a reputed publisher. The sale right of the video films were also given to some publishers.

The experiment started with the polytechnic subject teacher teaching the subject to 44 final year students following the teaching-learning model presented in figure 3.2 in Chapter 3. During the first phase of teaching-learning activities, students visited nearby industries and had interactions with field engineers, viewed the video films and had group discussions. The teacher presented 'Advance Organisers' showing the structure of the subject and related concepts and principles. Experts from industry made case study presentations. All these were aimed at creating the relevance of subject of study and thereby preparing students for learning of the subject. Use was made of materials like working drawings, various types of components and accessories for demonstration, manufacturer's leaflets, price list of components etc., during extension lectures by visiting experts. Besides other skills, the importance of reading and interpreting drawings was emphasised by the experts. The extension lectures were observed to be meaningful interacting sessions rather than mere lectures. Since students had industrial problems in front of them to be solved, they asked for practical informations from the experts which were neither available in text books nor was the class room teacher able to provide.

Teaching-learning consisted of students learning the basic concepts and principles by working on assignments, getting multi media presentations from the teacher, group discussions, self study, periodical test and feedback, making use of remedial study material, and receiving enrichment lectures from field experts. Demonstrations and practicals were organised to correlate theory and practice. The universal type experimental board and the associated work-book helped students design certain given circuits, wire them on the universal board and test the working of such circuits. The teacher spent most of his time in having discussions with students to remove individual difficulties. The progress of each student was recorded on day to day basis. This provided feedback to the teacher to extend special attention to those students whose pace of learning were comparatively slow. By placing the responsibilities of learning on the students and by keeping their motivation level high through learning activities, it was possible for the teacher to teach the given course content within 5 weeks which otherwise was taught in 9 weeks through conventional teacher centred instruction. This information was provided by the teacher himself on the basis of his past experience in teaching this subject. Curriculum document also provides for 8 to 9 weeks of teaching for this part of the subject. Thus there was a net saving of 4 weeks time. This period of 4 weeks was devoted in giving the student experience of open-ended problem solving, the problem being of interest to the industries. For this purpose the students in groups of six to seven were alloted one real life problem , from those assigned by the industries. The subject had 8 periods of student contact hours and was alloted 4 periods per day twice in a week. The students and the teacher visited the industries to have a feel of the problem, to collect data, and to discuss the problem with the engineers. Visits were made during the available working hours. To avoid loss of time, the students decided on the appointed days to report directly to the industries , instead of first reporting to the polytechnic and then go to industries. In some cases visits were also arranged on Saturdays. The students returned to class-rooms with required informations and data related to the problems assigned to them.

The class room time was utilised by the students, in cooperation with their teacher, in analysing the problems. Experts from industries visited the polytechnic for providing guidance and on occasions students had interactions with the industries through visits. Students also had to do market survey and collect data from other sources through personal effort. Enrichment lectures by the teacher and field engineers were also organised which helped students in problem solving. The students had to consult literature, reference books, data book, Indian Standards,Electricity Rules, etc. to work out possible solutions to the problems.

The students performed the following activities as a part of their project activities:

(i) Information collections through market survey;

(ii) Preparing a plan of action;

(iii) Perceiving possible solutions;

(iv) Preparation of Single line drawings,where required,

(v) Discussions within the groups and with others for arriving at a solution;

(vi) Consulting literature, data books, Indian Standards and Electricity rules, Standard text books, Manufacturers leaflets, price lists,etc;

(vii) Estimation and costing;

(viii) Preparation of total drawing;

(ix) Discussing the solution with clients;

(x) Preparation of a Technical report;

(xi) Presentation of the report.

The solutions to problems were presented by the students through technical report.

The problem solving abilities of students were evaluated jointly by the representative of the relevant industries and the subject teacher. Evaluation of students on problem solving were done by assessing their abilities in terms of knowledge and concepts, principles, and their application, intellectual abilities in problem solving, communication skill, skill in engineering drawing, professional judgement, creativity, self reliance, documentation, initiative and leadership qualities. Evaluation was done using Quiz, Seminar, Viva-voce, Group discussion, Assignments, Class Work, Report Writing and day to day Observations using the evaluation matrix as used in experiment described in Chapter 4.

Students were also given periodical tests during the course of their learning of the subject matter and also a comprehensive written test covering the entire course content.

It was possible during the experiment to observe each student closely and identify their real abilities. A record of these were maintained and a certificate was issued to each student which indicated the good qualities of a particular student as well as the areas in which he needed improvement.

5.9 Results of Student Evaluation and feedback

Students were evaluated on their problem solving abilities using multiple evaluation matrix before and after the experiment. Continuous evaluation of students were made on the basis of periodical tests and assignments and these scores are termed 'CN' (Annexure 5.4). A comprehensive post test covering the course content was conducted at the end of the semester. After the semester work the students appeared in the examination conducted by the SBTE. Students' scores in the subject in the Board examination were collected. Also scores of students of the previous batch in the same subject were collected.

For the purpose of comparison, scores of students in the examination conducted by SBTE in the related subjects taught in the previous two semesters were also collected. Further, students' perceptions on certain aspects of teaching-learning before and after the experiment were taken using feedback questionnaire as explained in section 5.5.4.

5.10 Analysis of student evaluation and feedback data

The students of the experimental group scored an average of 52.09 marks in the examination conducted by the State Board of Technical Education.

Mean score of students in the related subjects, i.e, Electrical Design and Drawing I and II, in the Board examination bas been calculated as equal to 46.71.

Mean score of students of the previous batch, in the same subject which the experimental group had studied, in the Board examination has been calculated as equal to 46.5.

This shows an increase in the average performance of students in the examination conducted by the State Boards of Technical Education. However, it should be mentioned here that this comparison is made on the effect of students' working on related projects for half a semester only.

2. Average Problem Solving Score of students at the initial phase and towards the end of the experiment has been 29.0 and 64.4 respectively. This shows a marked increase in the problem solving abilities of students.

3. The correlation coefficient of scores between problem solving activities,PS and the scores in comprehensive post test,PT has been calculated as equal to 0.37.

Similarly correlation coefficient of scores of problem solving,PS and the scores of examination conducted by the SBTE, BD has been calculated as equal to 0.45 . (Annexure 5.4).

4. Average percentage achievements as perceived by students on certain critical factors of teaching-learning, based on data collected before and after the experiment,were calculated for the purpose of comparison. These have been presented in figure 5.3.

5. On the basis of continuous evaluation,while the students were on problem solving assignments, a record of each individual's personality attributes was made. This evaluation data was used to issue certificate (Annexure 5.5) to students indicating their strong areas as well as their areas needing improvement. The record showed that students good at cognitive abilities were not necessarily good at leadership qualities, communication abilities, etc. Participating industries viewed this kind of certification of students useful to them for the purpose of recruitment for various job requirements.

On the basis of analysis of data, as discussed above the following conclusions are made:-

(i) Open-ended problem solving as part of the teaching-learning process has not only helped students develop all such skills which are demanded by the world of work, but also has helped them understand the subject content better.

(ii) Industrial problem solving as an integral part of institution based study of subjects provided an opportunity to evaluate various personality attributes of a student, which are significant in the real life situations.

(iii) The poor correlation between the test scores of problem solving and traditional paper and pencil test leads to a vital question as to whether the traditional test conducted by the SBTE truly reflects the actual abilities of students in terms of application of knowledge in problem solving in the field including such abilities as professional judgement, decision making ability, Communication, Initiative, Self-reliance, Team work, Leadership, Ability to meet the dead lines, etc.

(iv) It was possible to identify best quality of each student as well as the areas of weakness, in relation to the needs of the world of work, through continuous observation during the problem solving phase of teaching-learning. Certification of student indicating clearly his strong areas has been considered more meaningful by the employer as against stating only the percentage of marks scored in different subjects, as being done by the certifying authorities at present.

(v) Perceptions of students on their achievements on various critical factors of learning, as collected before and after the conduct of the experiment, and as represented in figure 5.3, show a significant rise in students' achievement in terms of understanding purpose, seeing practical applications, understanding problems of industry, Confidence in problem solving, and demonstrating competence.

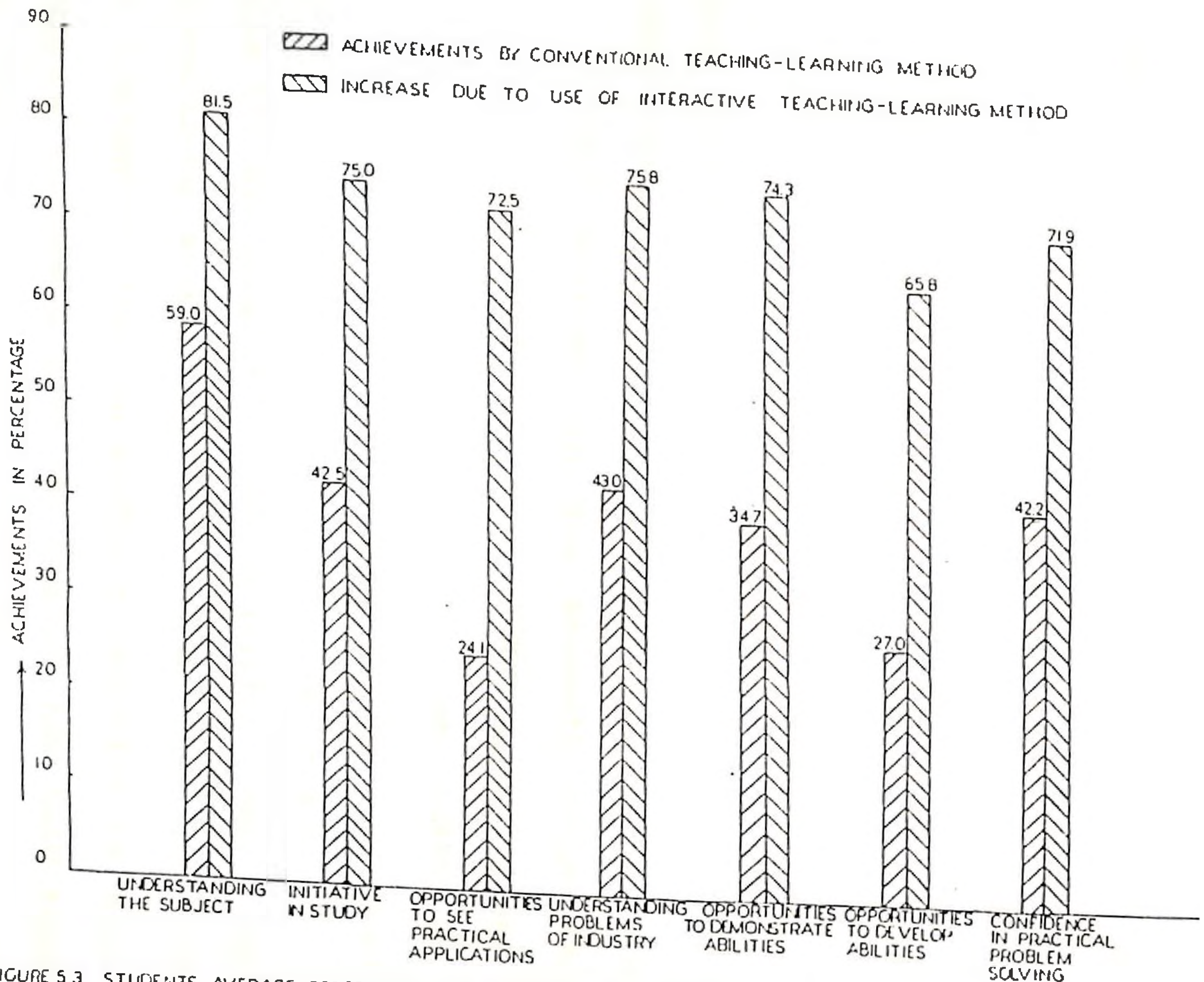


FIGURE 5.3 STUDENTS AVERAGE PERCEPTION ON CERTAIN FACTORS INFLUENCING TEACHING-LEARNING

5.11 Observation on various aspects of teaching-learning prior to and during the experiment

Prior to the conduct of the experiment, the researcher made close observations of the teaching-learning process by attending classes engaged by the subject teacher. An observation table was prepared for this purpose. Similarly, observations on teaching-learning process were made during the experiment also.These observations are described as follows:

5.11.1 Teaching-learning process as observed prior to the experiment

The teacher taught the subject through lecture method using black board as the only aid. The teacher took up the task of completing the syllabus keeping the students passive listeners. Neither did the students raise many querries, nor did the teacher encourage students to discuss and clarify their doubts. When the teacher was asked to comment on his method teaching, he mentioned that they went on asking questions and clarifying doubts, he would not be able to cover the syllabus within the available time. Student-teacher interactions were limited to occasional questions asked by the teacehr on the informations provided by him and asking stduents to repeat what the teacher had told them. Question like 'do you follow?', 'Is it clear?', 'Is it OK?' were more frequently used. The teacher taught the subject in a logical manner but without creating in students the felt need for studying the subject. The introductory remarks were very sketchy and not much curiosity in the students for knowing the details was observed.

The teacher neither showed any practical application of the topics he was teaching through field visits nor did he make any visual presentations for the purpose. Most of the time, class and home assignments were in the form of preparing drawings by copying from books or drawings drawn by teacher on the black-board.

Evaluation of students for award of sessional marks was on the basis of class-work, preparation of drawings in the class from drawings provided in books, class tests and home assignments. Two class tests of paper and pencil type were conducted where students had to prepare circuit diagrams of problems already solved in the class by the teacher.

Most of the students were found shy in asking questions to the teacher. Many students were found copying the class-work from other students. The teacher could not provide special attention to individual students as he had to teach to cover the syllabus.

5.11.2 Teaching-learning process as observed during the experiment

Students saw the various application industries related to the subject of study through study visits to local industries as also through a video film presentation . The video film which covered a large number of industries showed the relevance of the various topics included in the subject. The film also included interviews with industrial managers who emphasised the importance of study of this subject. Group discussion held after the visits and viewing of the film generated enthusiasm in students in learning of the subject as they got a clear picture of the relevance of the subject of study through direct as well as audio-visual experience. The structure of the subject presented as an 'advance organiser' by the teacher provided an 'intellectual scaffolding' which formed the basis for further study of various topics in details.

Involvement of students through the use of self study material, work-book, demonstration models, experimental boards, etc. provided opportunities to students for participation in the learning process. The students were observed learning by themselves which was followed by group discussions after each unit of study. The teacher was relieved from the task of making presentations in the form of lectures and found more time for interacting with the students and for providing individual guidance as required by the students. Thus the teaching-learning was observed more of a student centred one. Students were observed learning from each other but took the help of the teacher in case of felt need only. The students studied the syllabus in about half the time than that provided in the curriculum. The demonstration models and the experimental boards were found very useful by the students in clarifying their ideas and also in verifying the principles by actual experimentation.

Project activities led students carryout tasks of data collection, reference to norms and standards, drawing work, estimating and costing, interpretation and evaluation of results, report writing etc. These tasks, the students found challenging but motivating as the sum of all tasks resulted in the solution of an open-ended problem. The teacher played the role of a guide and led the students to find solutions to the problems. Throughout the problem solving phase of teaching-learning, the students were found sorting out things for them-selves. The problems, although were related to the particular subject of study required informations from other related subjects. The student were seen consulting related books, literature of other subjects and also consulting other teachers.

Groups discussions provided opportunity to each student to express their ideas and get feedback from others. Students were observed co-operating amongst themselves within the group to complete the total task within the prescribed time limit. There was competition between the groups to produce quality work acceptable to the industry who assigned them the problems. The researcher also observed the quality of questions asked by the students to the teacher and to the industrial experts. Most of the questions asked by the students were of higher order type and needed a lot of thinking to provide suitable answers. To answer some of the questions the teacher had also to consult reference literature and consult other practicing engineers. Involvement of industrial experts in guiding students in problem solving resulted in a real interactive teaching-learning situation between the student, the subject teacher and the potential employer.

5.12 Feedback from students, industries and polytechnic

Feedback from students, industries and the polytechnic faculty including Head of Department and the Principal were obtained through questionnaire, interview and group discussion. Their reactions as recorded are described in the following sections:

5.12.1 Feedback from students

Feedback from students through questionnaire and the specific comments of students, as gathered during interviews with them are stated as follows:

(i) For the first time in their course of study in the polytechnic, the students got an opportunity to interact with the industry and solve open-ended problems.

(ii) All students strongly expressed that other subjects should also be taught on similar lines. They wondered why the other teachers so long did not adopt such an interactive method of teaching-learning !

(iii) The learning material provided to them were rated to be excellent as compared to the material available in the market.

(iv) The problem solving approach to learning helped students in demonstrating their competence and they felt that they would be in a better position to face industries while seeking employment.

(v) They could correlate theoretical study with practical applications for the first time.

(vi) They could interact purposefully with the teachers, industrial experts and the fellow students in solving open-ended problems.

(vii) The students could see the interrelationship of different subjects of study as the problem solving activity led them to collect information from other subject areas.

(viii) Earlier, the students did not realise the importance of drawing skill required to be developed.

(ix) For the first time, they got an opportunity for meaningful technical communication.

(x) Real life problem solving task in front of them created motivation to acquire the basic knowledge and skill ,and this they could do in less time than the time taken, if covered through lectures alone.Since, the study was through a variety of learning materials, their understanding of the subject was better.

(xi) Students appreciated the cooperation extended by the industries while learning open-ended problem solving.

5.12.2 Feedback from Industries

Some industries initially showed apprehensions about the abilities of students in open-ended problem solving. However, out of 10 industry contacted, six volunteered to experiment, and assigned problems. As the experiment progressed, the industries found satisfaction in this cooperative endeavour and provided full support. Representatives from all the industries frequently visited the polytechnic and had interactions with the students. Three industries sent their engineers in delivering expert lectures on related aspects free of cost. They also had interactions with the Principal and Head of Department of the Polytechnic and assured all help in future. Industries also sent their concerned engineers to evaluate the students on problem solving during the experiment. The industrial experts were shown the evaluation system followed by SBTE including some of the past question papers.

The evaluation system adopted during the experiment was considered relevant and realistic as compared to the written test conducted by SBTE. Polytechnic Principal, Head of the Department, and the subject teachers found to their surprise that many of the industrial experts who provided cooperation in this experimental study were their own outputs and wondered why they did not seek help from them earlier. These experts remarked that after they had left the polytechnic, there was no effort to seek help from them for which they were always willing. All the industries appreciated the work done by the students and mentioned that the project output were of use to them. Regarding the existing polytechnic curriculum, the industrial experts mentioned that it required revision and such revision work could be taken up by the polytechnic system in collaboration with industries.

5.12.3 Feedback from polytechnic

The Head of Department was thrilled in seeing the students engaged in problem solving activities and regularly visited the class and had discussions with the teacher and students. He felt that this interactive method of teaching-learning could be pursued further so as to allow the system internalise such an innovative method of teaching-learning. He said that he would,on his own, also contact some more industries for their cooperation in improving teaching-learning.

The teacher found this experience a unique one and was seen enthusiastic. He expressed that he would like to teach, following the same method, in the coming semesters. Since the solutions to the problems assigned to students were not known to him, he found guiding the students a challenging task. Further, he considered involvement of industrial experts in students' guidance necessary as he alone was not able to provide the required guidance. The teacher mentioned that the student evaluation system followed by the SBTE did not really measure the abilities of students in terms of field requirements.However,the teacher expressed satisfaction in this teaching-learning assignment as he also learnt a lot and developed confidence in open-ended problem solving. The teacher expressed that he was in a better position to provide feedback for curriculum revision.

Both the teacher and the Head of the Department mentioned about the need for flexibility in terms of time-tabling and rules and regulations to enable students and teacher interact with the industries.

5.13 Validation

Validation of any system model is done in terms of achieving the stated objectives. The objective of this teaching-learning system model has been to achieve the expected quality in the trained students as per the requirements of the changing technological world of work. Since the model involves human elements both in its process as well as in its product, the evaluation is to be done both in terms of the quality output as well as the process involved.The view of the employer,who is the receiver of the output,the teacher who is the manager of the process,the student,who is the beneficiary,and the polytechnic,who is the overall facilitator in the whole process have to be consider in validating this model.

Student evaluation has shown marked improvement in terms of their problem solving abilities which is the requirement of the world of work; feedback from students indicates better student motivation in the learning process; feedback from teachers indicates their better job satisfaction; response from industries about the quality of student output has shown encouraging trend; and for the management, the process involved minimal resource input requirements in improving the quality of education.

Thus this conceptual model of teaching-learning, which incorporated open-ended project based student teacher involvement as an integral part of class-room instruction, finds its validity in terms of achieving the total objectives of the system.

This teaching-learning model was further experimented on a larger group as reported in the subsequent sections of this Chapter.

5.14 Scaled up implementation of project-based student teacher involvement as an integral part of class-room instruction

5.14.1 Preparatory phase

After completing the pilot experimentation in 1989, it was decided, in consultation with the Polytechnic Principal and Head of Electrical Engineering Department, to repeat the experiment for a full Semester and for two subjects. Since, preparation of instructional material for the two subjects and identification of problems in industries had to be done before the conduct of the experiment, it was thought appropriate to conduct the experiment in the semester beginning July,1990. In the July-December semester, the Electrical Engineering students of Third Semester study 'Electrical Design and Drawing I' while students of Fifth Semester study 'Electrical Design and Drawing III'. It was decided to conduct the experiment with these two classes and the subjects mentioned above.

In association with the subject teachers, total teaching-learning material on the above two subjects were developed around the prescribed course content which included students notes, audio-visual materials, demonstration and experimental boards, workbooks, graded exercises, assignments, etc. The instructional material already developed for the pilot experiment were also included for use during this experiment as they formed a part of the teaching-learning material required for the subject of 'Electrical Design and Drawing III'. The evaluation tools for assessing problem solving competence as used in the pilot experiment were to be used in this experiment also. Comprehensive test question papers on the two subjects covering the whole curriculum were prepared with the help of outside polytechnic teachers. These question papers were got validated in terms of their coverage of course content and difficulty level from other polytechnic subject teachers. The total instructional package has been shown in figure 5.2 earlier.

For identifying problems for the students of both Third and Fifth Semesters, it was required to contact more number of industries. However, the six industries who assigned projects during the pilot experiment were first contacted. All the six industries agreed to assign problems, this time also. However, the problems identified by two industries did not fall within the scope of learning of the target group of students and hence problems from the remaining four industries were accepted. In addition, twelve more local industries assigned problems. A total of seventeen problems received from sixteen industries were then classified into two groups on the basis of relevance of the subject of study and the ability level of Third semester and Fifth semester students (Annexure 5.6). Experience in identifying problems revealed that problems related with electricity existed in almost all types of industries. This time, in addition to approaching only the electrical industries, problems were collected from electrical contactors, flour mills,etc. Allocation of subjects for teaching during the Semester was done as follows: The teacher who was associated in teaching Fifth Semester stu - dents during the pilot experiment was asked to teach the Third Semester students. Responsibility of teaching Fifth Semester students was given to another teacher.

All the instructional materials developed were made available in required quantity to the teachers for use. Experts from industries were contacted for extension lectures and project guidance and their schedule of lecture/visits were prepared.Experts were also explained the evaluation tools.

5.14.2 Implementation

The two teachers taught their alloted subjects during the Semester August,1990-February,1991 (The Semester got extended due to the disturbance in academic work created as a result of student agitation against one Commission's Report).

The teaching-learning activities included three phases namely introductory phase, acquisition of basic knowledge and skill phase, and project activity phase. On the first day of the session students' perception on certain aspects of learning based on their past experience in the polytechnic was collected. Student progress was recorded through continuous evaluation and feedback. Evaluation of problem solving abilities was done jointly by the teacher and representatives of industries. For project activities, the students visited industries for collection of data and in having discussions with the industry. On an average 5 to 6 students worked in each group. Experts from industries delivered extension lectures on the dates as decided. Experts from four industries delivered lectures to Third Semester and Fifth Semester students on seven occasions. Students were given a written test using the question papers already got prepared. Feedback from students were collected on their perceptions on certain critical aspects of learning after the experiment also. Project reports prepared by student groups were presented to the respective industries for their use. Students were issued certificates on the basis of continuous evaluation record maintained by the teacher indicating their total personality traits.

5.14.3 Results of Students' evaluation

Students were evaluated on a continuous basis through assignments, class-tests, and observation as is normally done by a polytechnic teacher as per curriculum requirement. In addition, students' problem solving abilities and their knowledge of the subject matter were evaluated respectively through use of evaluation tools for problem solving and a written test. Students' scores in the Board examination were collected. Students' scores in the Board examination by the previous batches, in the subjects ,were collected for the purpose of comparison. Also, the students' scores in the related subjects i.e. in Electrical Design and Drawing I and II, studied in the previous two semesters were taken and their average calculated.

5.14.4 Analysis of data

The mean of scores of students of Fifth semester in various tests and the correlation coefficients of scores were calculated (Annexure 5.7) and are presented below:

(a) Mean of Scores:

Previous Semester average score of students in the related subjects (PR) (in examination conducted by SBTE)	40.02
Average score by students of the previous three batches in the same subject (PB) (in examination conducted by SBTE)	48.90
Continuous Evaluation(CN)	60.56
Problem Solving(PS)	47.87
Post Test (PT)	55.87
Board Examination(BD)	59.02

(b) Correlation Coefficients:

	PR	CN	PS	PT	BD
PR	1.00	0.47	0.29	0.40	0.45
CN	0.47	1.00	0.50	0.72	0.52
PS	0.29	0.50	1.00	0.39	0.34
PT	0.40	0.72	0.39	1.00	0.60
BD	0.45	0.52	0.34	0.60	1.00

The mean scores of students of Third Semester in various tests and the correlation coefficients of scores as calculated (Annexure 5.8) are presented below:

(a) Mean of Scores:

Average score in the same subject by previous batch of students(PB)*	39.26
Continuous Evaluation (CN)	66.26
Problem Solving (PS)	50.73
Post Test (PT)	52.43
Board Examination(BD)	48.30

*In case of Third Semester students, as it was not possible to identify related subjects of study in the previous Semesters, scores of previous batch of students in the same subject were taken and average calculated.

(b) Correlation Coefficients

	CN	PS	PT	BD
CN	1.00	0.37	0.71	0.56
PS	0.37	1.00	0.48	0.43
PT	0.71	0.48	1.00	0.68
BD	0.56	0.43	0.68	1.00

Feedback on certain critical factors of teaching-learning as perceived by students before and after the experiment, on the basis of a five point scale questionnaire, were analysed and are presented in figure 5.4 for Fifth Semester students, and in figure 5.5 for the Third Semester students.

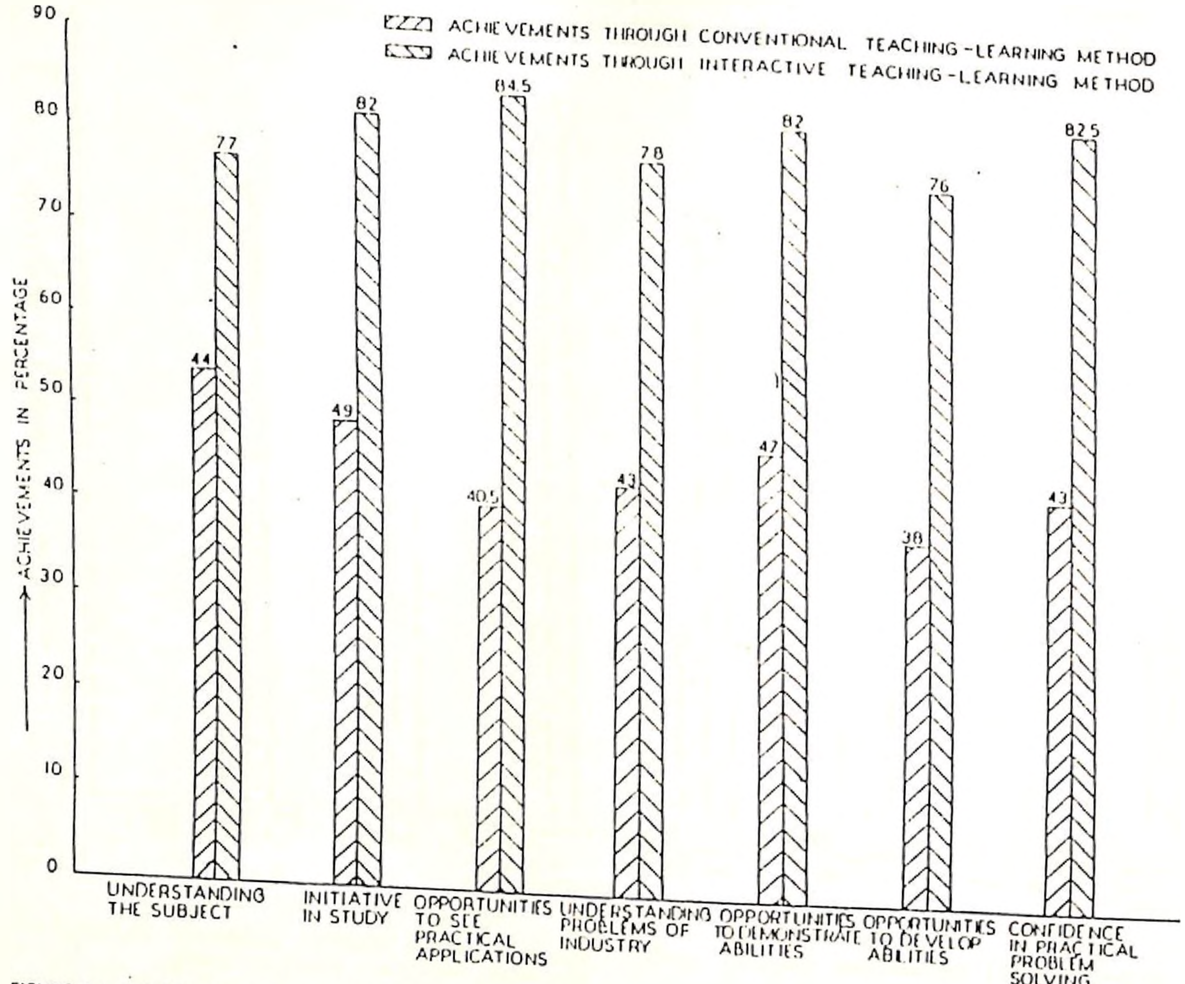


FIGURE 5.4 STUDENTS AVERAGE PERCEPTIONS ON CERTAIN FACTORS INFLUENCING TEACHING-LEARNING (DATA OF FIFTH SEMESTER STUDENT)

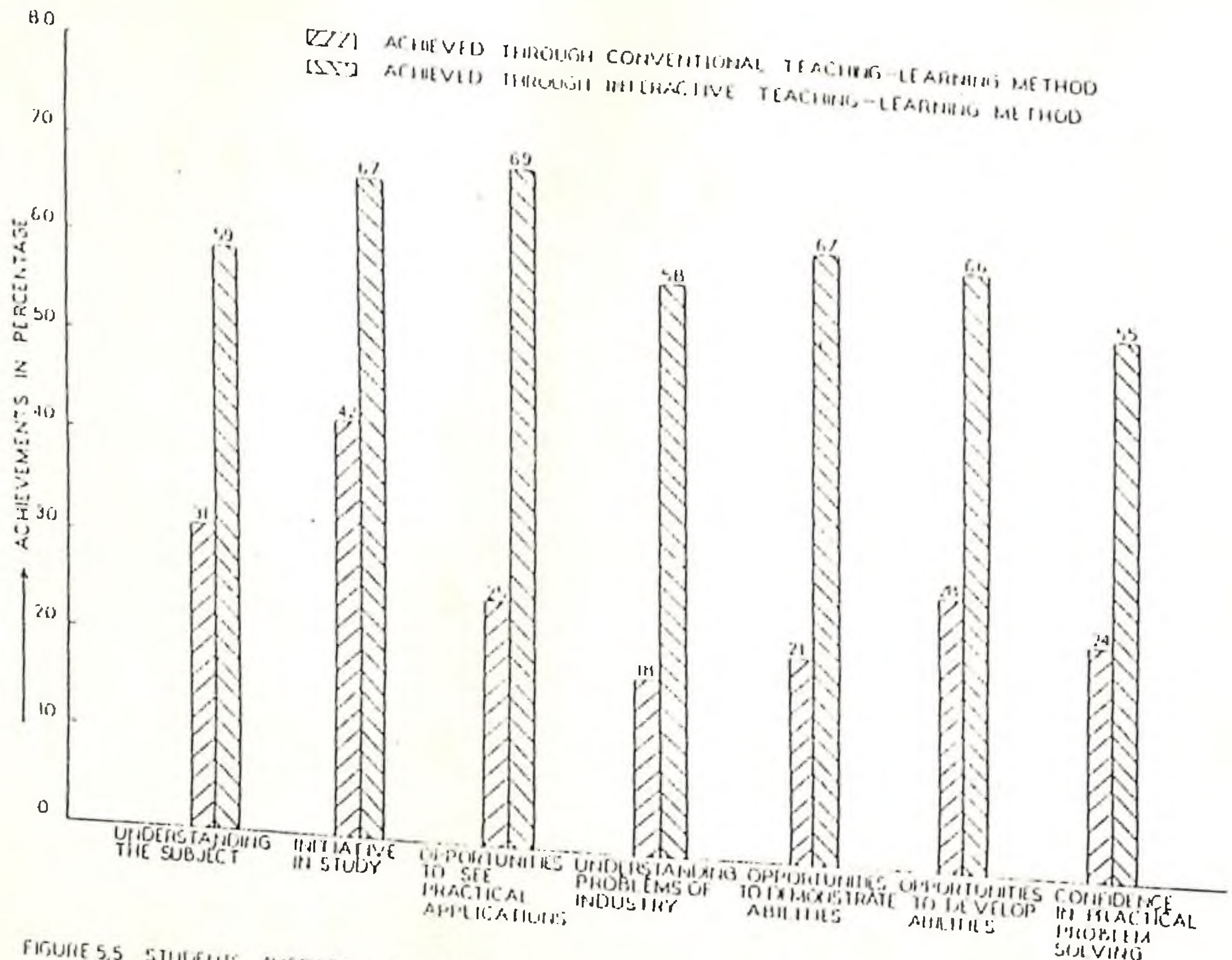


FIGURE 5.5 STUDENTS AVERAGE PRECEPTIONS ON CERTAIN FACTORS INFLUENCING TEACHING-LEARNING (DATA OF THIRD SEMESTER STUDENTS)

Correlation coefficients of scores of Quiz, Seminar, Group discussion, Technical report, and Observation as achieved by students were calculated for both Fifth Semester and Third Semester students as shown below:

(i) For Fifth Semester students

	QZ	SM	GD	RP	OBS
QZ	1.00	0.79	0.82	0.86	0.78
SM		1.00	0.83	0.82	0.83
GD			1.00	0.86	0.82
RP				1.00	0.89
OBS					1.00

(ii) For Third Semester students

	QZ	SM	GD	RP	OBS
QZ	1.00	0.55	0.65	0.63	0.52
SM		1.00	0.66	0.84	0.65
GD			1.00	0.76	0.68
RP				1.00	0.84
OBS					1.00

The scores of students in the Board examination in this subject of study by the four consecutive batches were collected and the average score for each batch of Fifth Semester students are plotted as in figure 5.6.

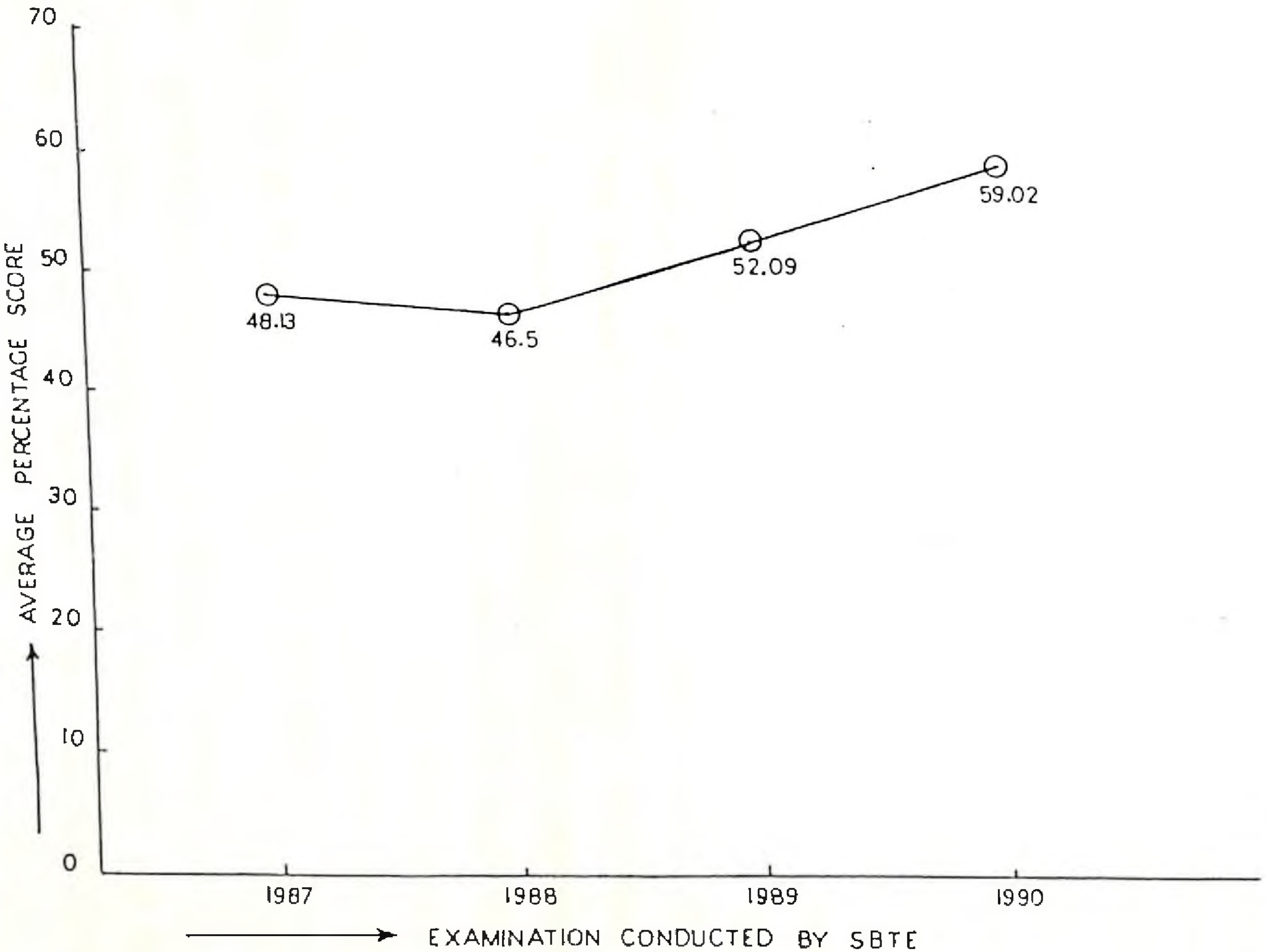


FIGURE 5.6: AVERAGE SCORE OF STUDENTS OF DIFFERENT BATCHES IN THE EXAMINATION CONDUCTED BY SBTE.

5.14.5 Interpretation of results

On the basis of analysis of results of student evaluation, the following conclusions are made:

(i) Performance of students in the examination conducted by the SBTE has been better as compared to the performance of the previous batches of students. This is evident when a comparison is made between the performance of students of this experimental group either with their own performance in similar subjects in the previous semesters or with the performance of previous batches of students in the same subject. When a comparison is made between the performance of students of four consequitive batches in the particular subject of study (as in figure 5.6), it is seen that the present group of students performed better in the Board examination. Average performance of students of 1989 batch have been better than the average performance of students of 1987 and 1988 batch because of the positive effect of pilot experiment conducted for a period of 9 weeks during the Semester.

(ii) Correlation coefficients betwen scores of continuous evaluation and Post-test have been 0.72 and 0.71 for the two groups of students. However, the correlation coefficients have been 0.39 and 0.48 between problem solving scores and Post-test scores; 0.34 and 0.43 between Problem Solving scores and the scores in the Board examination. Thus, although a fair correlation is observed between Continuous evaluation and Post-test, correlation coefficient between Problem solving scores and Post-test or for that matter the scores in Board examination has been rather poor. This leads to the conclusion that the examination conducted by the SBTE does not necessarily evaluate students for their abilities required by the world of work.

(iii) Range of correlation coefficients of students' scores in Quiz, Seminar, Group discussion, Report Writing, and Observation varies from 0.78 to 0.89 for one group, and from 0.55 to 0.84 for the other group. This shows that there has been positive gain by the students in each of the area: of development, as measured by the evaluation instruments.

(iv) Significant increase in achievement, as perceived by the students, is observed in terms of understanding the purpose of studying the subject, interest in study, opportunities to see and understand practical applications of the subject of study, understanding the nature of problem, demonstrating one's own abilities, and confidence in solving practical problems.

5.14.6 Feedback from Students, Teachers, and Industries

Feedback from students, teachers, and industries were collected through questionnaire, interview and group discussions and during the seminar conducted by the students. Analysis of the feedback received reveals the following:

(i) 85 per cent of the students could complete the projects which were found useful by the sponsoring industries. The others although learnt the method of problem solving could not complete their tasks within the available time.

(ii) All the students felt that they understood the subject matter better by undertaking project activities.

(iii) All the students expressed that such project activities should form an essential part of curriculum in each of the applied engineering subject.

(iv) Instructional material provided were found very useful in terms of their quality of presentations including treatment of different concepts and principles. The students could learn most of the course content through self study as the learning material provided were mostly self explanatory and included plenty of illustrations.

(v) All the students found attitude of industries as positive, which facilitated to a large extent learning of open-ended problem solving.

(vi) Extension lectures delivered by industries were of immense use and contained lot of practical informations which are normally not available in text-books.

(vii) Students did not express any difficulty in visiting industries on their own. However, the teachers felt that expenses for visiting industries be allowed to facilitate frequent interactions.

(viii) Guidance provided by industrial experts in problem solving was appreciated by all the students and they expressed that consultations with industrial experts were essential for solution of problems.

(ix) Teachers found guiding students in problem solving a challenging task as compared to teaching of a given course content.

(x) After interacting with industry, the teachers expressed that the curriculum required revision so as to make it respond to the actual needs.

(xi) The teachers found industry cooperative and willing to participate in activities related to improvement of teaching-learning.

(xii) The evaluation system and the tools used, the teachers considered, were more suitable for developing students' abilities, as also in providing feedback.

(xiii) The teachers felt that for implementing this model of teaching-learning for all the subjects, flexible time-tabling would be required to enable teachers and students interact with the world of work while pursuing teaching-learning activities.

(xiv) Development of a problem bank for use as projects in all applied engineering was essential so as to implement this model in teaching, all the teachers emphasised.

Polytechnic management expressed their satisfaction on the quality of work done by students and the cooperation received from industries.

50% of the experts, who participated, were passouts of the same polytechnic and were willing to extend cooperation.

(xvi) Students were found putting in extra effort in learning as evidenced by their completing the course content before the stipulated time, as also the total number of assignments completed.

(xvii) The students were observed asking better quality of questions to the teachers as well as to the experts.

(xviii) Many of the querries made by the students, the teachers found difficult to answer and had to consult either reference literatures or take assistance of experts.

(xix) Both the teachers expressed that the open-ended problem solving experience, provided them with feedback for self development. The teachers expressed that, in addition to gaining theoretical knowledge, they required to have regular exposure to industries, for which a mechanism was to be developed.

(xx) All the experts from industries expressed that they participated in polytechnic teaching-learning for the frist time and derived satisfaction from this collaborative effort.

(xxi) While going through the course content, participating industrial experts expressed that there was urgent need for revision of curriculum in view of the rapid changes that had taken place in the world of work. The experts also indicated that topics like energy management, environmental pollution control, safety measures, preventive maintenance, entrepreneurship, etc. should also be incorporated into the subjects of study of engineering subjects.

(xxii) Commenting on method of student evaluation, the experts expressed that the evaluation method used in this experiment was more meaningful and acceptable to industries than the conventional method of student evaluation.

5.14.7 Difficulties faced in conduct of the experiment

It was possible to conduct the experiment as per the plan with the cooperation of all concerned. However, some of difficulties faced are mentioned as follows:-

(i) It was initially difficult to convince the industries about the capabilities of polytechnic students to solve practical problems faced by the industries, as there was no previous evidence to support such a claim. However, constant interactions and follow-up, made the industries see the keenness of this group, and they agreed to try on an experimental basis. The researcher would like to record here that feedback from industries has shown, beyond doubt, that the industries who cooperated were not disappointed to the least. This is evident from the fact that the industries who assigned problems in the pilot experiment, once again assigned new problems during the scaled up implementation phase of the experiment. This shows that the polytechnic student-teacher team has to establish their credibility by creating evidences that they have the ability to contribute to problem solving, given the opportunity and needed support. At the initial stage, like any other entrepreneural activity, extra effort is required to be made to involve as many number of industries to collaborate in improving polytechnic teaching-learning.

(ii) Identification of problems in industries for use by the polytechnic student-teacher team was a difficult task and required interactions at the shop floor level.

(iii) Enabling teachers interact with industries right from the problem identification phase to the project guidance and student evaluation phase required flexible financial and other rules and regulations. The existing rules and regulations need to be modified or an alternative worked out, to encourage teachers to interact with industries for the improvement of teaching-learning.

(iv) Development of instructional material appropriate to the level of polytechnic students and having a self learning character, required investment of good amount of man-hours. However, looking into the long-term benefit of such material and the large target population who could use such materials, the exercise was worth taking. The instructional material developed by the researcher, and used as self study type modules in this experiment, were reviewed by M/s Wiley Eastern Limited, New Delhi and published them in 1991 as a text book entitled, 'Electrical Design Estimating and Costing', of which the researcher is a co-author.

The video films were got reviewed by a panel of experts and their sale right has been given to one private distributor so that these materials are available to the poly-technic system for use. A leaflet indicating the utility of 'Control Circuit Trainer' and the work-book was prepared and circulated to all the polytechnics in the northern region. Further, a short-term training programme for polytechnic teachers was also conducted where the trainer was used. Negotiations are on for giving the sale right of the trainer to any private agency. The material contained in the work-book as also field problems and the assignments used in this experiment were used to develop a 'continuing education module' for working technicians/engineers. The module entitled 'Contactor Control Circuits' has been published by Indian Society of Techncial Education (ISTE), of which the researcher is the first author.

CHAPTER - SIX

USE OF TEACHER MADE GRADED EXERCISES FOR DEVELOPING PROBLEM SOLVING COMPETENCE

6.1 Introduction

This experiment was aimed at developing problem-solving competence in students through use of graded exercises/tasks prepared by the teacher. A large number of exercises to cover the entire course content as prescribed by the State Board of Technical Education formed the basis of students learning activities. The students were expected to work on their own on these exercises in the class. The teacher provided enrichment lectures during the course of study. Individual guidance was available to each student as per the need. Group interactions were arranged after study of each unit. Interaction with industrial experts was limited to their participation in students' evaluation only.

6.2 Selection of subject for the experiment

While interacting with the industries during conduct of experiment I as reported in Chapter IV, one of the important deficiencies in polytechnic output as expressed by industries was that the polytechnic diploma holders were lacking in the skill of reading and interpreting engineering drawings. Some of the common deficiencies observed were:

(i) inability to comprehend detail drawings for preparing bill of materials;

(ii) lack of understanding of stipulated tolerances, norms and standards;

(iii) inability to draw free-hand sketches showing details of components for the purpose of technical communication;

(iv) lack of ability to comprehend and interpret drawings for installation and commissioning of equipment and accessories;

(v) lack of ability to integrate the given details for conceptualising the object/component;

(vi) inability to depict equipment/components in isometric view.

Returning to the polytechnics,the researcher made a study of the teaching-learning of the subject of Electrical Drawing in five polytechnics. This study was conducted through actual observation, feedback through questionnaire and inter-views with students and teachers. An analysis of the above showed the following as regards the status of teaching-learning of Electrical Drawing in polytechnics:-

(a) On the basis of actual observation and interviews in four polytechnics in three states:

(i) Students normally copy drawings from books;

(ii) Good books on Electrical Engineering Drawing are not available in the market;

(iii) Students do not get opportunities for enough practice because of time constraints;

(iv) Drawing is considered a practical subject and therefore does not carry as much importance as a theory subject,both to teachers and students;

(v) Teachers hardly use any teaching aid like models, charts etc. for explaining the concepts;

(vi) There is less emphasis in the curriculum on developing knowledge of working drawings.

(b) On the basis of response to questionnaire:

Responses received from 190 students in five polytechnics were analysed. Response on a few key points are given in table 6.1.

Table 6.1

Students response on teaching-learning of electrical engineering drawing in polytechnics

Sr.No	Key Points	Students response in percentage-Yes
1	Teacher teaches the subject through lectures only	72
2	Teacher uses teaching aids like model charts, etc. to explain various concepts	16
3	Students visualize the type of work they will be required to do in industry with respect to the subject	23
4	Students get ample opportunity for practice	12
5	Teacher is seen in a hurry to cover the syllabus rather than emphasising on student learning	61
6	Students mostly redraw the drawings given in the books or by the teacher	89
7	Good text books on the subject are not available in the market.	83

(c) On the basis of discussions with teachers of five polytechnics revealed the following:

(i) Good text material on the subject is not available;

(ii) Teachers teach the subject using black board only. No other teaching aids are used;

(iii) Teachers have not been able to develop motivating methods of teaching the subject;

(iv) Existing examination system does not evaluate students' real abilities;

(v) Teaching is mainly to cover the syllabus and prepare students for the Board's examination.

From the above observations, it was thought appropriate to experiment with teaching of the subject of 'Electrical Engineering Drawing' with the students of one of the Polytechnics. This subject is included in the fourth Semester study scheme of polytechnics for Electrical engineering students.

6.3 Selection of Polytechnics

It was decided to approach two neighbouring polytechnics for conduct of the experiment. Both Central Polytechnic, Chandigarh and Government Polytechnic, Ambala agreed to provide opportunities for the experiment. However, for the convenience of the researcher in monitoring the experiment, the nearest polytechnic from his place of work i.e. Central Polytechnic, Chandigarh was chosen. A letter was written to the Principal of the Polytechnic explaining the objective and methodology of the project and his permission was obtained for the conduct of the experiment.

6.4 Interactions with the Teacher

The subject teacher was contacted through his Head of Department and a meeting was organised so as to explain the teaching-learning strategy to be followed in the proposed experiment. The teacher himself expressed dissatisfaction on the teaching-learning activities followed by him earlier and was interested to innovate. The course content for the subject and the conceptual teaching-learning model, i.e. use of graded exercises for developing problem solving competence were discussed and it was decided to develop the total teaching-learning material for the subject in association with teachers teaching the subject.

The teaching-learning phases and curriculum activities as identified during interactions with the subject teacher is given in Table 6.2.

Table 6.2

Teaching-learning activities for developing skill in reading & interpreting drawings using graded exercises with feedback and following model III as explained in Chapter III.

Teaching-learning Phases	Curriculum Activities
Motivating students	-Use of Objectives -Presenting structure of the subject
Student learning activity	-Graded exercises for problem solving competence -Assignments -Individual Guidance -Reinforcement/Feedback
Evaluation of students	-Observation on the basis of interactions -Paper and pencil tests -Evaluation of Assignments -Ability of reading & interpreting drawings by experts drawn from industry

The curriculum activities as listed in table 6.2 as also the course content for the subject formed the basis for develop -

ing the required instructional material.

6.5 Development of Instructional Material

6.5.1 Analysis of the subject

For the purpose of developing Teaching-learning material, the syllabus as prescribed by the Boards of Technical Education, Punjab, (Annexure 6.1) was analysed to identify the knowledge and skill components that are to be learnt by the students. Reading and Interpreting drawing is basically a perceptive skill and therefore, the sub-skills involving various concepts, principles and procedures and the method of their integration were first analysed as under.

Engineering Drawing is broadly classified as:

(i) Assembly drawings and
(ii) Component detail drawings

The basic skills required for learning the above are identified as:

(i) Projections;
(ii) Line work;
(iii) Dimensioning;
(iv) Sectioning;
(v) Isometric view;
(vi) Lettering; and
(vii) Free Hand sketching.

The basic skills as mentioned above are the part skills. The integration of these parts is to be learned as well as the learning of the component part-skills by the students. Learning to integrate part-skills is recognised by experts as a highly significant aspect of total learning required. Integration of sub-skills is required in assembly drawings as well as in component detail drawings. In case a student is able to draw the details of a given assembly and vice-versa, it can be assumed that he has learnt to integrate the component sub-skills i.e. he has developed the required abilities of reading and interpreting engineering drawings. The following informations are considered helpful in making assembly and component detail drawings:-

(a) Assembly drawing:

(i) Knowledge of parts and their functions;

(ii) Dimensions;

(iii) Number off from the list of items;

(iv) Sectional views.

From the above informations, a student should be able to sketch out the assembly. Sketching is to be done as easily and freely as writing, so that the mind is always centred on the idea and not on the technique of sketching.

(b) Component detail drawing:

(i) Identification of number of components in the given assembly and preparation of list items;

(ii) Study of dimensions of various components of the assembly;

(iii) "Block in" of the views using light construction lines;

(iv) Completing the details and darkening of object lines;

(v) Sketching the extension lines and dimension lines including arrow heads;

(vi) Completion of drawing by adding dimension,notes, title, date, etc.;

(vii) Checking of the entire drawing.

Ample opportunity is, therefore, to be provided to students to learn to integrate part-skills through a variety of exercises on assembly and detail drawings. Plenty of sketching exercises may be incorporated instead of giving too much importance on line work, dimensioning techniques, lettering, etc.

The above analysis for the development of exercises was got validated by expert opinion of teachers of five polytechnics.

6.5.2 Development of Graded Exercises

Before developing exercises for students it was felt necessary to write the learning objectives of the course content. The learning objectives were written jointly by the researcher and the subject teacher. These were circulated to five polytechnics in the states of Punjab and Haryana and on the basis of comments received, the learning objectives were revised (Annexure 6.2).

Graded drawing exercises incorporating the various sub-skills around the course content were prepared. The latest publications of Bureau of Indian Standards were consulted.Fifty-one graded exercises with feedback were developed.The exercises were simple to complex but spiral in nature.

The exercises have been designed giving due regard to the following:

(i) heirarchy of learning of part skills;

(ii) sequencing problems from simple to complex, concrete to abstract, and known to unknown;

(iii) providing opportunities for practice in order to internalise the part and integrative skills;

(iv) relating the exercises to the competencies needed in the world of work;

(v) providing a variety of exercises (completion type, reading and identifying errors, interpreting assembly and detail drawings, sketching, dimensioning etc.) for promoting thinking abilities;

(vi) having problem-solving abilities through open-ended exercises requiring applications of knowledge and skills.

The exercises so designed, had to be administered through self-learning activity-oriented modules. Each successive module included advance organisers linking the new structures to the previous ones. Each exercise was followed by feedback. The completion of each module had to be followed by group discussion and enrichment lecture.

Actual objects and models of some of the drawing exercises were collected/prepared. Remedial study material based on the prerequisite knowledge was also developed. Figure 6.1 shows the nature of learning experiences and the corresponding teaching-learning material developed including a photographic view of the total instructional package.

6.6 Development of Evaluation tools

The following evaluation tools were developed for use in this experiment:

(i) Pre-test to know the entry behaviour of students.This included a written test with ten small questions to assess the students entry behaviour and providing feedback and remedial self study reference material for needy students.

(ii) Criterion for continuous evaluation of students were identified and got validated by five experts. This included students' class-work, home assignments, and periodical tests and their abilities of reading and interpreting drawings as observed in the class.

(iii) Semester-end test paper covering the whole course content and the range of objectives. This paper was prepared with the help of another polytechnic teacher who was provided with last five years State Board of Technical Education question papers for reference.

(iv) A five point scale for receiving students' reaction on certain aspects of teaching-learning. This was got validated through expert opinion from 5 teachers.

(v) Students' problem solving abilities were to be evaluated by industrial experts for

TEACHING-LEARNING PACKAGE-III

(Package III illustrated for 'Electrical Drawing' taught to fourth semester electrical engineering students)

Learning Experiences	Nature of Instructional material	Specific material developed
1. Vicarious learning for perceiving relevance of the subject of study	Self study type print material	(i) Booklet containing objectives of the subject electrical drawing as derived from the syllabus and the structure of the subject showing the super ordinate, sub ordinate and co-ordinate relationship between the concepts and principles
2. Simulated problem solving experience and vicarious learning of related theory	Graded exercises assignment sheets, field drawings and printed text material	(i) A set of modules containing Graded exercises with feedback on Electrical Drawing.
		(ii) Assignment sheets on drawing, reading and interpreting electrical drawings.
		(iii) Cut models of electrical machines and machine parts.
		(iv) A set of field drawings on Electrical Installations.
		(v) Text material on Electrical Drawing .

Figure: 6.1: Schematic of the interactive teaching-learning package for Model III.

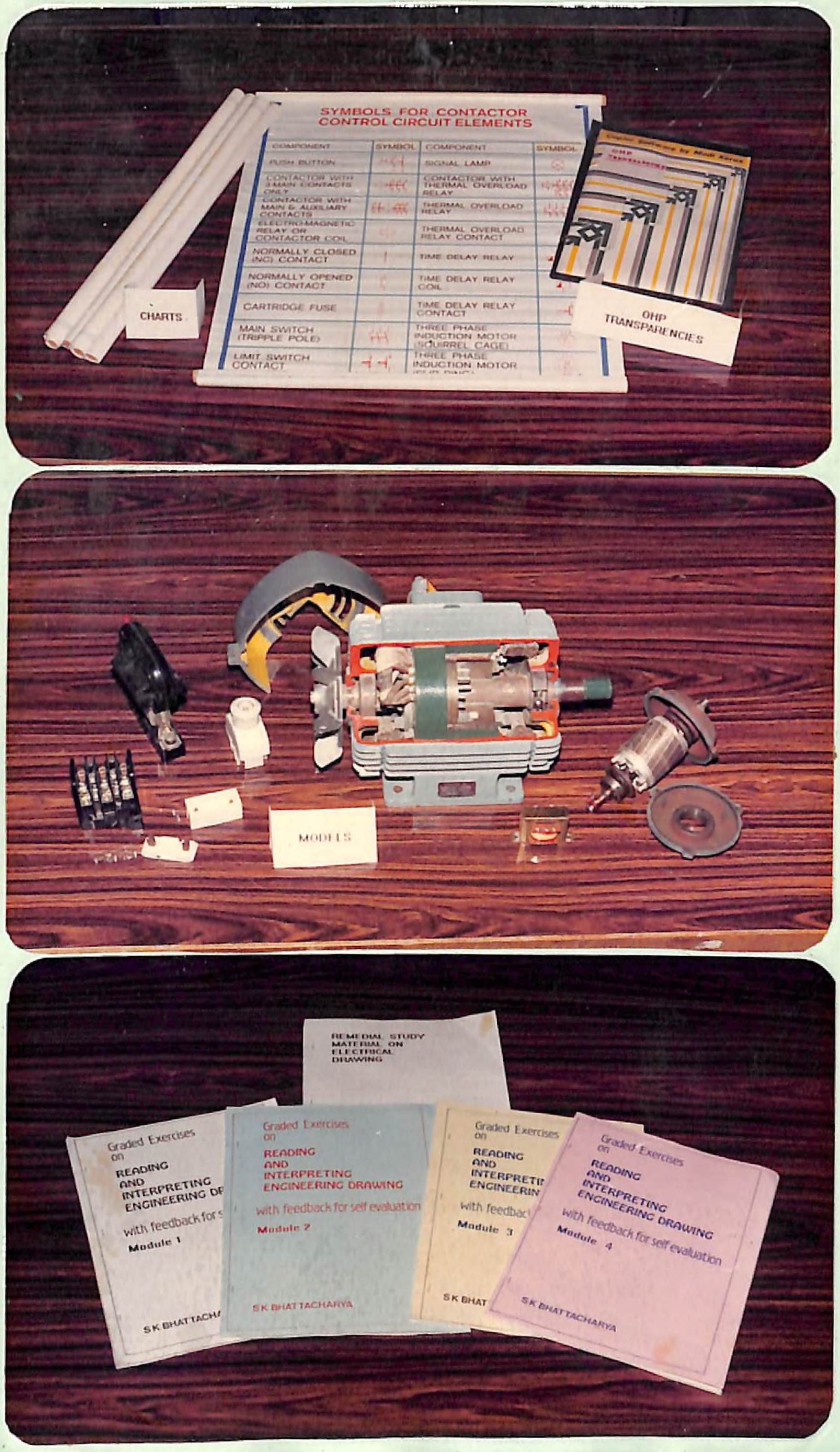


Figure 6.1 : Photographic view of interactive teaching-learning material developed (Charts, OHP transparencies, models, four modules of graded exercises with feedback and remedial study material).

which a five point rating scale was developed in consultation with the field experts(Annexure 6.3).

6.7 Conduct of instruction using graded exercises

Fortytwo students of fourth Semester Electrical Engineering discipline of Central Polytechnic,Chandigarh were taught the subject of Electrical Drawing for a Semester (February 1990 to May 1990) using the instruction material and method developed for the purpose.

6.7.1 Motivating students

The objectives of the subject of study, both in general as well as in specific terms were explained to students on the first day of the Semester. The structure of the subject showing the super-ordinate, sub-ordinate, and co-ordinate relationships of concepts and principles were also presented to the students.

6.7.2 Pre-test, feedback and remedial study

Students were given a pre-test using the post-test question paper to determine their initial preparation through a written test and the record of students' scores was kept for evaluating the comparative gain by different students after the instruction. Further, students were evaluated using small tests in the class and feedback provided on individual basis. For students who were weak, remedial study materials were given to them for self study at home. The remedial study materials included self evaluation test questions with feedback.

6.7.3 Learning by students through graded exercises

Graded exercises were divided into units each comprising 10 to 15 exercises. Individual student was provided with the unit to work independently. At the end of each unit, feedback in the form of sample solutions were provided. Those of the students who completed the set of exercises before the stipulated time were asked to work on some additional exercises. Such students were asked to interact with the teacher after completion of the exercises. Students who were comparatively slow, were also given these additional exercises to work at home. Students could complete each unit of study within above 8 to 10 hours of class work. At the end of each unit of study by all the students, group discussions were organised to enrich the knowledge gained by students through interactions. Depending on the requirement, enrichment lectures were also delivered by the teacher. A unit test was conducted for evaluating the knowledge and skill gained by students. This formed a part of the continuous evaluation of students. Assignments were given to students to work at home covering the content of a particular unit. The students had to submit such assignments regularly and receive feedback.

Students were evaluated on a continuous basis on their performance in the classwork, assignments and periodical unit tests. In the class, in addition to students working on their own on the graded exercises, they were asked to check the assignments done by other students and provide feedback in presence of the teacher thus providing for developing reading and interpreting drawings. Students ability of reading and interpreting drawings prepared by fellow students was recorded and this also formed a part of continuous evaluation of students' class work. After completion of learning and evaluation of one unit of exercises, the students were given the next set of exercises and the same procedure of students' learning and assessment followed. Throughout the students' learning period, the teacher was available for consultation and removal of difficulties. For final evaluation of students at the end of the semester, a comprehensive written post-test was conducted for which a question paper was already set by an external teacher. The students were evaluated by the teacher and a viva-voce conducted The answer books were returned to the students after evaluation and comments.

Students were also evaluated on their ability of reading and interpreting drawings by two external experts drawn from local industries in association with the subject teacher. The external experts were provided with the informations regarding the background of the experiment and was asked to evaluate students on their abilities of reading and interpreting engineering drawing. The experts brought with them working drawings from different industries and used them for testing the abilities of students in reading and interpreting drawings. They also tested students for their drawing skills and knowledge of norms and standards.

6.7.4 Observations by the teacher

The teacher kept of record of certain observations made by him on students' learning. These were analysed and are presented as follows:

(i) Students were active and could learn the course content by working through the graded exercises without depending much on the teacher;

(ii) The teacher had sufficient time available for providing need based individual guidance;

(iii) The students could complete the study of the course content through graded exercises within the available time in the semester;

(iv) The number of exercises done by students in the class as well as the number of home assignment sheets completed by students were one and half times more than what such a class had done in previous years;

(v) The quality of work done by students in the class and as home assignments were studied and compared with some sample work of previous batch. The quality of work done by students were found better;

(vi) Group discussions after each unit of study were lively as students asked need based questions which they could not sort out themselves;

(vii) Immediate feedback on the students worked as motivators, as students were found working hard and completed all the exercises before the estimated time.

6.7.5 Feedback from students

Feedback from students were collected through a questionnaire, and their reactions through group discussion organised on the last day of the semester. The feedback received are listed as follows:

(i) Activity oriented teaching-learning motivated students;

(ii) Students were able to discuss their points of difficulties with the teacher on an individual basis;

(iii) The learning material provided was considered very useful from the point of view of understanding the subject as well as their preparation for examinations;

(iv) All the students expressed that interactions with fellow students and the teacher at the end of learning of each unit were very useful in clarifying doubts;

(v) Students expressed that the enrichment lectures delivered by teachers were useful and really interactive as the lectures turned into group discussions rather than simply getting informations from the teachers;

(vi) Immediate feedback on completion of a set of exercises, the students expressed ,was motivating towards further learning;

(vii) Students expressed that they wanted to visit some industries to see the quality and type of drawings used in actual situations.

6.7.6 Feedback from industrial experts

A meeting was organised with the industrial experts who evaluated the students. The experts were diploma holders and had worked in large scale industry for over 15 years and later had set up their own industries. The polytechnic curriculum and the instructional material used were shown to these experts and were asked to comment on the abilities gained by students in terms of objectives of the subject, the curriculum, the graded exercises used, and the assignments given to students. The comments of the experts as gathered during the interaction session are presented as follows:

(i) There was scope for improvement of quality of exercises assigned to students. These could be reviewed by experts from industries;

(ii) The curriculum needed revision in view of the field requirements;

(iii) General performance of students in terms of their abilities of reading and interpreting field drawings was rated at the average level only;

(iv) The experts suggested that the students be given more pratice in reading and interpreting varieties of field drawings;

(v) Experts from industries could have been involved in delivering extension lectures and also in group discussions.

6.8 Students' evaluation data

Students were evaluated on the basis of their day-to-day performance. This included their class-work, as well as home assignments and periodical tests. The sum of all these scores constituted continuous evaluation score of students. Students' achievement scores in pre-test and post-test, marks obtained by the students in the examination conducted by the State Board of Technical Education in the subject, and their scores in continuous evaluation were recorded for the purpose of analysis. Also the performance of students in the previous three semesters in the Board examination was studied.

For the purpose of comparison of achievements of students, they were divided into two groups, namely, the upper group and the lower group. The division was made on the basis of average score of students in the previous three semesters of study.

Scores of students in the evaluation made by experts from industries were also compared with other evaluation data.

6.9 Interpretation of results of students' evaluation

(a) Correlation coefficients of scores:

Correlation coefficients of scores of students in continuous evaluation, Post test, and evaluation by industry are calculated as at Annexure 6.4.

	Continuous Evaluation	Post-Test	Evaluation by industry	Evaluation by SBTE
CN	1	0.79	0.66	0.50
PT		1	0.66	0.45
IN			1	0.25
BD				1

Correlation coefficients between continuous evaluation and post test is 0.79 and when the same are calculated separately for the upper and lower group of students, the values come as 0.62 and 0.68 respectively. This shows a fair degree of correlation between continuous evaluation and evaluation made at the end of the course. Evaluation by industry and by the SBTE has a poor correlation of 0.25 only.

(b) Performance in Board examination:

The average score of students in the same subject by three successive batches of students are calculated as:-

Average score of 1987-88 batch of students:	41.67%
Average score of 1988-89 batch of students:	31.60%
Average score of 1989-90 batch of students (experimental group):	47.80%

The results show an increase in average score of the experimental group as compared to the previous two batches.

(c) Level of significance of achievements of students:

To determine the level of significance of achievements of students belonging to the upper group and those belonging to the lower group, t-test has been applied using null hypothesis.

To test null hypothesis using t-distribution, the first step is to calculate the t-ratio for the data. The t-ratio is then compared with the tabled value of t(as in Annexure 6.5) for the degrees of freedom, df , and the level of significance, α .

The calculations made are as follows:-

Number of students = n

degrees of freedom, df = n - 1

level of significance considered α = 0.05

$$t = \frac{(\bar{x} - \mu_0)\sqrt{n}}{s}$$

where $\bar{x}$ is the mean of difference of scores of the sample of students

μ_0 is the mean of difference of scores of population of students which is assumed to be zero according to null hypothesis

s is the standard deviation $= \sqrt{\frac{n\Sigma d^2 - (\Sigma d)^2}{n(n-1)}}$

d is the difference in scores of students

The value of t for the upper group is calculated as 17.8 (for df = 20 and α = 0.05)

The value of t for the lower group is calculated as 15.5 (for df = 20 and α = 0.05)

The tabled values of t are cut -off points needed to reject the null hypothesis at predetermined probability level as shown in figure 6.2.

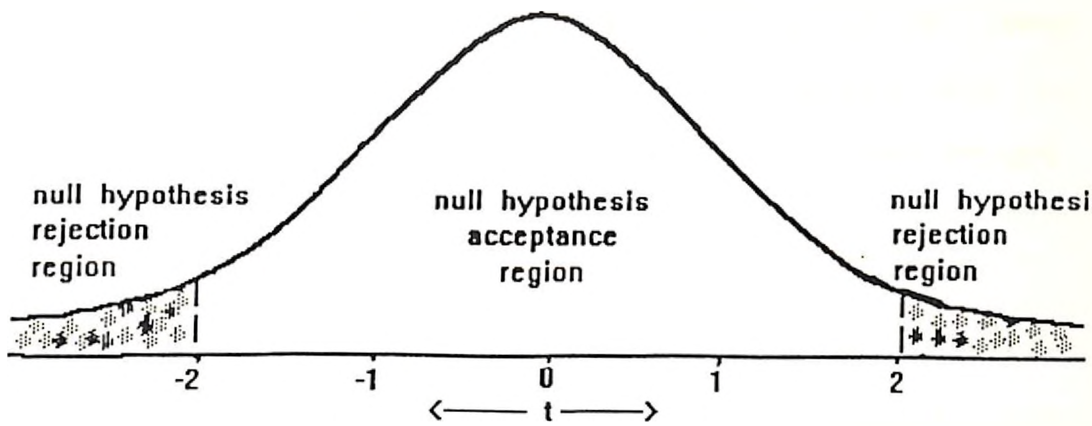


Figure 6.2: t-curve for null hypothesis acceptance and rejection regions for df = 20 and α = 0.05

The critical value of t=2.086 for df = 20 and α = 0.05 as in figure 6.2.

Comparing the calculated values from the experimental data it is seen that t value for the upper group and for the lower group are greater than the critical value i.e.

For the upper group, $t = 17.7 > 2.086$

and for the lower group, $t = 15.5 > 2.086$

It is thus concluded that there is significant difference in achievements of students of both the upper group and lower group.

(d) Comparative achievements of upper group and lower group of students:

To find which of the above groups, upper group or lower group had gained more, t-test is again carried out on the Mean of the difference in scores of the two groups

$$t = \frac{\bar{x}_1 - \bar{x}_2}{S_{ED}}$$

where $\bar{x}_1$ is the mean of the difference of scores of the upper group of students

$\bar{x}_2$ is the mean of the difference of scores of the lower group of students

S_{ED} is the estimated standard error of the difference between two means $S_{ED} = \frac{s}{\sqrt{n}}$

$$\text{i.e } S_{ED} = \sqrt{\frac{(n_1 - 1)\, s_1^2 + (n_2 - 1)\, s_2^2}{(n_1 + n_2 - 2)} \left(\frac{1}{n_1} + \frac{1}{n_2}\right)}$$

where n_1 is the number of students in upper group

n_2 is the number of students in lower group

s_1 is the standard deviation of the upper group

s_2 is the standard deviation of the lower group

degrees of freedom $df = n_1 + n_2 - 2$

The value of t calculated is

$$t = 2.2 > 2.021$$

(where critical value of $t = 2.021$ for $df = 40$ and $\alpha = 0.05$)

This shows that there is a significant difference in achievement of students in the upper group than the students in the lower group.

6.10 Difficulties experienced in conduct of the experiment

The experiment laid emphasis on student centred learning through teacher made graded exercises for developing problem solving abilities. Formulation of graded exercises reflecting the field requirements was a difficult task and required thorough knowledge of the subject. Further, as the field requirements were not fully identified, the exercises were built around the given curriculum and were mostly oriented towards covering the course content. Moreover, the development of exercises with feedback system required expertise of preparation of instructional material using the knowledge of educational technology. The researcher, as a teacher, developed the basic material and got them reviewed by five polytechnic teachers through a workshop. The revised material in the form of modules were got multiplied in required numbers and supplied to the teacher for use as the polytechnic does not have the required facilities.

The researcher at a later stage could get these materials compiled together, reviewed by field experts, and submitted the manuscript to a reputed publisher. A better strategy would have been to get such material prepared by a group of subject teachers and publish them in their name after the materials have been field tested, reviewed and revised.

Polytechnics normally do not involve industries in student evaluation. Further, they do not have any information about the availability of experts in different subject areas . They have not been able to keep a record of their passed out diploma holders employed in neighbouring industries who could be involved in many of the academic activities organised in the polytechnic. In this experiment, the researcher had to take initiative in identifying and inviting the competent experts from industries.

CHAPTER-SEVEN

STUDY OF FUNCTIONAL CURRICULUM AND INTERNSHIP IN INDUSTRY

7.1 Introduction

In the previous three experiments, teaching-learning in the institutes were organised with the existing curriculum prescribed by the State Boards of Technical Education. In this experiment, a functional curriculum was developed through activity analysis of diploma holders in industry. The requirements of knowledge, skill and attitudes were reflected in the course content and appropriate teaching-learning material were developed. Students were taught the functional curriculum through institutional training followed by their attachment in industries to work as interns in different functional areas and thereby develop problem solving abilities. Evaluation of students was done by industries against certain evaluation criterion as demanded by the world of work.

7.2 Selection of subject

'Electrical Machines' is an applied engineering subject taught in polytechnics. It was decided to take a part of the subject for the experiment. Study of the topic of 'Transformer' is considered significant to the functional requirement of diploma holders who may be employed in Electricity Boards or in manufacturing industries. Keeping in view that a bulk of the diploma holders in Electrical Engineering are employed in Electricity Boards, it was decided to experiment on the 'study of Transformers' by the students.

7.3 Development of Curriculum

A review of literature on 'Curriculum' reveals marked difference in the way each perceives and defines the term 'Curriculum'. Those who consider instruction as synonymous to curriculum, define curriculum as

> "Composed of all the experiences children have under the guidance of teachers".

Such a view where 'curriculum planning, implementation or instructional systems are all seen as curriculum may be applicable in the lower grades of primary education. In a complex educational system with large number of variables involved, curriculum and instructional systems need to be separated. According to MacDonald(1971),

> "they are essentially two separate action contexts. One (curriculum) producing plans for further action and the other (instruction) putting plans into action".

Two extreme views on curriculum are mentioned below.

Some believe that instruction covers all planning including the selection of content, organisation, lesson planning, implementation,evaluation,etc. In view of some others, it is only necessary to provide the teachers with a list of contents or topic outlines generally called the syllabus.

The other researchers take the view of considering "curriculum as an educational programme designed and implemented to achieve specified educational objectives". Such a view is advantageous,as it considers:

(i) that education is purposeful;
(ii) that there is an organised plan of action;
(iii) that such a plan is translated into action through

appropriate strategies of implementation.

It assumes that the educational programme is designed/ set down in a curriculum document to ascertain that the educational objectives specified are being achieved. Design of curriculum would involve many decisions e.g. which objectives are worth including, what should be the subject coverage, which principles will guide selection, organisation, implementation, etc. One of the basic decisions which influences the design strategy concerns with the sources which should be used for selecting objectives, content, etc. The sources which provide important decisions like objectives and contents are:

(i) Need of the individual learners(individual-needs approach);

(ii) Structure of the organised body of knowledge (Subject specialisation approach);

(iii) Need of the society (Social-demand and job analysis approach).

No expert denies that sources other than those selected by him are important. Those who select, for example, a social-needs approach for curriculum design will maintain that they also consider the structure of discipline for organising the content and the needs and interests of students during the implementation stage.

In individual-needs approach curriculum, education is considered to be for the development and growth of an individual to his fullest potential.

Subject-specialisation approach aims to introduce students to the universe of discourse, the ways of life, represented by the fields of scholarship. Typical examples of this approach may be found in the procedures used in developing curriculum through various national curriculum projects in disciplines like physics, chemistry, mathematics or biology for primary and secondary schools in many countries.

The philosophy underlying the job analysis approach of curriculum design is that if education is to satisfy needs of society, then it should be relevant to those needs. Education is treated as preparation for life. Life consists of performance of specific activities which can be analysed and taught. These activities then form the objectives of the curriculum.

Basing all decisions on the 'individual-needs approach' is obviously not appropriate to technician education and training. Further, it is realised that a technician need not be trained to become a subject specialists like a physicist or a chemist. He has to be educated and trained in such a manner that he can integrate and use knoweldge from different fields.

The 'social-demand approach' is considered sound for curriculum design for technician education when in actual practice it does not merely concentrate on task analysis alone but considers both 'action tasks' as well as 'cognitive tasks' which a technician is required to perform. Such a curriculum may be termed as functional curriculum for technician education and training.

The main purpose of technician education is to provide a particular type of manpower for various sectors of economy. Technicians will work in industry, in commerce, in government enterprises, in transport and communications and many other economic sectors. It is generally agreed that technicians are responsible for jobs such as erecting, commissioning, testing, maintaining, estimating, fault finding, sales etc. Developing a curriculum for such requirements would demand identification of functional areas, activity analysis in those functional areas, identification of requirements of knowledge, skill and attitude and their applications.

7.3.1 Identification of functional areas in relevant industries/organisations

The following five functional areas were identified by interacting with a group of industrial experts:

(a) Design;
(b) Manufacture/Fabrication;
(c) Installation and Commissioning;
(d) Operation and Maintenance;and
(e) Repair

For activity analysis of diploma holders in different functional areas, representative industries were identified as in table 7.1.

Table 7.1
Representative industries where activity analysis of diploma holders were carried out

Sr.No.	Name of Industry	Activity analysis for diploma holders in functional areas of
1.	Haryana State Electricity Board Transformer Grid Sub-station under construction at Ram Garh	Installation and Commissioning
2.	Electric Construction and Equipment, Transformer Division, Sonepat	Manufacture
3.	HSEB Transformer Repair/Fabrication Workshop, Dhulkot, Ambala	Repair
4.	Bhakra Beas Management Board Grid Sub-station, Dhulkot, Ambala	Operation and Maintenance
5.	HSEB Power Transformer Repair W/shop, Panipat	Repair
6.	UT Electricity Department, Chandigarh	Operation & Maint.
7.	Bhasin Industrial Corporation, Industrial Area, Chandigarh.	Manufacture

7.3.2 Procedure for activity analysis

Activity analysis of Electrical Diploma holders was undertaken in seven industries through personal observations and discussions with the diploma holders working in these industries. In total 35 diploma holders were interviewed. In addition, through a feedback questionnaire, a draft activity chart of diploma holders with respect to the topic was prepared. This was circulated to 10 field experts for their comments and subsequently revision of the activity chart was done.

7 3.3 Activity analysis and identification of knowledge and skill requirement

The activity analysis in four functional areas were recorded on the basis of feedback from 10 field / industrial experts.Comments were received either by post or through personal visits from all these 10 experts. The revised activity chart is shown in table 7.2. Four functional areas were covered in the activity analysis. The design area was not included, as feedback from industry showed that only a very small percentage of diploma holders were engaged in the design of transformers. From the activity analysis the knowledge, skill, and attitudinal requirements were identified. This was done using a format as shown below:

Activity	Knowledge	Skill	Attitude

From this analysis, all the components for each activity were evaluated against their educational requirements and a consolidated list was prepared as shown in table 7.3.

7.4 The functional curriculum

The activity analysis and identification of knowledge, skill, and attitudinal requirements provided a basis for development of a functional curriculum for the topic of transformer to be taught to diploma students. The course content as emerged from the activity analysis is given in Table 7.4. The curriculum includes basic principles and concepts and also contents related to functional areas. The curriculum so prepared were circulated to the seven industries for their comments. The indsutries found this curriculum responding to the actual needs of diploma holders in their industries.

7.5 Analysis of the functional curriculum

7.5.1 Gap between existing curriculum and the one developed through task analysis

For the purpose of comparison, the existing curriculum of the State Boards of Technical Education (meant for polytechnics) and also the University curriculum (followed in engineering colleges) were collected as given in Annexure 7.1 (a, b, c).

It was observed that there was much similarity between the engineering college curriculum and the curriculum followed

Table 7.2

Functions of Electrical Diploma Holders in Field/Industry

MANUFACTURE OF TRANSFORMER -FUNCTIONS	INSTALLATION AND COMMISSIONING OF TRANSFORMERS- FUNCTIONS	REPAIRING OF TRANSFORMERS -FUNCTIONS	OPERATION & MAINTENANCE OF TRANSFORMERS -FUNCTIONS
1. To prepare estimate of material and manpower for number of transformers in a month/ year. 2. To prepare indent and draw material for manufacturing transformers as per target during the month. 3. To store the indented material at shop floor and keep proper pecords. To issue materials to the workers as per their requirement. 4. To distribute the work amongst the staff and to solve their day-to-day problems. 5. To maintain the job cards including material consumed, their cost and man hours. 6. To ensure standard practices of transformer manufacture to reduce failure rate, and to implement safety rules. 7. To carry out test-checking of various components at intermediate stages of production 8. To carry out Testing of manufactured transformers.	1. To supervise handling of transformers at site. 2. To carryout Inspection and storage of transformers at site 3. To take all necessary precautions before starting erection work. 4. To supervise fitting of all accessories to the transformers. 5. Measurement of Insulation resistance and to dry-out transformer if the value is less. 6. Filling of transformer oil which meet IS-355 requirements. If it does not meet this requirement then to improve its quality. 7. Maintaining of Insulation resistance and oil test records. 8. To carry out typical tests recommended by ISI before commissioning. 9. To supervise laying of control cables between control room and switch yard and control panel wiring	1. To keep record of damaged transformers 2. To prepare estimate for repair after physical inspection and testing 3. To procure material for repair 4. To supervise nepairing process. 5. To carryout testing of repaired transformers(same as done with new transformers) 6. To supervise Despatch to consumer/store.	1. To supervise work of station attendent 2. To inspect and maintain following accessories as per schedule a)Silicagel breather, b)Explosion vent, c)Bushings, d)Buchholz relay e)Temp Ind., f) Tap-Changer g)Protection scheme, h) Cooling equipment 3. To maintain the Insulating oil and to get oil samples tested for various tests at required intervals and keep the record. 4. To carryout dehydration of oil on deterioration of dielectric strength or to change oil if it cannot be reclaimed. 5. To carryout inspection of bushings, power connections and measure insulating resistance values as per schedule and keep record and to compare it with original values 6. To draw inference about type of fault from panel board relay display and take remedial measures.

Table 7.3

Knowledge, Skill and Attitudinal requirement of diploma holders as derived from activity analysis.

Manufacturing	Installation & Commissioning	Repair	Operation & Maintenance
1. Ability to study drawings and estimates prepared by design office. 2. Ability to physically verify the quality and quantity of various materials. 3. Store management 4. Human relation, communication, 5. Manufacturing Process of Transformer. 6. Record keeping 7. Standard manufacturing/assembling/testing processes, safety rules 8. Measurement techniques. a) Knowledge of IS:2026 b) Test procedure c) Connection diagram d) Related calculations	1. Handling and unloading procedure 2. Various inspections to be carried out. 3. Knowledge of store methods. 4. Knowledge of all precautions to be taken before starting erection. 5. Knowledge about Erection, functions and importance of accessories like Conservator, Silca-gel-dehydrating breather, Explosion vent, Buchholz relay, Temperature indicators, Bushings, Tap changer, Cooling equipment. 6. Procedure for measuring the Insulation Resistance, Various Procedures for dryout tests, Precautions when drying. 7. Oil filling procedure, methods for improving the quality of transformer oil. 8. a) Importance of maintaining records. b) Importance of various tests of oil like Dielectric test, Acidic test, Resistivity test, Dissipation factor test, Water content test, Inter facial test, Dissolved gas analysis test. 9. Procedure for carrying out following tests for energisation a) Resistance measurement of windings. b) Ratio test c) Flux distribution test d) Magnetising current test e) Checking of protecting scheme f) Polarity and Phasing out test g) Various other checks as per ISI 10. Study of assembly drawing of various parts of transformer and protection circuit diagrams	1. Knowledge of various transformers and accessories 2. Testing of Transformer, Knowledge of normal values of Tr. parameters. Ascertaining extent of damage. 3. Material Management 4. Repairing and testing of Transformers 5. Calculation of actual cost of repairing. 6. Knowledge of IS:2026 7. Knowledge of Tools and plants (T&P) required for carrying out different repairing jobs.	1. Importance of recording the hourly/weekly/monthly readings of various parameters like temp, oil level, load current, voltage. 2. Procedure of carrying out checks as per maintenance schedule. 3. Importance of various tests performed on Insulating oil like a) Dielectric test, b) Acidity test c) Resistivity test, d) Dielectric dissipation factor test, e) water content test, f) Inter-facial test g) Dissolved gas analysis test 4. Knowledge about the dehydrating process 5. Knowledge of transformer protection schemes. 6. Operation and resetting of different types of protective relays. 7. Knowledge about sub-station layout and requirement such as circuit breaker isolator, ct, pvt, LA, wave trap, PLCC, battery, air compressor, D.G set etc. 8. Knowledge about operating sequence for loading, unloading, tap changing etc.

Table 7.4

Detailed contents of a Functional curriculum on 'transformer' - diploma students

1. Basic principle, turn ratio, emf equation, no-load and full load current, resistance, reactance, losses and efficiency. Constructional details, Standard ratings and interpretation of name-plate data.

2. Manufacturing procedure

   2.1 Raw materials required and their specifications for manufacture
   2.2 Manufacturing processes
   2.3 Supervision of manufacturing processes
   2.4 Testing & Certification
   2.5 Storage, Despatch of Transformers to user

3 Installation and Commissioning of Transformers

   3.1 Measurement of insulation resistance, drying out procedure, filling of Transformer with oil
   3.2 Testing of Transformer oil
   3.3 Procedure for energisation of a Transformer
   3.4 Earthing of Transformer
   3.5 Parallel operation

4 Operation and Maintenance

   4.1 Maintenance Schedule & Recording of Data
   4.2 Dehydration of Transformer oil
   4.3 Tap changing methods
   4.4 Use of CT and PT
   4.5 Transformer Protection Scheme
   4.6 Control Room Operation in a Transformer Sub-station

5. Repairing of Transformer

   5.1 Identification of faults in a damaged transformer
   5.2 Preparation of estimate for repair
   5.3 Supervision of repair
   5.4 Testing after repair

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   3.2 Testing of Transformer oil
   3.3 Procedure for energisation of a Transformer
   3.4 Earthing of Transformer
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   5.1 Identification of faults in a damaged transformer
   5.2 Preparation of estimate for repair
   5.3 Supervision of repair
   5.4 Testing after repair

by the polytechnics. Both had the same science base. Polytechnic curriculum, however, was somewhat diluted version of the degree curriculum.

The topics which diploma students are not taught but degree students being taught are: Effect of saturation on exciting current and voltage, Determination of equivalent circuit by o.c and s.c tests, Separation of losses, Phasor diagram and equivalent circuit of auto transformer, Three phase transformers, Effect of connections on exciting current harmonics; Inrush current phenomenon, Phase Conversion, Three winding transformer-equvialent circuit.

It is about 25% of the total degree content. Seventy-five percent of degree content was similar to the diploma curriculum.

7.5.2 Comparison of existing diploma curriculum and the curriculum developed through activity analysis

In the revised curriculum, it is seen that about 25% of the content have been replaced by content emphasising practical aspects required in operation, maintenance and repairing of transformers. The topics which have been removed are: Mutual and leakage fluxes, Leakage reactance; Analysis of equivalent circuit ; Phasor diagram onload, Derivation of expression for voltage regulation; Derivation of condition for maximum efficiency and all day efficiency.

The topics which have been added, include: Construction and various accessories; Name plate details, Specifications, Three-phase connections and vector groups; Oil testing and dehydration process, Measurement of IR and winding resistance; Parallel operation procedure of 3- phase transformers; Maintenance schedule of transformers, Location of faults, Repairing and testing after repairing, Study of relevant IS on operation and maintenance of transformers.

7.6 Development of student learning material including evaluation tools

7.6.1 Student reference material

The available text books in the market were reviewed. None of these books contained learning material suitable to the entire course content so developed. It was therefore necessary to prepare student learning material for the course content. Course material on the basic concepts, principles and informations were prepared using the principles of learning. For presentation of the subject matter, the principles as propounded by Ausubel (4) was found useful. According to Ausubel subject matter is organised and presented using the principles of

(i) Progressive differentiation;
(ii) Integrative reconciliation;
(iii) Sequential organisation; and
(iv) Consolidation.

Progressive differentiation means beginning explanation with all inclusive ideas to enable the reader to get an overall view of the interrelationship of the concepts which are going to be discussed in further details.

Integrative reconciliation attempts to integrate all ideas previously explained upto a particular point and offers to develop further relationship with forthcoming ideas.

Sequential organisation aims at providing an outline not only of the sequence in which the topics would be presented but also their super-ordinate, sub-ordinate, and co-ordinate relationship. To anchor the ideas into the mind of the reader, consolidation provides a summary presentation of the concepts involved at the end of each section of presentation.

For preparing learning material on the functional areas, the researcher had to consult a variety of sources. Students' notes, so prepared on the basic material provided a knowledge base which was essential for acquiring knowledge and skills in the functional areas.

After consulting sources like manufacturers' instruction leaflets, reference books, users' guides, Indian Standards and also by actual study in the work being done in the field, students' reference material for four functional areas were prepared. Figure 7.1 shows a schematic diagram of the interactive teaching-learning system for model IV together with photographic presentation of the material developed. The reference material contained details of processes and field practices. Reference material in four functional areas viz. in Manufacture, Installation and Commissioning, Operation and Maintenance, and in Repair were developed.

7.6.2 Evaluation tools

For evaluating the students on their ability to solve open-ended problems, the evaluation tools as explained in

TEACHING-LEARNING PACKAGE- IV

(Package IV, illustrated for a part of a course in Electrical Machines, namely "Transformers," taught to fourth semester electrical engineering stduents)

Learning Experiences	Nature of Instructional material	Specific material developed
1. Vicarious learning of basic concepts, principles and related theory.	Text material, Bank of test items with feedback	(i) Self study Text material on Transformers. (ii) Objective type question with feedback covering the complete theory of transformers
2. Direct purposeful or contrived experiences	Instruction Manual	(i) Laboratory manual for performing experiments on Transformers in laboratories.
3. Vicarious learning of problem solving procedure	Printed booklet	(i) A booklet containing the concept of internship and procedure for open-ended problem solving in functional areas
4. Interactive on-the-job experiential learning at the work-bench.	Printed self-study type booklets in the form of Supervisors' Guides.	(i) Self study type reference material in the form of supervisors' guide in four functional areas viz, Manufacture of Transformers, Installation and Commissioning of transformers, Operation and Maintenance of transformers, and Repair of transformers.

Figure 7.1: Schematic of the interactive teaching-learning system for model IV.

section 3.6.3.5 were to be used in this experiment also.

A written test paper was prepared on the basis of the course content followed in the polytechnics i.e. according to the same course content as prescribed by SBTE. The question paper contained objective type test items covering the entire curriculum as well as short answer type questions. This question paper was got validated by the polytechnic subject teachers and industrial experts from the point of content coverage and difficulty level. The question paper had two parts. Part-A included questions on basic theory whereas Part -B included questions on functional aspects. Part A of the question paper included 77 objective type test items and 35 short answer type questions. Part-B of the question paper included 25 short answer type questions. To collect feedback from the students, teachers, and industries, separate questionnaires were prepared (Annexure 7.2 a,b,c)

7 .7 Planning for conduct of experiment

7.7.1 Identification of polytechnic

For the convenience of monitoring by the researcher, it was decided to contact a nearby polytechnic for the experiment. The Government Polytechnic, Ambala City was contacted. After briefing the principal of the polytechnic about the experiment, a meeting was held with the Electrical Engineering faculty of the polytechnic. The faculty expressed that it was not feasible to conduct any experiment with the changed curriculum during the semester. However, looking into the merit of the experimental study, the group suggested that the experiment could be conducted during summer vacation. Separate meetings were organised with the subject teacher and a total design of the experiment worked out.

7.7.2 Design of the experiment

Design of the experiment included identification of students, deciding the duration of the experiment and teaching-learning strategies including evaluation methods as stated below:

(i) Identification of students

Ten to fifteen students of Electrical Engineering branch who have not studied the topic for which the functional curriculum has been developed.These students are to be chosen on random basis.

(ii) Duration of Conduct of the experiment

Six weeks during summer vacation. A part of this learning period will be spent at the institution and the other in industries.

(iii) Teaching-learning method

Class-room based teaching-learning with the help of a teacher followed by attachment of students in different functional areas in related industries for working as interns.

(iv) Instructional Material

(a) Students' notes on basic principle and related theory required to understand the functional aspects;

(b) Reference material in the related functional areas to be used by students during their industrial attachment period.

(v) Method of Evaluation

Students will be evaluated on their performance through the following:

(a) Technical report

(b) Viva-voce

(c) Quiz/Seminar

(d) Group discussion

(e) Day to day observation

Performance of this group of students will be compared, against the performance of another group of students of second year of the same polytechnic who have been taught the subject in the polytechnic using the conventional approach and following the existing curriculum, through a written test and interviews conducted by employers.

In addition, feedback from teachers, students, and industries will be recorded for evaluating the effectiveness of curriculum, the instructional material and teaching-learning method.

(vi) Evaluation tools

(a) Evaluation matrix for assessment of students' performance

(b) Written test paper

(c) Questionnaire for students, teachers and industries

(d) Interview by employers

7.7.3 Identification of industries

Chief Engineers of HSEB, BBMB, and U.T. Electricity Department were approached to collaborate in this experiment. Having understood the objective of the experiment all of them readily agreed and issued letters of permission. They also wanted to know the result of this kind of education and training which, according to them had not been tried earlier. Their past experience with industrial training of students was not very good in the sense that such training was not planned and the students spent their training period without much gain. The industry considered taking students on training as a burden.

7.7.4 Identification of students

The topic 'Transformer' is taught under the subject 'Electrical Machines I' to the fourth Semester Electrical Engineering students in the polytechnic. The summer vacation falls after the even semesters, and as such the experiment could not be conducted with fourth semester students who would just be completing study of the subject before going for summer vacation. It was therefore decided to conduct the experiment with second semester electrical engineering students after completion of their Semester examination. For selection of students, the researcher along with the subject teacher explained the purpose of the experiment to the whole class. The students were asked to give their consent in writing by filling in a proforma supplied to each student. The students were told the names of industries where they were expected to be placed after their institutional training.They were also advised to consider their convenience in reporting to polytechnic and industries from their places of stay during the vacation period. Out of 42 students of the class, 25 students submitted their forms duly filled in. Out of this list, 10 students of second semester were selected on random basis. It was also decided to include a few students of fourth semester in this experiment, who had just completed study of the course. The subject teacher was suggested to identify few students of fourth semester who would vounteer to take the course again during this experiment. The teacher announced this opportunity to the fourth semester students. Out of five willing students only three students, who did not have any supplementary examination to prepare for during the vacation period and could easily attend polytechnic and industries, were selected. Thus a total 13 students, 10 of second semester and 3 of fourth semester were selected for participation in the experiment.

7.7.5 Orientation of students,industries and polytechnic management

7.7.5.1 Orientation of students

One week before the experiment, a meeting was organised in the polytechnic with the students, the subject teacher, Head of Department and the Principal. The schedule of institutional training and industrial attachment were prepared and given to the teacher. For institutional training, the students were asked to report to the polytechnic for attending classes for 3 periods per day for 7 working days. After institutional training,the students had to report to industries directly.

7.7.5.2 Orientation of Industries

Visits were made to the industries by the researcher alongwith the polytechnic Head of Department and the subject teacher. It was considered essential to orient the participating industries before sending the student interns to them. Discussions were held with the Shop Floor Supervisors, Sub-station Engineers, Control Room Operators about the objective of the industrial attachment of students. Daily schedule of assignments for the students were worked out in consultation. However, it was understood that depending on the requirements, the Supervisors could change the schedule. The Supervisors were briefed about the procedure for student assessment and were asked to keep record of the students' progress. A schedule for attachment of students in industries was prepared in consultation with the industries and the same was handed over to the concerned supervisors as in Table 7.5.

7.7.5.3 Orientation of polytechnic management

A meeting was organised with the polytechnic principal where Head of Electrical Engineering Department and the subject teacher participated. The total programme of the experiment was presented to the group. For monitoring of the experiment, the principal appointed the Head of the Department as the local co-ordinator. The Principal also detained both the Head of the Department and the subject teacher during the period of the experiment on official duty. A class-room was allocated for the institutional training, and the laboratory staff were also informed. A time table was prepared for circulation to the students. A schedule of visits by faculty and the Head

Table 7.5

SCHEDULE OF INDUSTRIAL TRAINING OF I AND II YEAR STUDENTS OF GOVERNMENT POLYTECHNIC, AMBALA, HARYANA

29-6-1990 to 25-7-1990

Training Place	Contact person	Supervisor	Students name & Roll No.	Functional area of training
			I year Electrical	
220 kv, BBMB Sub-station, Dhulkot, Ambala	Er.SC Mangal, Sr.SSE, 220 KV Grid S/S Dhulkot, Ambala	Mr.R.C.Sharma Mr.Parmjeet	1.Mr.Parveen Kumar 220/89 2.Mr.Puneet Sharma 221/89 3.Mr.Gurcharan Sharma 208/89 4.Miss Rajni Gupta 229/89 5.Miss Suman Bala Jain 243/89	Operation and maintenance
			I Year Electrical	
Transformer Repair W/shop HSEB, Dhulkot Ambala	Er.GC Jain Executive Engr., Transformer Repair Workshop, HSEB, Ambala	Coil Winding: Mr.Balbir Singh Repair/Assembly: Mr.RN Bajaj Testing: Mr.Shamsher Singh	1.Mr.Keshav Prashad 214/89 2.Mr.Narender Singh 215/89 3.Mr.Anil Kardam 203/89 4.Mr.Deepak Maheshwari 248/89 5.Mr.Ajay Das 201/89	Manufacturing Repairing and testing
UT Electricity Department, Chandigarh			II Year Electrical	
i)Operation & Maintenance Divn	Er.V.K.Mahindru, Executive Engineer, (Construction Divn) Sec-34, Chandigarh Ph.22967	Er.SS Paul, AEE, Const.Divn, Sector-26, Chd. Ph-22534	1.Mr.Neeraj Tandon 225/88 2.Mr.Ajai Jain 2/88	Operation & Maintenanc
			II Year Electrical	
ii)Installation & Commissioning Division	Er.VK Mahindru, Executive Engr., (Construction Divn) Sec-34, Chandigarh Ph 22967	Er.SS Paul, AEE, Const.Divn, Sector 26, Chd. Ph-22534	1.Mr.Suresh Ahlawat 240/88	Installation and commissioning

of the Department to the industries was also prepared. Since the principal was keen to know about the outcome of the experiment and wanted to discuss the same with other teachers and students of the polytechnic , it was decided to conduct a seminar at the polytechnic immediately after the experiment.

Copies of the functional curriculum and instructional material were handed over to the subject teacher for distribution to students on the first day of the institutional training. It was also decided that the researcher would do over-all coordination of the experiment with the assistance of the local coordinator.

7.8 Implementation of instructional plan

7.8.1 Institutional instruction

All the thirteen students (10 second semester students and 3 fourth semester students) reported to the polytechnic on 20.6.90. The students were given copies of the curriculum and instructional material. The course was taught to students by the subject teacher using the instructional material developed for the purpose. Class-room activities included lectures and group discussions followed by practicals. Half the available time was devoted to theoretical instructions and half the time on practical work. In addition, students were given daily home assignments which were corrected and returned. Institutional instructions were completed by 28.6.90 i.e. ,the students were taught for 7 working days for 3 hours per day. Only the basic theory was taught in details. For the content of functional aspects,only an overview was given. However,the students got the detailed reference material for study during their industrial attachment period.

7.8.2 Industrial attachment

After the institutional instruction, the students were given the industrial attachment schedule and were asked to report to the respective industries. The students were provided with training record diary and an instruction sheet containing general discipline and other requirements of industries. All the students were issued identity cards also. students were told that the polytechnic faculty would visit them and also participate in group discussions. All the students reported to their respective indsutries on 29.6.1990 and worked in industries as interns till 25.7.1990. on the first day of industrial attachment, the researcher, the subject teacher, and the Head of the Department visited the industries to ensure placement of students with the right persons. They also had discussions with the supervisors to ensure that these students were given assignments to work on, and also, evaluated against their acquiring of performance abilities. It was decided to rotate the students in the functional areas after a period of time. Students were thus attached to the supervisors and they worked as assistants to them. For the initial period they studied the work of the supervisors through observation. The students also consulted the reference material supplied to them for understanding the work performed. They had group discussions with the supervisors for clarifying doubts and strengthening their understanding. This was followed by specific tasks given to them by the supervisors. The students learnt the following during their industrial attachment period:

(i) Allocation of work to the workers;

(ii) Preparation of bill of materials;

(iii) Assemblying of transformers;

(iv) Reading assembly and detail drawings;

(v) Testing as per Indian Standards;

(vi) Inspection of material;

(vii) Inspection of transformers received for repair and identification of faults through visual inspection and tests;

(viii) Preparation of estimates for repair;

(ix) Procedure for repair of transformers;

(x) Quality Control checks;

(xi) Testing of repaired transformers;

(xii) Operation of control room of a Grid sub-station;

(xiii) Safety precautions;

(xiv) Protection scheme for transformers;

(xv) Routine maintenance of power transformers;

(xvi) Procedure for installation of transformers;

(xvii) Study of equipment and instruments for manufacturing and repair of transformers;

(xviii) Verification of stores

7.8.3 Evaluation of students

Evaluation of students on their problem solving abilities were done on a continuous basis jointly by the industrial supervisors and the visiting faculty. A written test was conducted on the last day of the industrial attachment for the experimental group of students as well as for 10 other students of second year who had studied through institutional training only.In addition,interview was conducted by a panel of experts for all the students.

7.8.3.1 Continuous evaluation of students

Students were evaluated through multiple evaluation instruments of Quiz, Group discussion, Observation, Techncial report/diary, and Viva-voce by the industrial supervisors and the visiting faculty. Group discussions were held on weekly basis where the concerned supervisor and the visiting faculty participated. The topics for discussion were chosen by the students. Each student submitted their technical report and the training diary for evaluation on the last day of their industrial attachment. The report included the description and analysis of the assignments completed by the students. The training diary was evaluated on the basis of amount of informations collected by the students. Viva-voce was conducted to assess the students' understanding of the assignments completed,and their intellectual abilities.

7.8.3.2 Evaluation through written test

In addition to the 13 students of the experimental group, 10 more students of the same polytechnic of second year who had studied the subject through institutional training only were given the written test. These second year students were selected on random basis by their Head of Department. These students were informed about the written test one week in advance and were asked to come prepared. They were also informed that an interview would be conducted by a panel of experts, in the indsutry. On the day of the test and interview these students were asked to report to one of the industries.

The written test paper had 70 percent component of basic theory related to the existing polytechnic curriculum and 30 percent on functional curriculum. The questions were of multiple choice type and of short answer type. The answer sheets were evaluated by a teacher drawn from a different polytechnic.

7.8.3.3 Evaluation by employers

A panel of experts from industries who were not connected with the experiment were invited to interview the students from the point of view of the requirements for employment. These experts were briefed about the objectives of the experiment and were asked to evaluate the students. The identify of students in terms of whether they belonged to first year or second year, or whether they were placed in industries or otherwise, was not disclosed to the experts. Only the names of students in alphabetical order were written on paper and given to the experts. The Head of the Department of the polytechnic was also included in the panel of experts and was asked to evaluate the students. The researcher and the subject teacher were present as observers during the interview.

Evaluation data of students of first year and that of second year as done through written test and also by a panel of experts have been presented in Annexure 7.3.

7.9 Interpretation of student evaluation

Correlation coefficients of scores of 13 students of the experimental group were calculated as at Annexure 7.4.

The correlation coefficients are:

(a) Between continuous evaluation and written test: 0.82

(b) Between continuous evaluation and evaluation by employers: 0.63

(c) Between written test and evaluation by employers: 0.39

Comparative achievements of students of first year and second year are presented in table 7.6.

Table 7.6

Comparative achievements of students of experimental group and control group

Group of students	ACHIEVEMENT IN PERCENT				
	Written test on Basic Theory	Written test on functional aspects	Total score	Evaluation by industrial experts (Average score)	Evaluation by HOD
Experimental Group, First year	67.0	50.0	58.5	71.75	76.0
Experimental Group, Second year	83.3	54.4	68.8	72.5	80.0
Control Group, Second year	49.7	14.6	32.1	46.75	33.0

From the results the following observations are made:-

(i) First year students, who were taught the functional curriculum followed by industrial attachment, performed better than the second year students (Control Group), who had studied the existing curriculum through institutional class room and laboratory based instructions.

Further, the performance of first year students in basic theory was also better than the students of control group (i.e. an average of 67% as against 49.7%). Thus, it can be concluded that students who studied the functional curriculum followed by industrial attachment in functional areas have understood the basic theory better than the students who studied a science base curriculum through institutional training alone.

(ii) The performance of second year students of the experimental group in the written test, both in the basic theory as well as in the functional aspects, was better than the first year students. This was because of the intellectual maturity of second year students as well as their having studied the core engineering subjects in the second year. From table 7.6, it is seen that maximum advantage in learning could have been derived if second year students were taught the functional curriculum followed by industrial attachment in functional areas.

(iii) In the evaluation by employers the experimental group performed much better than the control group. However, performance of second year students of experimental group was better than the first year students.

(iv) It was felt necessary to compare the performance of students who study the conventional science curriculum and are attached to functional areas in industry as against students who study the functional curriculum and are attached to functional areas in industry . No separate experiment was conducted for the purpose as it was known that the collaborating industries had been receiving trainees from polytechnics who study the conventional science base curriculum. The industries therefore, had the previous experience with such students. The engineers and supervisors of the industries were asked to compare the performance of the present group of students who had studied the functional curriculum as against the performance of other trainees received by them earlier.

(v) Poor Correlation coefficient of 0.39 between written test and evaluation by employers shows that students' achievements in written test alone do not reflect their real abilities as, required by the employer.

7.10 Feedback from industries, teachers and students

Feedback from industries, teachers, and students were collected through a seminar organised in the polytechnic on 1.8.1990 i.e. a week after the completion of industrial attachment of students. In the seminar representatives from the collaborating industries, faculty of Electrical Engineering Department of the polytechnic, all the departmental eads, the polytechnic principal, the students who were involved in the experiment as also the other students of first, second and third year participated. The programme of the seminar included presentations of achievements made by the individual students, presentations by industries' representatives, and group discussions. The seminar was conducted by the students of the experimental group. The researcher and two other faculty of TTTI also participated. Feedback as collected during the seminar and also the feedback response of industries, teachers, and students collected through questionnaires are presented in the following sections.

7.10.1 Feedback from industries

A questionnaire was given to all the industrial supervisors after the industrial attachment of students. Interviews were also conducted with the representatives of the industry. The feedback received from industries through questionnaire, and their reactions during interviews are listed as follows:

(i) As the interns were involved in the work of of the industry, all the supervisors found this group of students a help rather than a burden. The industry found the students as additional manpower and a help in their day to day activities. The quality of interactions with students were meaningful as students were found asking higher order questions. Many a times, students came out with suggestions for improv -

ing the productivity of the organisation/section. The students were regular and punctual and observed the discipline of the organisation. Within a short period of exposure and involvement, students could take up work assignments independently;

(ii) All the industries expressed that they would be willing to receive students regularly on internship basis;

(iii) All the industrial supervisors indicated that students should be placed in industries with work assignments where they would first observe the work of supervisors and then assist them in the work . Attachment of students in industries for observation only was not very useful, the supervisors expressed.

(iv) The evaluation instruments used were rated as appropriate for assessing students' real abilities. 100% of the supervisors indicated that their interactions with students were learning experience to them also.

(v) Industry found the functional curriculum satisfying the knowledge and skill requirements of diploma holders;

(vi) Regular visits of teachers and their participation in group discussion and students' evaluation were essential, the supervisors expressed;

(vii) Reference material supplied to students were found to be very useful by the industrial supervisors also;

(viii) Overall performance of students during industrial attachment phase was rated at 80%by the industrial supervisors.

7.10.2 Feedback from teachers

Feedback from teachers of the polytechnic, who participated in the seminar conducted after the experiment, was collected through a questionnaire. Their reactions, during question answer session, were also collected. The response of teachers are presented as follows:

(i) 91% of the teachers expressed that this group of students was better prepared in terms of practical knowledge gained, self confidence, and in communication abilities as compared to similar groups of students of the same polytechnic.

(ii) 100% of the teachers expressed that the existing student evaluation system prescribed by the SBTE did not evaluate real abilities of students. After studying the student evaluation method followed in the experiment, all the teachers expressed that the method adopted was superior to the existing method;

(iii) 80% of the teachers expressed that there was a need for development of curriculum,similar to the one used in the experiment,for all the subjects;while the remaining 20% suggested revision of the existing curriculum;

(iv) After going through the instructional material used in the experiment, the teachers indicated that such material, although very useful, were not readily available in the market. Further,they indicated that such student learning material required to be made available to students at subsidised rates.

75% of teachers suggested that the problem solving approach to teaching-learning could also be incorporated in the institutional training;

(v) 30% of the teachers suggested that the problem solving approach to teaching-learning could also be incorporated in the institutional training;

(vi) 100% of the teachers indicated that there was need to develop interactions with the industry at the level of the teacher so as to make teaching-learning respond to the requirements of students as well as of employers. The teachers expressed that they were not satisfied with the existing method of curriculum implementation where the teacher was expected to confine teaching-learning activities within the four walls of the class-room only;

(vii) The Head of Department observed that involvement of students in problem solving activities had helped all the students to develop self confidence, which the traditional system of teaching-learning has not been able to achieve;

(viii) Regarding functional curriculum,the Principal of the Polytechnic expressed his views as: "The curriculum is required to be developed at the state level or at the regional level by the Directorates of Technical Education in association with polytechnics and other resource organisations like the TTTIs. The curriculum document prescribed by the SBTE does not include any implementation strategy and as such the assumption made is that the curriculum will be implemented through institutional training only. The encouraging experimental results should guide in revising curriculum implementation strategies. I, as a Principal, would like to continue sending students in industries on specific assignments in large numbers during vacation periods. Regarding curriculum revision, I would share the ideas with all my colleagues in the polytechnic and would also provide feedback to SBTE for consideration".

7.10.3 Feedback from students

Feedback from students were collected through a questionnaire and also during the Seminar conducted at the polytechnic where the students made formal presentations of their learning experiences and answered questions asked by other students, teachers and representatives of industry. Feedback from students as collected through a questionnaire(Annexure 7.2c) as well as their reactions observed during Seminar are presented below:

(i) All the students expressed that the course content taught in the polytechnic had direct relevance to the work of a technician in the respective functional areas. The content on basic principle and theory was also found to be adequate;

(ii) Institutional based teaching-learning of basic principle and the related theory was rated at 70% level by the students;

(iii) 100% of the students expressed that on reporting to the industry they felt excited to learn new things related to their subject of study. All the students found supervisors very cooperative,and they involved them in day to day work. All the students were assigned specific tasks to perform under the guidance of the supervisors;

(iv) All the students indicated that the notes and reference material supplied on different functional areas were very useful companion while working in industry;

(v) Analysis of problems and their solutions were arrived at through group discussion and interaction with the supervisors. All the students expressed that they learnt maximum through group discussions which were held regularly after every task observed and performed by them;

(vi) All the students indicated that through this industrial attachment they developed the skill in reading technical drawings,measurement of various electrical quantities using precision instruments, testing as per standards, preparation of estimate, and carrying out maintenance work as per specified norms;

(vii) 90% of the students expressed that they were able to work effectively in different functional areas with a little orientation;

(viii) Self evaluation of students on their achievements on certain important skills are as follows:

(a) Communication skill	75%
(b) Ability to participate in group discussion	70%
(c) Ability to prepare technical report	80%

(ix) All the students were appreciative of the method of teaching-learning followed and they enquired as to why such opportunities for self development were not provided to all the students;

(x) 90% of the students expressed that for the first time in their study period they got an opportunity to speak in front of an audience.which gave them lot of confidence;

(xi) Involvement in a variety of tasks in industry helped all the students to perceive the kind of activities a diploma engineer has to perform;

(xii) All the students expressed that, for the first time , they saw the relevance of the subjects being taught in the polytechnic.They also realised their areas of weakness.

and could get opportunities for development;

(xiii) All the students indicated that the industrial attachment had improved their motivation for further study.

7.11 Problems faced in conduct of the experiment

Conduct of this experiment placed a heavy demand on the researcher in terms of development of a functional curriculum, preparation of instructional material in functional areas, identification of places of internships for students in related industries, placement of students in industries under the supervision of industrial experts, orienting teachers and industries in student evaluation, and in overall monitoring of the programme.

7.11.1 Development of functional curriculum

A study of the existing curriculum showed that it had a heavy bias on subject specialisation somewhat similar to curriculum of physics, mathematics, or Biology.

Technician education is treated as preparation for life. Life consists of performance of specific activities which can be analysed and taught. These activities then form the objectives of the curriculum. Such an approach, called functional approach to curriculum development, would make analysis of functions of technicians to incorporate the "action tasks" as well as the "cognitive tasks" performed by technicians in different functional areas. The existing method of curriculum development is mainly based on subject specialisation approach rather than job analysis approach and is carried out, in general, through committee decisions.

It was therefore necessary to evolve a method of development of functional curriculum through activity analysis by intense involvement of relevant industries for which the researcher had to take the initiative, as the polytechnic teachers neither had the know-how nor had the commitment to get involved in these activities. The curriculum development tasks involved identification of functional areas of employment of diploma holders in such areas, identification of knowledge, skill, and attitudinal requirements and then developing the course content. Informations had to be collected through questionnaires, personal visits, interviews and actual observations on the job. Polytechnic faculty could not be involved in these tasks because of their being not available for such elaborate activities. The existing rules and regulations also did not permit them to visit industries as a part of institutional activities.

7.11.2 Development of instructional material

The teaching-learning material available in the market on the subject were studied and analysed. These materials, by and large, are of the same type and have written mainly from the point of view of examination conducted by the State Board of Technical Education. Teaching-learning material appropriate to the level of polytechnic students covering the functional aspects were not readily available. The teachers, due to their limited experience in functional areas, were also not able to contribute much in the development of such material. The researcher had to contact the relevant industries, consult the various literature available with State Electricity Boards and manufacturers, contact some field organisations for collecting training manuals, collect informations from Indian Standards, consult various reference books and then compile, edit and thus prepare the student learning material in the form of "Supervisors' Guides". Such guides were prepared covering functional areas of Manufacture, Installation and Commissioning, Operation and Maintenance, and of Repair. In addition, instructional materials for learning of basic concepts and principles were also prepared. Knowledge of educational technology for deciding about the presentation of such material was considered essential. Most of the polytechnic teachers did not have such expertise and as such the work had to be carried out bv the researcher himself. However, while doing so he received needed cooperation from industries, who also asked for copies of such material for their own use.

The researcher got a feeling that although the work was time consuming and needed expertise, the material developed were of use to both polytechnics and industries, thus opening another area of interaction between polytechnics and industries for mutual benefit.

7.11.3 Involvement of industries for internship of students

Letters explaining the concept of the students' internship in industries had to be prepared and supplied to the polytechnic to enable them to write to a few industries. Follow - up visits were organised to these industries along with the concerned polytechnic faculty. The industries had the past experience of receiving students for summer vacation training, where the students were given exposure oriented training. Since, this internship concept was new, the industries had to be explained about it. The procedure for evaluation of students had also to be explained to the industrial supervisors. The supervisors realised that unlike receiving students for summer vacation training, as was in the past, this time they were provided with additional hands which they could use for assisting them in their work. Arrangements were also made to rotate the interns in different functional areas to provide opportunities for experiential learning in all the areas.

7.11.4 Involvement of polytechnic faculty in supervision, monitoring and evaluation of students in industries

In earlier practice of students' training in industries, the polytechnics did not involve the faculty in supervision, monitoring and evaluation of students. These activities were expected to be done by the Training and Placement Officer (T.P.O.) for students of all the disciplines. An analysis of the past practice indicated that the T.P.O. made occasional visits to some of the industries, and in most cases, left all aspects of student training and evaluation to the industries. The polytechnic also did not provide any guidelines for evaluation of students.

In the present case the polytechnic principal got convinced about the need for regular supervision, monitoring, and evaluation of students in industries by the concerned departmental faculty under the overall supervision of Head of department. Thus, for the first time in this polytechnic, the job was shifted to the concerned department. The polytechnic faculty were placed on duty during the vacation period to supervise students in industries. Meetings were organised at the departmental level, to understand the various aspects of the students' internship, its academic value, the purpose and method of student evaluation. A tentative schedule of visits to industries by the polytechnic faculty was thus prepared. This had to be coordinated locally by the Head of Department. The researcher had to continuously remind the local co-ordinator of the schedule of visits by the faculty. For visiting industries by the faculty, conveyance facilities were not available.

7.11.5 Conduct of Seminar and Collection of feedback

Receiving feedback from students and industries,although considered essential, was not practiced in the past by the polytechnic management. Arrangements regarding sending invitation to indsutries, briefing students and preparing questionnaire for receiving feedback had to be initiated by the researcher. The polytechnic management, the students, as well as the industries however, expressed need for such feedback for maintaining improved mutual relationship.

CHAPTER-EIGHT

ANALYSIS OF RESULTS

8.1 Summary of conduct of experiments

Experiments were conducted on each of the models according to the details given in Table 8.1.

Table 8.1
Details of the experiments conducted using different models

	Expt 1 Model I	Expt 2 Model II	Expt 3 Model III	Expt 4 Model IV
Number of polytechnics involved	4	1	1	1
Number of students involved	85	135	42	13+10
Number of industries involved	36	22	2	6
Duration of conduct of the experiments	8 weeks	9 weeks + 2 semesters	1 semester	6 weeks
Number of teachers involved	17	6	2	2

The experiments conducted were subjected to critical evaluation based on feedback from students, teachers, industries and also on results of students' performance. This Chapter presents a comprehensive analysis of results so obtained. The achievements and requirements as observed in the four experiments are presented separately for each experiment.

8.2 Experiment on Open-ended projects at work-bench

8.2.1 Observations based on experimental results

Twenty-five observations were made as under:

1. Project output of industrial use

60% of the students could complete their assignments of open-ended problems during their industrial attachment phase and submit reports. These were evaluated by the sponsoring industries and found to be of direct use to them.Thus,while students learnt problem solving,the industries also gained thereby making industry-institute interactions meaningful and beneficial to both.

2. Monitory incentives to students

Because of students' good work, industries provided monitory incentives ranging from Rs.300/- to Rs.800/-. 35% of the students received such incentives.

3. Better students' motivation in learning

Involvement of students in open-ended project activities which were relevant and meaningful, for the outcome of which there was a taker, and for arriving at the solution where need based guidance was available, worked as motivators to the students to put in their best in the learning process.The students were observed working hard cooperatively with their group members and were taking initiative in completing their tasks within the given time frame. This was very different from what happens in a conventional class-room where the teacher takes all the initiative and the students are mostly seen as passive listeners.

4. Opportunity for self development

Every student got opportunity for self development through project activities,ie,by participating in group activities and making contributions by way of presenting ideas for problem solution, communicating effectively with fellow students,teachers and industrial experts, writing technical report, taking initiative, demonstrating leadership qualities, observing discipline, appreciating value of time, material, and money, including all other abilities which are required for working in real life situations.

5. Improved communication skills

In a conventional teaching-learning situation, opportunities for developing communication skills are limited, as students are mostly passive listeners because of the very design of the instructional system. On the contrary, in this learning situation every student got opportunity to develop his communication skills, both verbal and in written, by participating in group discussions, seminar and in presenting his technical report. Most of the students expressed that they got such opportunities for the first time in their academic career. Developing effective communication skill is an essential requirement when one realises that these diploma holders are going to be supervisors who would lead a team of workers in the work situation and would work in close asssociation with engineers to achieve production targets of the industry.

6. Students becoming self reliant

Education and training is not to be seen as a process where knowledge and information are 'poured into' the minds of the students, but as a process, where the learner is made self reliant in acquiring knowledge through his own effort for the purpose of solving problems which he is going to face while working in the real life situations. He is to become a 'learner entrepreneur' who is desirous and capable of 'learning to learn'. In this experimental situation, while confronted with open-ended problems, students were observed to collect informations, develop hypothesis, arrive at plaussible solutions, evaluate them and prepare reports for presentation. Thus, the students sorted out problems by themselves and shared full responsibilities in the learning tasks thus becoming self reliant which is so essential in the present context of preparing students for effective participation in the changing technological scenario.

7. Presence of teacher essential

Considering industrial attachment of students a learning situation, a part of the learning tasks was shifted from institutional setting to the work-bench environment. For day to day supervision of students, for keeping record of progress made by the students in their learning tasks, for providing guidance to students in their problem solving effort, and for student evaluation, it was considered essential that the teacher was present on a full-time basis in the industry. The teacher, in addition to performing the above tasks was exposed to industrial processes and practices which enriched his knowledge thus providing multiple benefit to the system.

8. Need for flexible rules and regulations

This experiment involved constant interactions of teachers with the employer organisations in explaining to them the concept, identifying problems for assigning to students, getting permission for placement of students and teachers. This required a good amount of preparatory work. Further, placement of teachers in industries had to be supported by extending certain facilities to them. The existing rules and regulations do not encourage polytechnic teachers interact with the employers to bring in improvement in the teaching-learning process by receiving cooperation from them. Polytechnics need to have flexible rules and regulations including certain amount of autonomy so as to facilitate implementation of innovative teaching-learning.

9. Curriculum needs a fresh look

Placement of teachers in industries allowed them to compare closely the field requirements vis-a-vis the polytechnic curriculum. The teachers also collected feedback from industries during interaction sessions. It was observed that the existing curriculum contained much of obsolete topics whereas, on the other hand, did not contain topics of current requirement. The curriculum revision activities are carried out mainly by the involvement of teachers who are, by and large, cut off from the world of work. Exposure and involvement of teachers in industry provided feedback for having a fresh look on the curriculum -a need, felt by the vital system elements i.e. the teachers.

10. Students learn to work in teams for goal oriented time bound projects

Project activities led students to work cooperatively in teams where they had to learn to respect views of others and collectively arrive at decisions. Th y also learnt to express opinions which might be different than those of others. Such cooperative group performance was considered more important than individual performance by the employers.

11. Improved students' behavioural response

Being in actual field situation, students observed industrial discipline in terms of regularity and punctuality, learnt to take up individual as well as group responsibility, learnt method of dealing with colleagues and supervisors and also respecting other persons' point of view. Thus, an overall improvement in the behavioural response of students was observed.

12. New evaluation system

The evaluation system adopted in this experiment provided opportunity to judge the various personality attributes of a student which are significant in the real-life situations like, knowledge of concepts, application of principles, intellectual ability, creativity, decision making, inter-disciplinary approach, data handling skills, documentation, self-expression, initiative, self reliance, cooperation, leadership, indsutry, sense of responsibility and social sense. For evaluating the complete personality of the student, use was made of multiple evaluation instruments like Quiz, Seminar, Viva, Group Discussion, Report Writing, etc.

13. Teacher becoming a consultant

Guiding and evaluating students in the open-ended problem solving situation was also a learning experience to the teachers. The situation provided opportunity to the teachers also to learn open-ended problem solving by participating as a senior member of the project team. Such experiences were valued by the teachers in their becoming future industrial consultants.

14. Need for stress on basic skill development in institution based teaching-learning

As a prerequisite to taking up problem solving assignments, what the student is required to possess is the acquisition of basic skills like the knowledge of basic concepts and principles, the ability to read and interpret engineering drawing, skill in basic measurements, cooperative working, the spirit of enquiry, and so on. Institutional teaching need to aim at providing opportunities to students in attaining these abilities while teaching the given course content so as to prepare students to take up open-ended problem solving tasks.

15. Guiding students challenging and satisfying

Teaching a given course content over the years is viewed as a routine activity devoid of much challenge. Job satisfaction, a most essential requirement for any teacher, was derived by the teachers from the experience of guiding students in open-ended problem solving activities in the field situation.

16. Students secure employment

Students got opportunity to secure employment by demonstrating their real abilities in open-ended problem solving abilities. Industry could watch closely the work of a group of students and could select students for employment. 35% of the students got employment in the industries where they were placed on attachment for the particular period. However, those students who could not find immediate employment in the concerned industries were better prepared to face other industries in seeking employment.

17. Industry extends its resources for student training

Since the problems were sponsored by the industries, and they found student teacher team engaged in finding solutions to these problems, facilities were extended to the group in terms of consultancy, literature resources, monitory incentives and other physical facilities, which provided motivation and encouragement to the learner group.

18. Pedagogy useful to all industries

Students were placed in large and medium industries, as also in manufacturing and service industries, and the result showed that this teaching-learning system was beneficial to all of them in terms of usefulness of project output, opportunities for student selection for employment, and above all, making contributions to the process of developing better trained students.

19. Better curriculum feedback from teachers

Being exposed to industrial situations, feedback for curriculum revision came from the teachers which could be consolidated and used for bringing in the required changes in the curriculum. In the existing system of curriculum revision, although the teachers are involved, they are not able to contribute much in terms of field requirements for obvious reasons.

20. Employer able to make better selection of students for employment

A survey of procedure adopted by employers for selection of diploma holders for employment indicates that such selection is made, in most of the cases, on the basis of oral interview. Some employers also conduct written tests. However, in this case employers got opportunity to closely watch a group of students and also assess their total personality traits which helped them make better selection of students, matching their abilities with the job requirements.

21. Evaluation system meaningful to employer

The multiple evaluation instruments used for judging the total personality traits was considered more meaningful by the employers as against certificate awarded by the SBTE indicating the percentage marks obtained by students in different subjects.

22. Management needs to develop linkage with industries

The experience in conducting the experiment showed that the polytechnics do not have much linkage with the world of work for mutual advantage. The experiment was conducted for only a representative sample of the student population. To be able to extend the benefit of this experience to all students, polytechnics need to develop linkage with the industries for which constant interactions are required.

23. Polytechnics turning out better quality diploma holders

Quality implies matching the abilities of the student output with the field requirements. Field requirements are seen as those which are of immediate nature and the others of long-term needs. Equiping students with problem solving abilities and abilities of 'learning to learn' are considered essential for meeting the short term as well as the long term educational objectives. The experiment provided the students with all the opportunities for self development and thus turning out better quality of student output.

24. Restructuring of curriculum required

To enable student-teacher involvement at the work-bench, the curriculum needs to be restructured so as to keep the total duration of course offering unchanged. This could be possible by shifting part of the learning activities to the work bench environment.

25. Optimisation of infrastructure development requirements within the institute

No system can provide resources required to create opportunities for all types of learning experiences to students within the institute. Optimisation in resource requirements were achieved by utilising the facilities of the industry, which were available free of cost.

8.2.2 Reactions of students, teachers, and employers

Reactions of students indicated that they attained better communication abilities, developed better attitude towards learning, and got interest in learning modern technologies like use of computers, instrumentation and controls as also realised the importance of cooperative team working for completion of tasks within a given time frame. The students expressed that opportunities for group discussions with colleagues, teachers and with industrial consultants created self confidence in them as also enriched their learning. In 90 percent of the cases, the students found attitude of industry favourable towards pursuing learning tasks at the work-bench.

Teachers found the task of guiding students on open-ended projects at the field situations a unique experience, challenging, motivating and satisfying. The teachers expressed that with this enriched teaching-learning experience, they were better equiped to play multiple roles, i.e. as an effective teacher, a curriculum developer, and as a consultant. Indeed, this mechanism of work-bench based education has been an on-the-job faculty development programme for the teachers, which they considered most valuable and meaningful than the faculty programmes conducted by different training organisations.

Industries found project based student-teacher involvement at the work-bench a better educational design than the conventional industrial training of students organised by various techncial institutes. Effective linkage for mutual benefit could only be established through design of such mechanisms, the industries mentioned. Reactions of teachers indicated that the project method of teaching-learning was more job satisfying than merely teaching of a given course content through lecture method.

Industries expressed satisfaction from the experience of their involvement at the work-bench based education and training. They found project output useful to them. All the industries showed their willingness for participation in such cooperative working on a long term basis.

Polytechnic teachers including their principals mentioned that for implementation of this teaching-learning model, the Directors of Technical Education had to be involved. Technical Teachers' Training Institutes could play an important role in disseminating the concept to the DTE/BTEs and to the other polytechnics. Regarding involvement of faculty in student training in industries, the view expressed was that the principals of the polytechnics could be given the necessary administrative and financial powers to place faculty on duty with certain financial benefits. Possibility of payment of certain minimum amount of stipend to students could also be explored. The Apprenticeship Training Boards of Government of India could be approached to extend this facility. The teachers further suggested that seriousness in implementing this model could be brought in by making "students' attachment in industries" an essential requirement for the award of diploma. However,a student could opt for a diploma without industrial attachment requirement also, in which case,he could be offered, some additional subjects at the institute.

8.3 Experiment on project activities as an integral part of class-room instruction

8.3.1 Observations based on experimental results

Thirty-one observations were made as under:

1. Improved learner performance in Board Examination

Achievements of students in the examination conducted by SBTE have been better as compared to the achievements of students of previous batches. This shows that project activity as a part of institutional teaching-learning around the course content has not only helped students gain problem solving competence but also has helped them perform better in the conventional examination.

2. Skill development as also better understanding of the subject

Project activities have helped students develop all the related practical skills while at the same time understand the subject content better, as opportunities were available to apply the related concepts and principles in practical situations.

3. Availability of statement of strong and weak points of students

Day to day observations of students' performance in project activities as also the application of multiple evaluation tools for assessment of students' abilities, helped to prepare statements indicating strong and weak areas of each student, which helped in providing feedback to the students.

4. Improved learner perception

Perception is a complex process by which information is received from the environment. Perception is important because it sets limits on all subsequent cognitive processes. The better an object or event is perceived the more feasible and reliable will be the further cognitive processes e.g. memory, concept formation, problem solving, creativity, and attitude change. Open-ended problem solving assignments and exposure to work environment helped students perceive the relevance of the content before they studied the same.

5. Project method of teaching inculcates scientific problem solving competence

Project method of teaching involved formulating and testing of hypothesis . in an atmospehre that resembled that of a scientific laboratory. The same open minded and objective attitudes that characterise any scientific investigation prevailed thereby inculcating in students the abilities for open-ended problem solving.

6. Guiding students a challenging task

The teachers experienced guiding students on open-ended problem solving tasks a challenging task. This was contrary to the conventional teaching assignments carried out by them over the years.

7. Better learning of basic skills

The institutional teaching-learning activities oriented towards developing problem solving competence helped students develop their basic skills which they acquired through self study and through interactions with group members, teachers, and industrial consultants.

8. Better quality of questions asked by students

Students confronted with open-ended problems asked questions of higher order which created an atmosphere of mutual enquiry, referencing to the literature, as also consulting experts.

9. Extension lectures by industry enriched students' understanding

Industries delivered extension lectures on topics of practical significance related to the project activities undertaken by the students. Such lectures actually became interacting sessions where students had large number of relevant questions to ask, whose answers were not available in books. Such extension lectures helped students enrich their understanding of the subject of study.

10. Project output useful to employer

The project reports were evaluated by the sponsoring industries for award of marks to students. All the industries found project output of direct use to them.

11. Improved student motivation

Source of motivation has been seen by psychologists as needs, incentives, innate curiosity, and inner need that arises from within, as also those produced by pushes and pulls exerted by environment. Cognitive field psychologists tend to see the source of motivation as an interactive process-persons interacting with their perceived environments. The learning situations provided to students resulted in better student motivation in learning because of their purposive involvement in the learning tasks, and as a consequence, they were seen putting in hard work in completing their assignments.

12. Students learn to produce quality work

Since the projects were of practical significance, and students visualised the field requirements, they produced quality work right from the stage of preparation of plan of action to the analysis and interpretation of results and presentation of technical reports.

13. Teachers find guiding students a learning experience

Class-room activities centred around project activities, the teachers found, a learning experience, as answers to querries made by the students were also not known to them and for which they had to search literature or consult specialists.

14. Students find learning tasks challenging

Working on open-ended projects placed responsibilities on students to take initiative in learning, to sort out things for themselves, to collect the relevant informations from various sources, and arrive at the required problem solutions through cooperative group working -a learning experience which the students found more challenging as compared to the study of prescribed course content.

15. Improved communication skills

Group discussions, interactions with professionals, and presentation of technical reports helped students develop their communciation skills -an essential requirement for participating effectively in any real life situation.

16. New approach to student evaluation

Evaluation to judge students' total personality traits, was considered more relevant and meaningful than merely testing students for their knowledge through written tests. Such a comprehensive students' evaluation provided better feedback to students for their self development.

17. Need for supervisory skill development

Supervisory skills involve management of men and material for achieving production targets. Since the students worked at the institute on projects assigned by industries, it was not possible to allocate them problems exclusively dealing with supervisory skill development.

18. Need for teachers' interaction with industries to answer learner querries

Querries made by students while they were working on open-ended problems were found difficult to answer by the teachers and on many occasions interaction with industries' experts were found essential.

19. Students better prepared for employment

Industry found this group of students better trained for employment because of their competencies in terms of ability of applying basic knowledge and skills for practical problem solutions.

20. Need for development of problem bank

Selection of problems as projects from industries was a difficult task. The nature of such problems ought to have been such that they caused psychological tension in students to the point that they were involved and perplexed, but not frustrated. Development of a problem bank was an important requirement for making project method of teaching effective. In the absence of genuine problems, it was felt, project method of teaching could degenerate into students' working on stereo typed projects having low educational value.

21. Need for establishing linkage with industry

Polytechnics need to interact with industries for identification of problems, involvement of experts for project gudiance and student evaluation and for arrangement of extension lectures.

22. Need for flexible rules and regulations

The polytechnic faculty were of the opinion that rules and regulations of the polytechnics required to made flexible to encourage interactions with the environment.

23. Need for flexible time tabling

Time table of the polytechnic required to be made flexible to enable students-teacher team visit industries for collection of data, discussions with experts, consulting literature, etc. In this experiment, the time table was so adjusted that two clear half days were available for the subject.

24. Evaluation system reflects students' abilities

Multiple evaluation instruments viz Quiz, Seminar, Viva, Observation, Group discussion, Project report, evaluated students for their real abilities and thus it was possible to prepare evaluation reports stating students' strong as well as weak areas.

25. Activity in learning

The competencies that are required to be developed in students of polytechnics are such that acquiring of such competencies are best facilitated if 'learning' takes place 'by doing'. Opportunities for application of knowledge and skill, practice, and feedback enhanced quality of learning as well as its efficiency.

26. Need for instructional material development to help students learn basic concepts and principles

To help students learn basic concepts and principles, instructional material in various formats, keeping in view the learning styles of different categories of learners, were required to be developed. Such material in the form of activity package, programmed text, demonstration models, etc.

were to be developed covering all the subjects.

27. Continuous evaluation and feedback helps students in learning.

Learning tends to be rapid, efficient and pleasurable when students are provided information that they are becoming progressively more competent in complex problem solving skills. Continuous student evaluation and feedback used in this experiment helped students put in their best in the learning tasks.

28. Learning to work in groups.

Sharing of responsibilities in learning tasks as well as interacting with each other in expressing views and clarifying doubts, resulted in cooperative group learning, which the students valued as equally important as their individual learning.

29. Teachers get opportunity to interact with industrial experts.

Participation of industry in guiding students in their project activities, requirement of student-teacher team to visit industries and interact with experts,and involvement of professionals in student evaluation were unique opportunities available to teachers to update their knowledge and skills while at the same time carrying out teaching-learning duties.

30. Industries extended cooperation in curriculum implementation

Participation of industries in curriculum implementation was an exercise from which the students, teachers and the industrial experts, all alike, derived satisfaction.

31. Students' evaluation meaningful to employers

The evaluation system which assessed students' total personality traits, and the method of certification which stated students' strong areas as well as areas needing improvement, were found more meaningful by employers as against the marks sheets and certificates issued by the SBTEs.

8.3.2 Reactions of students, teachers and employers

Reactions of students, teachers and employers as collected during the experiment are summarised as follows:-

All the students expressed that they got an opportunity for applying their knowledge & skill in solving open-ended problems for the first time in their academic career where they could develop as well as demonstrate their real abilities. Interactions with the experts as well as with teachers and fellow students were purposeful, the students expressed. During project work, the students realised the importance of developing communication skills, cooperative group working, as also the need for becoming self reliant in the learning process. The students also could correlate their theoretical knowledge with practical applications for the first time. Attitude of collaborating industries was found favourable by the students. Students were appreciative of the interactive sessions they had during the extension lectures delivered by the experts. The teachers although faced difficulties in guiding students in open-ended projects showed their willingness to continue with project method of teaching. However, the teachers mentioned that, they could be provided with management support for implementing such teaching-learning method. The Head of the Department of the polytechnic suggested that more teachers could be given the experience of project method of teaching so that the model could be implemented at the institute level. The project method of teaching-learning demands a high degree of intellectual involvement of the teachers in the process, and hence, unless carefully designed and implemented, could degenerate into students working on stereo typed projects, or teachers falling back into the traditional lecture method of teaching, the Head of Department of the polytechnic remarked.

8.4 Experiment on developing problem solving competence through teacher made graded exercises

8.4.1 Observations based on experimental results

Sixteen observations were made as under:-

1. Students active in learning tasks

Graded exercises, assignments, group discussions, and need based guidance from teacher as also the enrichment lectures made students to be active in the learning process.

2. Self paced learning

Offering the exercises/tasks in modular fashion as also incorporating additional remedial study material in between two modules provided opportunity for the individual learner learn at his own pace but within the over all time available for the subject of study.

3. Individual guidance available to students

The teacher, being relieved from delivering routine lectures, could provide guidance to students on individual basis depending on the need felt by students or on the basis of his own diagnosis.

4. Increased student work output

The amount of work in terms of number and varieties of exercises and assignments done by students were found to be more as compared to the work done by students of previous batches.

5. Improved learner performance in Board Examination

Students performance in the examination conducted by the SBTE was better than the corresponding performance of students of previous batches.

6. Need for instructional material development

There was need to develop graded exercises of desired quality so as to help develop in students the competencies as per field requirements, as such materials were not readily available in the market.

7. Need for interaction of students with the world of work

Graded exercises and tasks as formulated by the teachers were only real life like and as perceived by the teacher. Feedback from industrial experts indicated that the students required interaction with world of work to strengthen their knowledge and skills in terms of actual field practices.

8. Immediate feedback on exercise motivating

Activity followed by immediate knoweldge of results improved students' motivation in learning.

9. Curriculum needs a fresh look

Feedback from field experts showed that the existing curriculum required revision in terms of inclusion of norms and standards as well as giving due weightage to more relevant topics.

10. Need to make learning experiences more challenging and motivating

Designing learning experiences through teacher made graded exercises challenging and motivating,required practical experience of the designer. Exercises could be better designed by seeking participation of practicing engineers and professionals.

11. Need for supervisory skill development

Exercises/tasks on supervisory skill development were difficult to design and implement in institutional setting.

12. Students' performance in evaluation by industry satisfactory

Field experts involved in student evaluation found the exercises, as also the abilities developed through such exercises, only at satisfactory level. There was scope for making improvement in the exercises designed. This could be achieved if the task was taken up jointly by the teachers and experts.

13. Teachers need to interact with industry for instructional material development

The strategy suggested for instructional material development was that the basic material could be developed by teachers and these could be improved by receiving feedback from professionals. Further, exposure of teachers in industry, the experts indicated, could help them design better exercises.

14. Teachers find time to guide students as per their needs

While students worked on graded exercises, teachers could provide need based individual guidance which otherwise was not possible if curriculum implementation had to be done by only through lecture method.

15. Need to develop a better student evaluation and certification method

Evaluation of students made by the teacher as also by the SBTE showed a poor correlation with the evaluation made by the industries' experts. There was need to use better student evaluation and certification method, reflecting the students ' real abilities, which could provide better feedback to students as also to potential employers.

16. Management support required for development of instructional material

Development of instructional material,could be better organised if the task was coordinated at the state level and assistance of subject teachers as also of field experts were taken. Planning for instructional material development could be done by the curriculum development cells of the Directorates of Technical Education, the teachers observed.

8.4.2 Reactions of students,teachers and employers

Students expressed that they could learn the course content by working through the graded exercises without depending much on their teachers. Feedback, individual guidance, and occasional lectures were useful in learning. However,students expressed that they could have related their learning tasks with field practices better if opportunities were provided for field visits.

Teachers initially were of the opinion that students required teaching of the entire course content, that is, they were required to 'cover the syllabus'. However, as the teaching-learning through graded exercises progressed, the teachers found students gradually becoming more self reliant in their learning tasks. The teachers expressed that organisation of student - centred teaching-learning required a lot of preparation in terms of developing exercises as also other self-learning materials. Interactions with students, the teachers experienced, were purposeful and provided opportunities to understand the weakness of individual students.

Industrial experts invited for student evaluation expresed that there was scope for improvement in the quality of exercises assigned to students. They also expressed that the curriculum required revision. The students were required to be given more practice in reading and interpreting drawings collected from the field. The experts were too willing to deliver extension lectures and to participate in group discussions, if required. The polytechnic teacher suggested that this type of instructional material development work could be undertaken as an institute activity by involving teachers from other polytechnics. Reprographic and other facilities could be extended to the teachers participating in the developmental work. For publication of the material developed, subsidy from the National Book Trust could be obtained so as to keep the price of such material at a reasonably low lelvel.

8.5 Experiment on use of Functional Curriculum and internship in industry

8.5.1 Observations based on experimental results

Forty-seven observations were made as under:-

1. More relevant curriculum

Functional curriculum developed on the basis of job analysis was found by the employers to be more relevant as compared to the existing curriculum.

2. Better subject understanding

Student interns working in functional areas could understand the subject better as evidenced by their superior performance in written tests as well as in interview conducted by the industrial experts.

3. Better performance in project activity

Students' performance in project activities were rated superior as compared to the performance of students in similar activities organised at the institute.

4. More useful learning material

Instructional material in the form of supervisors guides developed in association with field experts were found very useful by students for carrying out tasks.

5. More lively group discussions

Group discussions organised in industries, where student interns, industrial experts, and the visiting faculty participated, were found to be lively and educative

6. Industry benefit from students' suggestions

Being involved in the day to day work of industries under the guidance of the supervisors, the students made suggestions for improving the productivity, safety measures, waste control, workers welfare measures, etc., and these were valued by the industries.

7. Students better prepared for undertaking industries' assignments

This group of students were found better prepared to take up industries' assignments as compared to other students coming out of the polytechnic system.

8. Better performance in interview conducted by employers

Students' performance in the interview conducted by the group of industrial experts was better as compared to the performance of students trained through institution based conventional approach to teaching-learning.

9. New system of student evaluation

Multiple evaluation instruments used to judge the students' abilities of problem solving were found more useful in providing feedback to students as well as for certification than the evaluation procedure and tools used in polytechnics.

10. Better questions posed by students during interactions

The teachers expressed that the type of questions students asked during interacting sessions were of higher order as compared to the type of questions asked by the students in a polytechnic class.

11. Improved communication skills

Record of progress of learning as well as other related abilities particularly students' abilities in expressing ideas, presenting reports, and in preparing technical drawings, etc. showed significant improvement during the period of this experiment.

12. Learning of supervisory skills

Students while assisting the supervisors in their day-to-day functions learned supervisory skills i.e. the skill in managing men and material for achieving production targets -an experience which is most essential for a diploma holder and is difficult to provide through class-room lectures.

13. Students useful to industries' supervisors

Student interns were found as additional hands by the supervisors, as the interns shared responsibilities at the work place.

14. Improved attitude towards value of time, money and material

Students placed in real life situation realised the value of time, money and material and an attitudinal change was observed in them -a change which is difficult to bring about through lectures.

15. Students put in extra effort

Students were observed making extra effort in completing tasks assigned to them.

16. Favourable attitude of industry

Attitude of industry towards the interns was observed to be favourable. This was because the students were engaged in useful productive work

17. Students get opportunity for a variety of learning activities

Working in functional areas provided opportunities to students to gain experience in a variety of activities like managing men and material to achieve production target, interpreting technical drawings, testing and quality control, estimating and costing for repair of damaged transformers, reduction of waste, improving safety measures, pollution control,etc.

18. Better understanding of basic theory

Applications of basic concepts and principles in real life situations, group discussions, and back -up studies helped students understand the basic theory better.

19. Enriched learning of basic skills

Enriched learning of basic skills such as skills in use of tools and instruments for making measurements, skill in reading and interpreting technical drawings, skill in technical communication, etc. were observed during the experiment.

20. Better performance in written examination

As compared to others, these students performed better in comprehensive written test conducted at the end of the experiment covering the whole of basic theory and the functional aspects.

21. Teaching-learning material useful to students as well as to industries

Learning reference material in the form of 'Supervisors Guides' were found useful both by the students as well as by the industries.

22. Enriched learning through group discussion

Group discussions organised periodically in the industry where industries' experts participated helped students enrich their learning.

23. Optimisation of institutional resource requirements

Polytechnics were able to provide students with real life learning experiences by utilising the resources of industries, free of cost.

24. Continuous evaluation reflects students' real abilities

Day-to-day evaluation of student interns by their supervisors reflected students' real abilities.

25. Need for training of teachers in curriculum development

Curriculum development in functional areas required use of an appropriate strategy in which the teachers had to be trained.

26. Industry able to make better selection of students for employment

Observing students at work, helped industries identify potential candidates for selection for employment in future.

27. Pedagogy facilities functional mobility

Students' initial preparation, experience of internship in one functional area,learning the use of reference material, helped students move from one functional area to the other without much difficulty.

28. Opportunities for demonstration of abilities

Internship in industry demonstrated their abilities to their potential employers.

29. Better curriculum feedback through teachers

Involvement of teachers in implementing the instructional plan with the cooperation of industries helped them collect better curriculum feedback.

30. Need for flexibility in curriculum implementation

The polytechnic principal and HODs expressed that curriculum implementation with the requirement of placing students as interns in industries.as also involvement of faculty in monitoring students' internship demanded granting of academic autonomy to polytechnics.

31. Assignments by industry challenging and motivating

Working on open-ended type of assignments with the availability of expert guidance, the students found was challenging but motivating.

32. Attitudinal change in students towards acquiring of more knowledge

Attitudinal change was observed in students towards learning through a given task as also acquiring further knowledge through group interactions and self study.

33. Need for course design in functional areas

The existing polytechnic curriculum are science based and generalised in character. Views expressed by industries indicated their preference for course design in functional areas as against using a generalised curriculum.

34. Need for teachers involvement during students' internship in industry

Teachers were required to undertake the responsibilities of overall management of the teaching-learning aspects, participate in periodical group discussions,and in student evaluation to ensure learning by students.

35. Need for flexibility in institutes rules and regulations

Institute rules and regulations had to be made somewhat flexible to enable faculty implement the system effectively.

36. Need for instructional material development in functional areas

Reference type instructional material in functional areas was required to be developed for use by the student interns for understanding of the tasks performed by them. These were to be developed in association with the field experts.

37. Interactions with students and industry were learning experiences to teachers

Group discussions organised at work-site on important topics and on work done by the students, where industries experts also particiapted, were valued by teachers as very useful learning experiences.

38. Learning to learn by students

While working as interns, students were required to interact with professionals as also participate in group discussions. While they were assisting the supervisors in their work, they had to learn from various sources by themselves. Thus, the students were not only trained to acquire knowledge, but also to use them in problem solving.

39. Lively group discussions

In group discussions all the students were seen participating and taking advantage of the opportunity to express their own views as also of listening to others.

40. Students better equipped in seeking employment

Panel of experts drawn from different industries found these students better equipped for employment in terms of knowledge ana skill acquired by them.

41. Improved motivation towards learning

Students confronted with real life tasks and supported by expert guidance were better motivated, as observed from their increased interest in learning.

42. Need for developing linkage with industries

Polytechnics required to develop an on-going relationship with industries for securing places of internship for their students. For this, they required to be pro-active in establishing continuous dialogue with the neighbouring industries.

43. Students receive letters of appreciation

Industries issued letters of appreciation to all the students for their good work. They also expressed their willingness to select students from this group at appropriate time.

44. Need for research in developing methodology for curriculum development

Literature search on curriculum development showed that there was further scope for undertaking action research in determining methodologies of functional curriculum development. Such research gains significance in the context of competency based education and training as the future requirements of world of work.

45. Need for restructuring of curriculum

Curriculum was required to be restructured to accommodate internship of students in industry.

46. Evaluation meaningful to industry

Evaluation of students carried out during the experiment, where students were assessed on their total personality traits, was considered meaningful and appropriate by the industries.

47. Industry willing to maintain cooperative relationship

Industries expressed satisfaction from the experience of students' internship and assured cooperative relationship in all such activities which would benefit both the systems.

8.5.2 Reactions ot students, teachers and employers

Students appreciated the concept of internship in learning of theory and their applications and enquired as to why such a system of teaching-learning was not implemented earlier. The students expressed that they learnt maximum through group discussion as also through day-to-day interactions with the industrial supervisors. Students indicated that they were able to move from one functional area of work to the other with little orientation. The reference material in the form of 'Supervisors Guides' were of much use. Most of the students expressed that for the first time in their life they got opportunity to speak in front of an audience, which helped them in developing self confidence. All the students said that the attitude of industry was very favourable. Supervisors in industries were appreciative of the effort made by the students in 'learning by doing' and said that the students were helpful to them also. They found students observing norms of discipline of the industry. Regular visits by polytechnic faculty was considered necessary by industries as well as by the students.

Polytechnic faculty, Head of Department and the Principal found in this group of students a total transformation and were convinced that such experiential learning by students where opportunities of learning, the learning environment, and the expert guidance were available, was favourable in turning out the required quality ot student output. Regarding functional curriculum, they remarked that such developmental work had to be taken up at the state or regional level in association with industries. Similarly, instructional materials had to be developed at regional or at national level for bringing in optimisation in the efforts required. Principal remarked that he would like to continue sending students to industries to work as interns during summer vacations. Regarding curriculum revision,the Principal remarked that he would send the collected feedback to SBTE for use at appropriate time.

8.6 Issues and experimental observations

In Chapter I, eight pedagogic issues facing polytechnic education were raised. These were on achievement of quality and excellence, relevance of curriculum, teacher preparation, learner opportunities,student evaluation,instructional resources, interaction with employer and the management of teaching-learning.

Observation of critical factors in each of the four experiments against each of the issues of the research study have been presented in Table 8.2.This tabular presentation would enable making a comparative evaluation of each of the teaching-learning models in terms of the pedagogic issues mentioned above.

Table 8.2
Pedagogic Issues and Experimental Observations

ISSUES	OBSERVATIONS			
	Experiment I	Experiment II	Experiment III	Experiment IV
1.Achievement of quality and excellence	01.Improved student motivation 02.Teachers find guiding students challenging but motivating 03.Students becoming self reliant 04.Student evaluation meaningful to employer 05.Polytechnic output acceptable to employer 06.Need to develop linkage with industry 07.Need for curriculum restructuring	01.Better motivation in study 02.Improved learner perception 03.Better learning of basic skills 04.Students find project activities challenging and motivating 05.Learning to learn by students 06.Better preparation for employment 07.Student evaluation and certification meaningful to employer 08.Need for developing problem bank.	01.Student activity in learning 02.Continuous feedback motivating 03.Output quality satisfactory 04.Need for industries' involvement in exercise design 05.Need for student teacher exposure to industry	01.Improved stduent motivation in learning 02.Better performance of students in evaluation by industry 03.Enriched learning of basic skills 04.Learning to learn by students 05.Improved behavioural response of students 06.Curriculum relevant to requirements 07.Students more acceptable to industry 08.Need for developing linkage with industry 09.Need for course design in functional areas

Table 8. 2 continued

ISSUES	OBSERVATIONS			
	Experiment I	Experiment II	Experiment III	Experiment IV
		09. Need to train teachers in guiding project activities		010. Need for instructional material development 011. Need for involvement of teachers during students internship in industry 012. Need for research in developing functional curriculum 013. Need for restructuring of curriculum
2. Polytechnic curriculum	01. Curriculum requires a fresh look	01. Curriculum requires to be translated in problematic form 02. Need for flexible time tabling	01. Invovement of employer required for curriculum revision	01. More relevant curriculum 02. Useful curriculum material
3. Teacher preparation	01. Teachers becoming competent to play multiple roles	01. Students centered teaching motivating 02. Teachers find guiding students challenging task 03. Need for training of teachers	01. Need for exposure of teachers in industry	01. Teachers need to be trained in curriculum development 02. Teachers are in a better position to provide curriculum feedback

Table 8. 2 continued

ISSUES	OBSERVATIONS			
	Experiment I	Experiment II	Experiment III	Experiment IV
	03. Better motivation in students 04. Need for placement of teachers in industry for guidance in problem solving	04. Need for teachers exposure to industry 05. Need for teacher developing a problem bank		03. Interactions with students in indsutry -a learnering experience to teachers
4. Learner opportunities	01. Students find opportunities for self development 02. Students receive employment incentives by demonstrating their abilities 03. Students learn to work in teams.	01. Students find learning task challenging and motivating 02. Project teaching inculcates scientific problem solving 03. Skill development as also better understanding of subject matter 04. Better learning of basic skills 05. Improved technical communication	01. Activity in learning 02. Opportunity for self pacing 03. Need based lectures 04. More student output 05. Need for exposure to industry	01. Enriched learning of basic skills 02. Enriched learning through group discussion 03. Better understanding of basic theory 04. Improved behavioural response of students 05. Improved student motivation in learning 06. Learning of supervisory skills 07 Opportunities for demonstrating abilities

Table 8.2. continued

ISSUES	OBSERVATIONS			
	Experiment I	Experiment II	Experiment III	Experiment IV
	01. Students become self reliant 02. Stduents understand relevance of subject better 03. Presence of teacher a must	06. Better preparation for employment 07. Need for more exposure to work environment for supervisory skill development 08. Activity in learning motivating 09. Opportunity for working in team		08. Opportunities for varieties of learning experiences 09. Improved communication skills 10. Better employment prospects
5. Student evaluation	01. Multiple objective student evaluation reflects real abilities and is meaningful to employers	01. Multiple objective student evaluation reflects students real life problem solving abilities 02. Evaluation scheme & certification meaningful to employers	01. Need to develop better evaluation and certification method	01. Multiple objective evaluation of students meaningful to employer
6. Instructional resources	01. Need to develop basic skills through use of activity oriented teaching-learning in institutions.	01. Need to develop problem-bank for use in classroom based instruction 02. Need to develop instructional resources for teaching-learning of basic theory	01. Need to develop material for providing learning experiences with industries involvement	01. Need to develop reference material in functional areas 02. Material developed useful to students as also to industries

Table 8.2 continued

ISSUES	OBSERVATIONS			
	Experiment I	Experiment II	Experiment III	Experiment IV
7. Interaction with Employer	01. Employers participation in student training brings in optimisation in institutional resource requirements 02. Project output useful to industry 03. Positive attitude of employer for further collaboration 04. Pedagogy useful to all industries	01. Project output useful to employer 02. Employer participate in polytechnic course offering 03. Improved attitude of employer 04. Need for establishing continuous dialogue with industries	01. Need for industries' involvement in delivering extension lectures	01. Students are of use to industry 02. Indsutry extends its resources for student training 03. Students suggestions benefit industry 04. Industry able to identify students for employment through close observation 05. Need for developing linkage with indsutry 06. Need for planning student involvement in functional areas 07. Pedagogy useful for functional mobility 08. Attitudinal change in employer

Table 8.2 continued

ISSUES	OBSERVATIONS			
	Experiment I	Experiment II	Experiment III	Experiment IV
8.Management of teaching-learning	01.Better quality of student output 02.Management need to establish linkages with industries for mutual benefit 03.Need to initiate curriculum revision/ restructuring 04.Need to bring in flexibility in rules and regulations	01.Better quality of student output 02.Need to plan faculty development 03.Need to develop linkage with industry for industries' participation in institutional training	01.Quality of student output satisfactory 02.Need to plan for exposure of teachers in industry 03.Need to involve industry in developing instructional material	01.Better quality of student output 02.Optimisation in instructional infrastructure development requirement 03.Need to develop linkage with industry 04.Need to plan for development of functional curriculum with industries involvement 05.Need to develop student reference material 06.Need to plan faculty development programme with reference to curriculum development & instructional material development 07.Need to have flexible rules and regulations 08.Need to develop linkage with industry 09.Need to involve faculty in students' internship in industry

8.7 Cybernetic modelling

The interactive teaching-learning systems as tried out in the four experiments can be best represented through cybernetic modelling which convey self regulatory feedback control systems representing the process. In cybernetics, a discipline called human engineering, performance and learning is analysed in terms of the control relationship between human operator and instrumental situation. That is, learning is understood to be determined by the nature of the behaving individual as well as by the design of the learning situation. Further,human engineering analysis calls attention to the concept of the behaving individual as a closed-loop or cybernetic system utilising the processes of sensory feedback in the continuous control of behaviour. In keeping with this point of view,cybernetic research analyses the intrinsic mechanisms by means of which control is established and maintained that is,it analyses the closed-loop feedback mechanisms that define the interactions between the individual and his environment. In contrast, conventional learning research conducts open-loop analysis of the relationship between extrinsic events-stimuli and reinforcement and observed responses. The cybernetic view that human factors and educational design factors interact to define learners'changes in behaviour indicates that the determining factors in education are related to the particular features that characterise the learning situation.

Cybernetic models for each of the interactive teaching-learning systems have been represented in figures 8.1 to 8.4.

Results of interactions between the student,teacher and the employer around the project activity have been shown through control loops which can be seen as enriching the system shown at the centre of each figure. The shading portions in each loop give rise to issues which need to be resolved to make the system fully self regulatory.

8.8 Requirements and benefits of each experiment

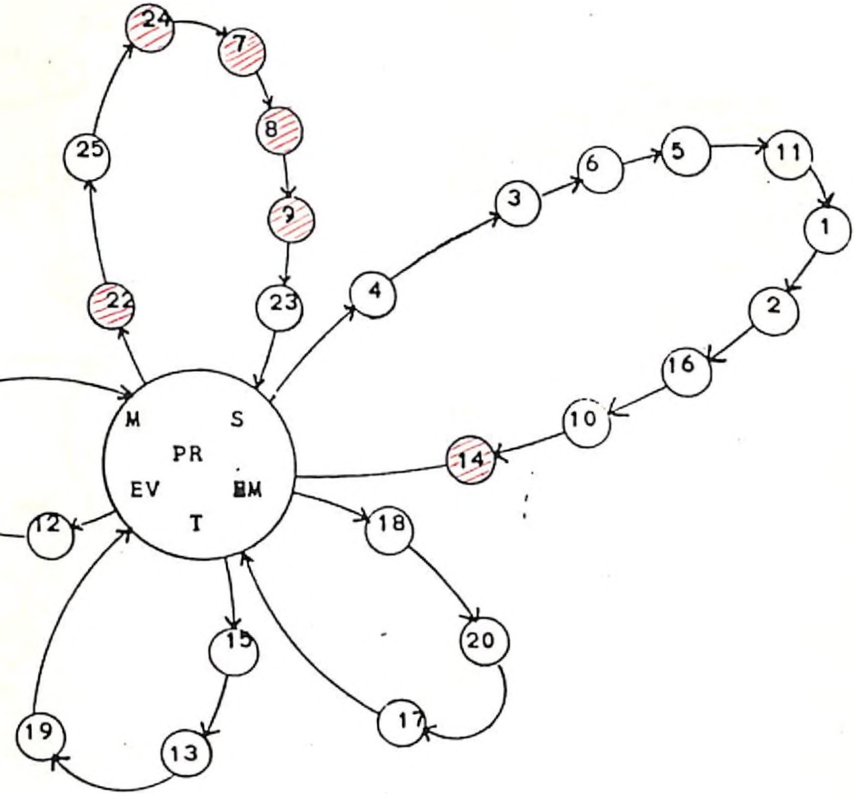
The results of each of the experimental models were analysed in terms of their benefits and requirements and represented through separate cybernetic flow diagrams as in figures 8.5 to 8.8.

8.1 Experiment on Open-ended projects at work-bench

Experimental Observations:

1. Project output of industrial use
2. Monitory incentives to students
3. Better student motivation in learning
4. Opportunities for self development
5. Improved communication skills
6. Students becoming self reliant
7. Presence of teacher essential
8. Need for flexible rules and regulations
9. Curriculum needs a fresh look
10. Students learn to work in teams for goal oriented time bound projects
11. Improved student behavioural response
12. New evaluation system
13. Teacher becoming a consultant
14. Need for stress on basic skill development in institution based teaching-learning
15. Guiding students challenging and satisfying
16. Students secure employment
17. Industry extends its resources for student training
18. Pedagogy useful to all industries
19. Better curriculum feedback from teachers
20. Employer able to make better selection of students for employment
21. Evaluation system meaningful to employer
22. Management needs to develop linkage with industries
23. Polytechnics turning out better quality of diploma holders
24. Restructuring of curriculum required
25. Optimisation of infrastructure development requirement within the institute

Figure 8.1:Cybernetic modelling of



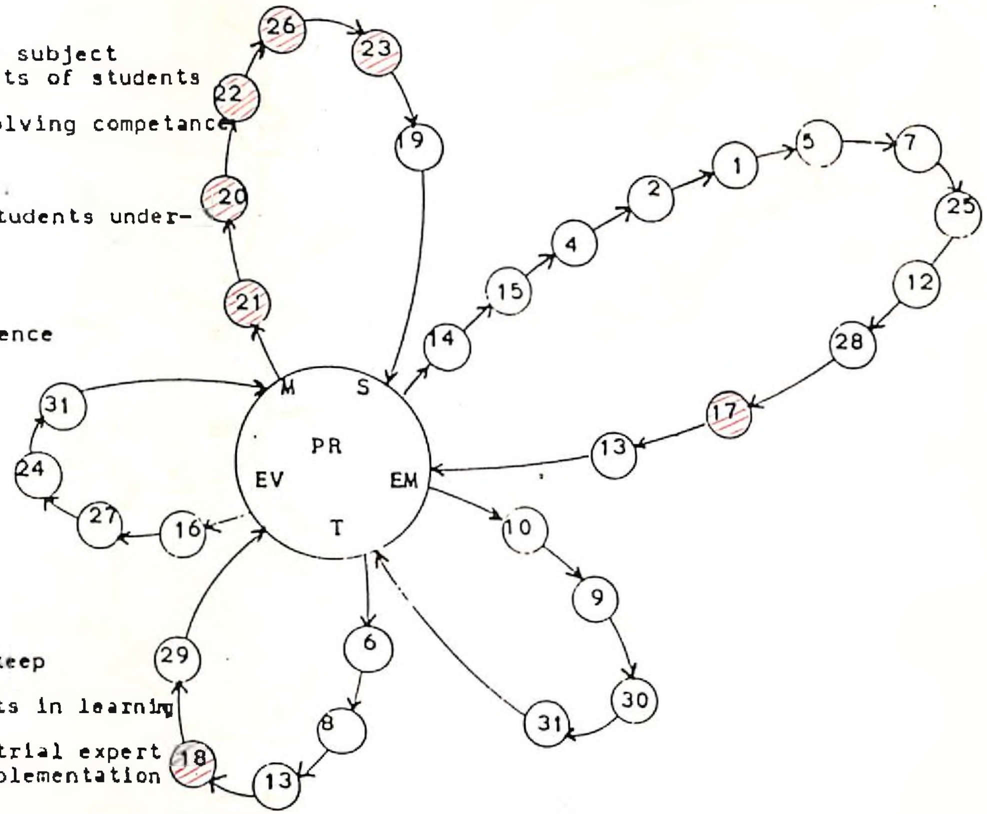
S : Student
T : Teacher
EM : Employer
EV : Evaluation
PR : Project Activity
M : Management

interactive teaching-learning as in experiment I

8.2 Experiment on Project activities as an integral part of class-room instruction

Experimental Observations:

1. Improved learner performance in Board examination
2. Skill development as also better understanding of subject
3. Availability of statement of strong and weak points of students
4. Improved learner perception
5. Project teaching inculcates scientific problem solving competance
6. Guiding students a challenging task
7. Better learning of basic skills
8. Better quality of questions asked by students
9. Industry delivers extension lectures to enrich students understanding
10. Project output useful to employer
11. Improved student motivation
12. Students learn to produce quality work
13. Teachers find guiding students a learning experience
14. Students' find task challenging
15. Improved communication skills
16. New approach to student evaluation
17. Need for supervisory skill development
18. Need for teachers interaction with industries to answer learners querries
19. Students better prepared for employment
20. Need for development of a problem bank
21. Need for establishing linkage with industry
22. Need for flexible rules and regulations
23. Need for flexible time-tabling
24. Evaluation system reflects students abilities
25. Activity in learning
26. Need for instructional material development to keep students learn basic concepts and principles
27. Contineous evaluation and feedback helps students in learning
28. Learning to work in groups
29. Teachers get opportunity to interact with industrial expert
30. Industries extend cooperation in curriculum implementation
31. Student evaluation meaningful to employers



S : Student

EM : Employer

T : Teacher

EV : Evaluation

PR : Project Activity

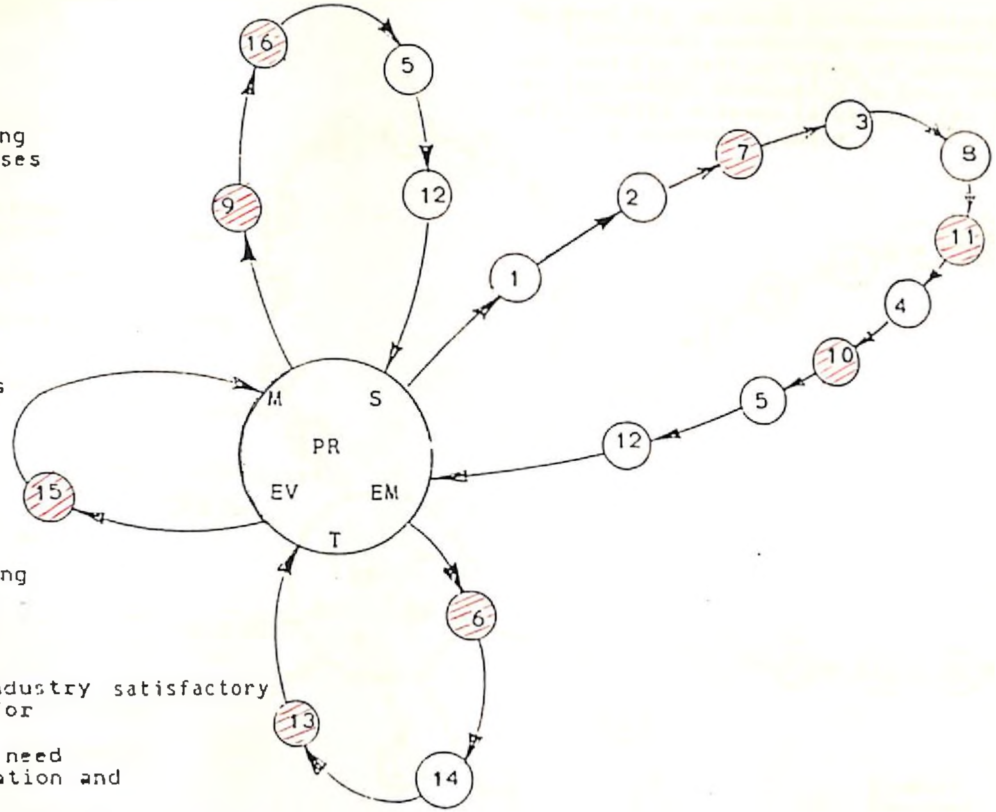
M : Management

Figure 8.2: Cybernetic modelling of interactive teaching-learning as in experiment II

8 .3 Experiment on developing problem solving competence through teacher made exercises

Experimental Observations:

1. Students active in learning tasks
2. Self paced learning
3. Individual guidance available to students
4. Increased student work output
5. Improved learner performance in Board examination
6. Need for instructional material development
7. Need for interaction of students with the world of work
8. Immediate feedback on exercises motivating
9. Curriculum needs a fresh look
10. Need to make Learning experiences more challenging and motivating
11. Need for supervisory skill development
12. Students performance in evaluation by industry satisfactory
13. Teacher need to interact with industry for instructional material development
14. Teacher finds time to guide student in need
15. Need to develop a better student evaluation and certification method.
16. Management support required for development of instructional material by having interaction with industry



S: Student
T: Teacher
EM: Employer
EV: Evaluation
PR: Project Activity
M: Management

Figure: 8 .3 : Cybernetic modelling of interactive teaching-learning as in Experiment III

8.4 Experiment IV: Use of Functional Curriculum and Internship in Industry

Experimental Observations:

1. More relevant curriculum
2. Better subject understanding
3. Better performance in project activity
4. More useful learning material
5. More lively group interactions
6. Industry benefit from students suggestions
7. Students better prepared for understanding industries assignments
8. Better performance in interview by employers
9. New system of student evaluation
10. Better questions posed by students during interactions
11. Improved Communication skill
12. Learning of supervisory skills
13. Students useful to industries supervisors
14. Improved attitude towards value of Time, Money and Material
15. Students put-in extra effort.
16. Favourable attitude of industry.
17. Students get opportunity for varieties of learning activities
18. Better understanding of basic theory
19. Enriched learning of basic skills
20. Better performance of students in written examination
21. Teaching-learning material useful to students as well as to industries
22. Enriched learning through group discussion
23. Optimization of institutional resource requirement
24. Continuous evaluation reflects students real abilities
25. Need teachers' training in curriculum development
26. Industry able to select students for employment through observation of their abilities
27. Pedagogy facilitates functional mobility
28. Opportunities for demonstration of abilities
29. Teachers in a better position in providing curriculum feedback
30. Need for flexibility in curriculum implementation
31. Assignments by industry challenging and motivating
32. Attitudinal changes in students towards acquiring more knowledge.
33. Need for course design in functional areas
34. Need for involvement of teachers during internship of students
35. Need for flexibility in rules and regulations in course offering
36. Need for instructional material development based on functional requirement
37. Interactions with students and indsutry provide learning experiences to teachers
38. Learning to learn by students
39. Lively group discussions
40. Students better equipped in seeking employment
41. Improved motivation towards learning
42. Need for developing linkages with industries
43. Students receive letters of appreciation.
44. Need for research in developing methodology of functional curriculum development
45. Need for restructuring of curriculum
46. Evaluation meaningful to industry
47. Industry extends facilities for student training on a continuous basis

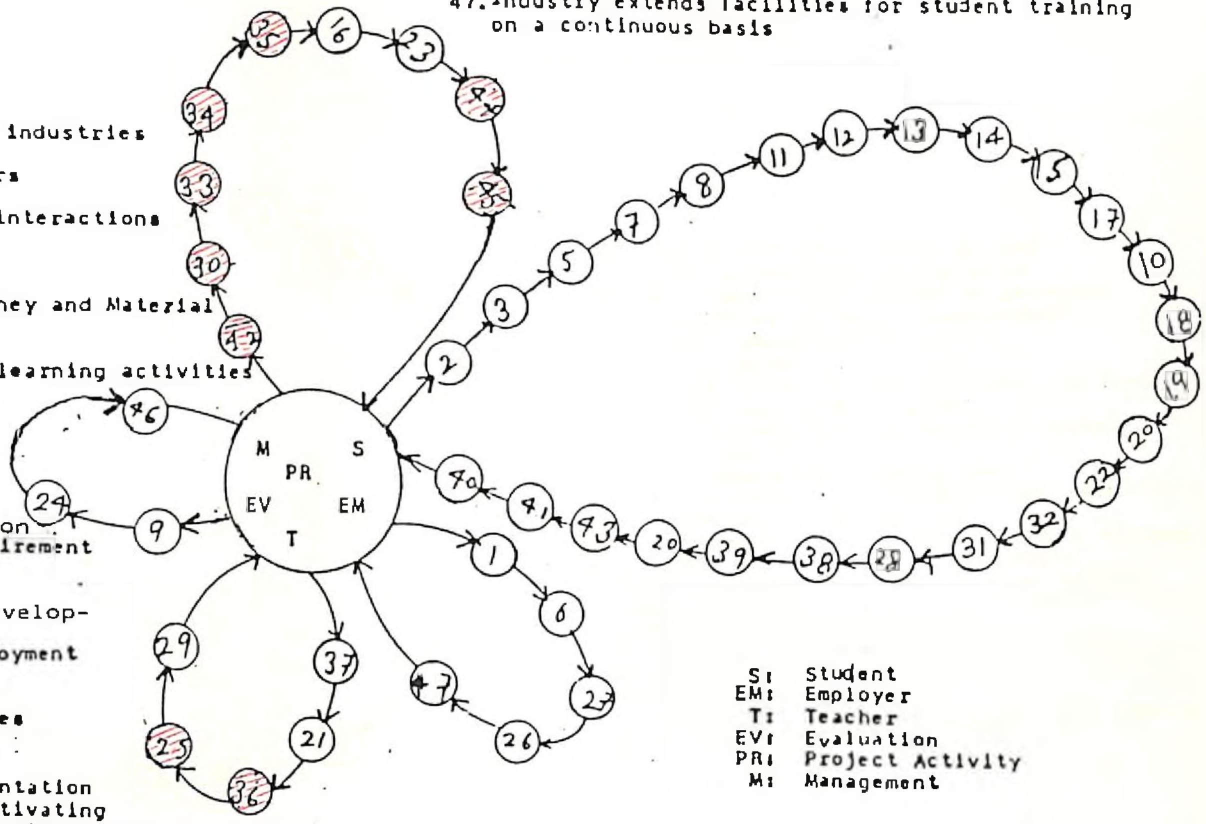
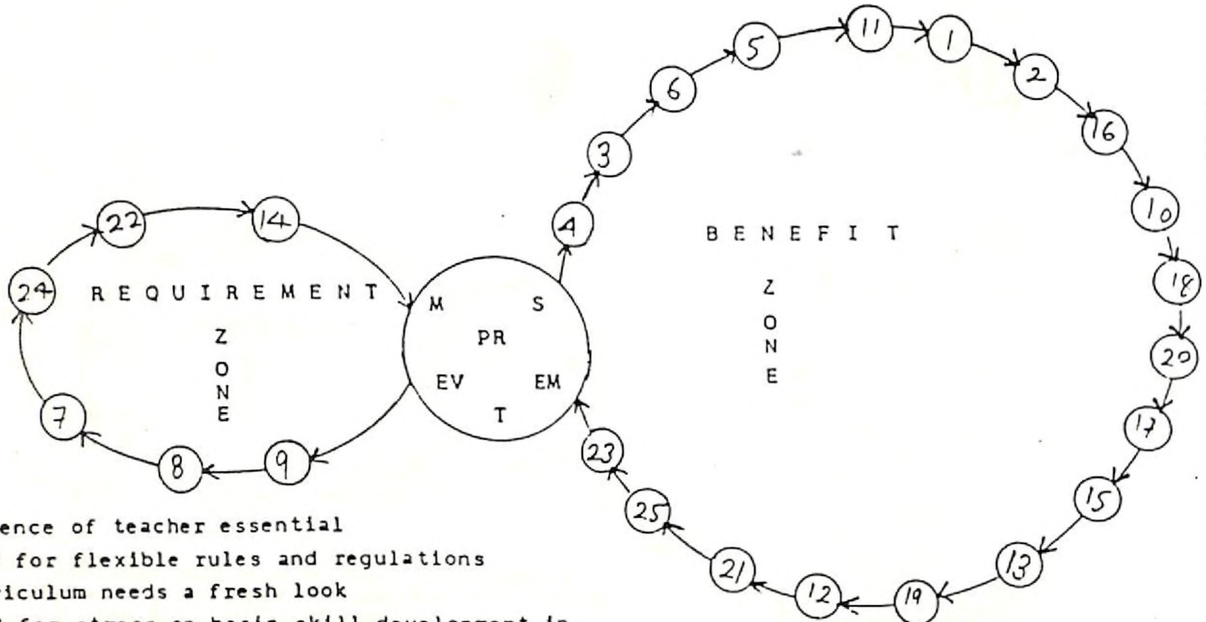


Figure 8.4: Cybernetic modelling of interactive teaching-learning as in Experiment IV

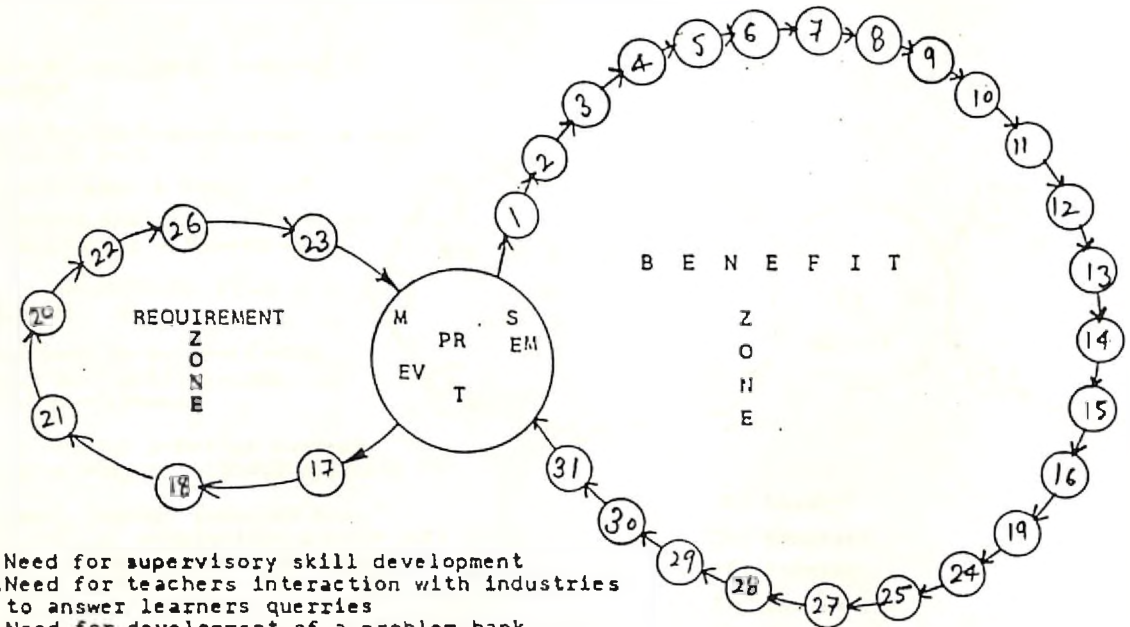


7.Presence of teacher essential
8.Need for flexible rules and regulations
9.Curriculum needs a fresh look
14.Need for stress on basic skill development in institution based teaching-learning
22.Management needs to develop linkage with industries
24.Restructuring of curriculum required

1.Project output of Industrial use
2.Monitory incentives to students
3.Better student motivation in learning
4.Opportunities for self development
5.Improved communication skills
6.Students becoming self reliant
10.Students learn to work in teams for goal oriented time bound projects
11.Improved student behavioural response
12.New evaluation system
13.Teacher becoming a consultant
15.Guiding students challenging and satisfying
16.Students secure employment
17.Industry extends its resources for student training
18.Pedagogy useful to all industries
19.Better curriculum feedback from teachers
20.Employer able to make better selection of students for employment
21.Evaluation system meaningful to employer
23.Polytechnics turning out better quality of diploma holders
25.Optimisation of infrastructure development requirement within the institute

S: Student
EM: Employer
T: Teacher
EV: Evaluation
PR: Project Activity
M: Management

Figure 8.5 Cybernatic modelling showing the benefit zone and requirement zone of experiment I



1.Improved learner performance in Board examination
2.Skill development as also better understanding of subject
3.Availability of statement of strong and week points of students
4.Improved learner perception
5.Project teaching inculcates scientific problem solving competence
6.Guiding students a challenging task
7.Better learning of basic skills
8.Better quality of questions asked by students
9.Industry delivers extension lectures to enrich students understanding
10.Project output useful to employer
11.Improved student motivation
12.Students learn to produce quality work
13.Teachers find guiding students a learning experience
14.Students' find task challenging
15.Improved communication skills
16.New approach to student evaluation
19.Students better prepared for employment
24.Evaluation system reflects students abilities
25.Activity in learning
27.Contineous evaluation and feedback helps students in learning
28.Learning to work in groups
29.Teachers get opportunity to interact with industrial experts
30.Industries extend cooperation in curriculum implementation
31.Student evaluation meaningful to employers.

17.Need for supervisory skill development
18.Need for teachers interaction with industries to answer learners querries
20.Need for development of a problem bank
21.Need for establishing linkage with industry
22.Need for flexible rules and regulations
23.Need for flexible time-tabling
26.Need for instructional material development to keep students learn basic concepts and principles

S: Student
EM: Employer
T: Teacher
EV: Evaluation
PR: Project Activity
M: Management

Figure 8.6: Cybernetic modelling showing the benefit zone and requirement zone of experiment-II

6. Need for instructional material development

7. Need for interaction of students with the world of work

9. Curriculum needs a fresh look

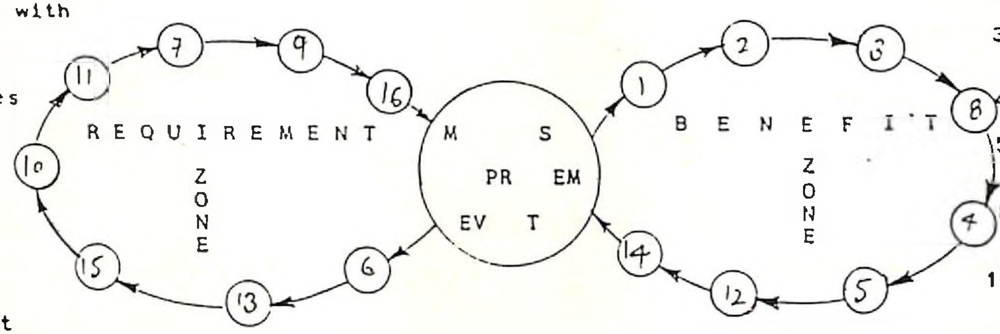
10. Need to make Learning experiences more challenging and motivating

11. Need for supervisory skill development

13. Teacher need to interact with industry for instructional material development

15. Need to develop a better student evaluation and certification method.

16. Management support required for development of instructional mate rial by having interaction with industry



1. Students active in learning tasks

2. Self paced . learning

3. Individual guidance available to students

4. Increased student work output

5. Improved learner performance in Board Examination

8. Immediate feedback on exercises motivating

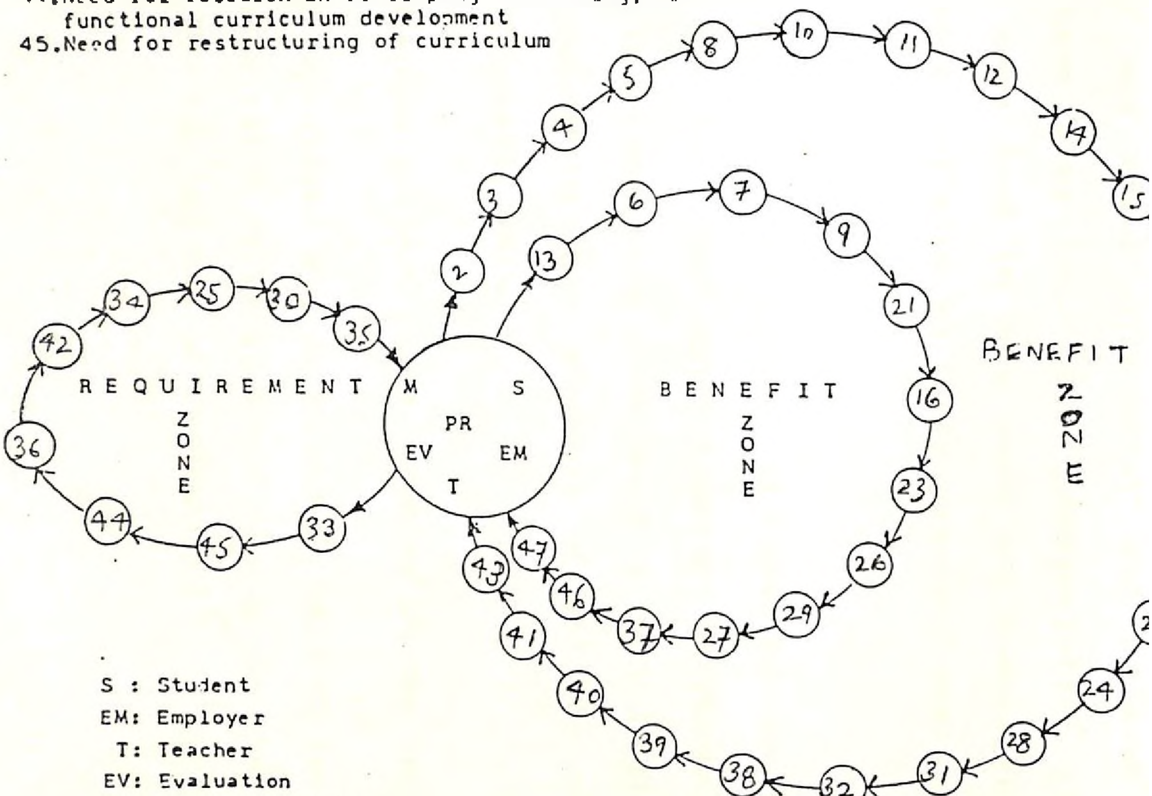
12. Students performance in evaluation by industry satisfactory

14. Teacher finds time to guide student in need

S: Student
EM: Employer
T: Teacher
EV: Evaluation
PR: Project Activity
M: Management

Figure 8.7: Cybernetic modelling showing the benefit zone and requirement zone of experiment III

25. Need for training of teachers in curriculum development
30. Need for flexibility in curriculum implementation
33. Need for course design in functional areas
34. Need for involvement of teachers during internship of students in industry
35. Need for flexibility in rules and regulations in course offering
36. Need for instructional material development based on functional requirement
42. Need for developing linkages with industries
44. Need for research in developing methodology of functional curriculum development
45. Need for restructuring of curriculum



S : Student
EM: Employer
T: Teacher
EV: Evaluation
PR: Project activity

1.More relevant curriculum
2.Better subject understanding
3.Better performance in project activity
4.More useful learning material
5.More lively group interactions
6.Industry benefit from students suugestions
7.Students better prepared for undertaking industries assignments
8.Better performance in interview by employers
9.Rew system of student evaluation
10.Better questions posed by students during interactions
11.Improved Communication skill
12.Learning of supervisory skills
13.Students useful to industries supervisors
14.Improved attitude towards value of Time, Money and Material
15.Students put-in extra effort
16.Favourable attitude of industry
17.Students get opportunity for varieties of learning activities
18.Better understanding of basic theory
19.Enriched learning of basic skills
20.Better performance of students in written examination
21.Teaching-learning material useful to students as well as to industries
22.Enrichment of learning through group discussion
23.Optimization of institutional resource requirement
24.Continuous evaluation of students reflects students real abilities

26.Industry able to select students for employment through observation of their abilities

27.Pedagogy facilities functional mobility
28.Opportunities for demonstration of abilities
29.Teachers in a better position in providing curriculum feedback
31.Assignments by industry challenging and motivating
32.Attitudinal changes in students towards acquiring more knowledge.
37.Interactions with students and industry provide learning

8.9 Analysis of students' evaluation

8.9.1 Student teacher involvement at work-bench on problem solving assignments

The students were evaluated for their problem solving abilities using multiple evaluation instruments of Quiz, Seminar/ Viva, Group Discussion, Technical Report Writing, and Observation by both the teacher and the industry. No written test was conducted. Refering to Table 4.6, it is observed that correlation coefficients between Quiz and seminar was 0.57, between Quiz and Group Discussion was 0.46, and between Quiz and Observation was 0.45. Although there has been somewhat satisfactory correlation between Quiz and Seminar, correlation between Quiz and Group Discussion and between Quiz and Observation have been low. The interpretation is that the students who were good in Quiz were not necessarily good in Group Discussion and also in their assessed abilities through observation.

Correlation coefficients of problem solving scores of students of the four participating polytechnics varied from 0.87 to 0.97 which is considered a very high degree of correlation indicating that students of all the polytechnics had performed equally well.

8.9.2 Open-ended project based learning at the institute

This experiment was conducted in 1989-90 for a period of 9 weeks for a batch of 44 students of a class. The experiment was repeated for two batches of students of 39 and 52 during 1990-91.

8.9.2.1 Experiment conducted during 1989-90

(i) The students' average score in Board examination was compared with the average scores of students of the previous two batches in the same subject. There had been an increase in performance of students to the extent of 10.1% i.e. 52.09 as against 47.31, an average of previous two batches of students in the Board examination. Students average score in problem solving abilities showed as sharp increase from mere 29.0 to 64.4.

(ii) Correlation coefficient of students' scores in problem solving abilities as evaluated through the evaluation matrix, and the comprehensive written test conducted at the end of the semester was calculated as 0.37. Similarly, correlation coefficient of students' scores in problem solving abilities and their scores in Board examination was calculated as 0.45. This shows a poor correlation between evaluation through written test and evaluation of problem solving abilities.

(iii) Students were given a questionnaire to assess, on the basis of their own experience and perception, certain factors with relation to the subjects already studied by them and the subject studied in the experiment. Feedback was received on the first day of the experiment and also on the last day of the experiment. The students' average 'experiential as well perceptual' differential scores have been shown in figure 5.3.

The percentage changes as calculated from the feedback, show a significant rise in all the items as shown in Table 8.3.

Table 8.3

Percentage gain in students' perception in certain critical factors

Factors affecting Teaching-Learning	Change From	To
i) Understanding the subject	59%	81.5%
ii) Initiative in study	42.5%	75%
iii) Opportunities to see practical applications	24.1%	72.5%
iv) Understanding problems of indsutry	43%	75.8%
v) Opportunities to demonstrate abilities	34.7%	74.3%
vi) Opportunities to develop abilities	27%	65.8%
vii) Confidence in practical problem solving	42.2%	71.9%

8.9.2.2 **Experiments conducted during 1990-91**

The experiment was repeated for two groups of students one of Third semester and the other of Fifth semester.

(i) The average score of students in the Board examination of these two groups were compared with the average scores of students in Board examination in the same subjects by the corresponding previous groups.

The average performance score of third semester students were better by 24.6% , i.e. 48.9 as against 39.26, and that of fifth semester students by 20.7% i.e.59.02 as against 48.90.

(ii) The correlation coefficients were calculated as:-

	For Third Semester Students	For Fifth Semester Students
Post-test and problem solving score	0.48	0.39
Board examination & problem solving score	0.43	0.34
Post test and continuous evaluation	0.71	0.72

The above shows a fairly good correlation between Post-test and continuous evaluation but a poor correlation between Post-test/Board examination scores and Problem Solving Scores. The interpretation made here is that evaluation made at the end of the course either by the teacher or by the SBTE through a written test does not necessarily assess students' abilities of problem solving.

(iii) Table 8.4 shows the percentage gain on certain critical factors as experienced/perceived by students for both third and fifth semesters.

Table 8.4
Percentage gain in students' perception on certain critical factors

Factors affecting teaching-learning	CHANGE					
	For Third Semester		For Fifth Semester		AVERAGE	
	From	To	From	To	From	To
i) Understanding the subject	31	59	44	77	37.5	68
ii) Initiative in study	42	67	49	82	45.5	74.5
iii) Opportunities to see practical applications	25	69	40.5	84.4	32.7	76.7
iv) Understanding problems	18	58	48	78	33	68
v) Opportunities to develop abilities	21	67	47	82	34	74.5
vi) Opportunities to develop abilities	28	66	38	76	33	71
vii) Confidence in practical problem solving	24	55	43	82.5	33.5	67.7

Comparing the data in Table 8.3 and Table 8.4, it is observed that everytime students perceived higher achievements in all the factors considered in the feedback questionnaire. This shows consistency of the effectiveness of the interactive teaching-learning system employed.

8.9.3 Learning through graded exercises for problem solving competence.

(i) Performance of students in Board examination showed an improvement of 30.6% i.e. 47.80 as gainst 36.63 when compared with the average performance of previous two batches of students in the same subject. Performance of upper group of students was compared with the performance of lower group of students. It was found that the gain was higher for the upper group of students. This leads to the conclusion that while all the stduents gained with respect to their performance in written test, the upper group of students gained more than the lower group.

(ii) Correlation coefficients of continuous evaluation and post-test was calculated as 0.79. This shows a good correlation of the formative and summative evaluation.

(iii) Correlation coefficient of scores in Board examination and evaluation by industry was calculated as 0.25, which is considered poor meaning that examination conducted by SBTE does not necessarily evaluate students for their problem solving abilities.

8.9.4 Study of functional curriculum and internship in industry

(i) Average score of students of experimental group in written test in basic theory and in functional aspects when compared with the corresponding scores of students of control group showed a significant increase, ie, 67% as against 49.7% and 50% as against 14.6% respectively.

(ii) Average performance of control group in interview by a panel of industrial and other experts showed a significant difference ie, 71.7% for experimental group as against 46.7% for the control group.

The above two observations indicate that study of functional curriculum and internship in industry have not only helped students develop problem solving skills but also have helped in understanding the subject matter better.

(iii) Certain problem solving skills as evaluated by the supervisors during the initial stage and during the final stage were analysed and are presented in Table 8.5. The data have been taken from the two evaluations made during the initial and final stages of students' internship in industry. Out of fourteen characteristics judged (using table 3.1), data of only six significant characteristics have been presented in the table.

Table 8.5

Gain in certain components of the problem solving abilities

Abilities evaluated	Percentage increase
i) Knowledge of concepts, principles, and application	37%
ii) Intellectual ability in problem solving	48%
iii) Professional judgement and decision making ability	76%
iv) Initiative	42%
v) Communication skills	38%
vi) Self Reliance	44%

(iv) Correlation coefficient between evaluation by industrial experts and polytechnic H.O.D. (through a comprehensive viva, group discussion and seminar) was calculated as 0.82.

This shows a good correlation of evaluation by industrial experts and by the Head of the Department of of the polytechnic.

(v) Average performance scores of first year and second year students of the experimental group were analysed. The results showed better performance of second year students as compared to first year students (i.e. by 16.3%) in written test in basic theory, 4.4% in functional aspects, and 1% in interview).

(vi) Average performance scores of second year students of the experimental group as compared to the average scores of second year students of the control group showed increase of 33.1% in basic theory, 39.9% in functional aspect, 25.8% in interview.

8.10 Choice of Models in terms of pedagogic issues

8.10.1 Comparative evaluation of the teaching-learning models

An examination of the benefits and requirements reveals that model for experiment IV has maximum benefits as well as maximum requirements. Model IV responds to all the pedagogic issues in terms of curriculum requirement, learner opportunities, instructional material requirement, and evaluation of students. However, it lays heavy demand on the management to put in extra effort in involving the faculty in developing functional curriculum and students' reference material through intense interactions with the employers , to find places of internship for students in industry, and to monitor students' progress through faculty deployment.

The polytechnics in a state have a common curriculum prescribed by the State Board of Technical Education. Curriculum is developed with the assistance of Technical Teachers' Training Institutes. TTTIs are also engaged in the development of instructional resources for use by polytechnics. It thus lays heavy demand on TTTIs to develop methodologies for the design of a functional curriculum and related resource material.

Model for experiment II responds to all the pedagogic issues except that it involves heavy demand on teacher preparation in terms of equipping them with technological developments in industry,in guiding open-ended project activities,and in establishing linkages with environment for developing and updating a problem bank. With a planned effort by the management in this direction, it should be possible, with the help of teachers, to bring in the required changes in the curriculum including method of course offering.

Model for experiment IV varies from model under experiment II mainly in terms of more benefits and more requirements but lays heavy demand on TTTIs for instructional material preparation and evolving a new approach to curriculum design.

Model for experiment I answers to all the issues except for the curriculum restructuring and planning by the individual polytechnic for student and faculty attachment in industries as part of curriculum requirement. Curriculum revision and instructional material development work for institutional training can be taken up as an on going process in association with other polytechnics as well as with the assistance of TTTIs. This model has lesser benefits and still lesser demands on the TTTIs, the reduction being in terms of quality of teacher training inputs. The model would demand polytechnic management playing a pro-active role in establishing linkage with the world of work as also in providing the required support to the faculty for their involvement, through flexible rules and regulations.

Model for experiment III has limited advantage inherent in the design as the exercises or tasks are only real life like in nature,and as perceived and developed by the teacher. This experience is inferior to the experiences available in other three models. Design and development of exercises would demand teachers' competency as also their devoting of time for the work. The quality of learning experiences and their transfer value will be governed by the quality of the exercises formulated by the teacher.

Industries' involvement in curriculum revision and in preparation of exercises and tasks, would improve the transfer value of such exercises and tasks, unless the teacher himself is the synthesis of a curriculum developer and an industrial manager.

Both model IV and model I can be implemented without increasing the total duration of polytechnic course, as certain institutional efforts in terms of curriculum offering may be shed off, and some others shifted to periods spent by students in industry with better results and at the same time bringing in optimisation in the infrastructure development requirement within the institute.

Model I, II and III offer possibility of students' receiving monitory incentives while pursuing studies in polytechnics (35% of students received monetary incentives in the model for experiment I and others received letters of appreciation from industry). Model I and IV had the added advantage over model II and III in the sense that they bring students in closer contact with industries, provide opportunity to students to get employment by demonstrating their abilities, help industries observe students closely over a period of time and make selection for employment in their own organisation.

8.10.2 Making an eclectic choice

None of the four teaching-learning models under consideration can be made prescriptive for polytechnics as the requirements of each of the models are different, and at the same time the profile of polytechnics contain a number of variables like their locational advantages or disadvantages, infrastructural facilities, human resources, management support, financial resources, etc.

Considering the variables contained in the profile of polytechnics, they can broadly be classified into three basic types, namely,

(i) Polytechnics situated in the neighbourhood of large number of industries having some academic autonomy;

(ii) Polytechnics situated in remote areas having limited human and physical resources;

(iii) Polytechnics having fairly normal facilities and situated in urban localities.

Taking into account the requirements of adopting each of the four models,polytechnics may make an eclectic choice of the models as suggested below:

Polytechnics falling in the category as in (i) above for example, may immediately go in for model I and at the same time start preparation for implementing model IV in near future. They could also use some elements of model III in their first few semesters of course offering so as to prepare students for effectively participating in open-ended problem solving situations,when placed in industries.

Polytechnics of category (ii) may consider use of model III with limited advantage. For developing teaching-learning material in the form suggested, collaboration of other polytechnics and resource organisations like the TTTIs could be obtained.

Most of the polytechnics in India fall into the category (iii) as mentioned above. Such institutions may go in for using model II with minimum of preparatory requirements and may also work for the implementation of model I in near future. They may also make use of model III at the elementary stages of course offering.

Further to these options, any institute may deliberately borrow ideas from each of these models and develop their own model of teaching-learning keeping in view the short-term as well as the long-term educational objectives of technical education system.

CHAPTER-NINE

CONCLUSIONS

This thesis has designed, developed and tested four teaching-learning packages with interactive features. These are namely,

I Student teacher involvement in open-ended project activities at the work-bench;

II Student-teacher involvement in open-ended project activities as an integral part of class-room activities;

III Use of teacher made graded exercises for developing problem solving competence; and

IV Teaching-learning of functional curriculum followed by internship in industry.

(a) Teaching-Learning Package I

In teaching-learning package as in I above, learning activities are designed to be at two places viz learning of subject matter in institutional setting, and learning of open-ended problem solving at the work-bench where the student-teacher team is placed on specific assignments given by the industry. The students under the guidance of their teacher co-operatively work for solutions of problems where the industries' experts work as consultants, thus establishing a triangular interactive relationship between them.

This interactiveness is meaningful as the students now have the opportunity to gain real life problem solving experiences in actual field situation and can develop,as also demonstrate their abilities by taking initiative, and have available with them the guidance from the teacher as well as from industrial experts. For the teachers, teaching becomes a challenging task as compared to teaching of a given syllabus. Further, they are now able to utilise the resources of the emploeyr organisation for student training while at the same time developing their own competencies. For the employers, the problem solutions are of direct relevance and use to them as also they have better trained student output for employment.

Planning for this kind of work-bench based inter-active teaching-learning involved discussions with students, industry, and the polytechnic faculty specifying the role of the above three groups so as to make interactions meaningful and productive in terms of student learning and project output. Interactions with students involved matching the students' abilities and interests with the problems assigned, and accordingly making allotment of training places. Interactions with industries involved mutual understanding of the purpose of placement of students in industries, identification of problems, identification of experts who would be associated with the student-teacher team, and understanding of the evaluation method and tools to be used.

Interactions with teachers involved understanding of the critical roles the teacher had to play in guiding and evaluating students in industries as well as in developing a long-term functional relationship with the industry.

The implementation of this teaching-learning system involved placing students along with their teacher in the respective industries to work on the problems assigned, monitoring, carrying out student evaluation, and collection of feedback.

Placement of students was done such that a student did not have to travel a long distance from his place of residence. The teachers required certain facilities and benefits to be on duty in industries. Evaluation of students was done jointly by the teacher and the industrial experts on a continuous basis using multiple evaluation instruments to judge the students' total personality traits. Feedback from all concerned was collected for making improvement in future implementation of this teaching-learning system.

Results of the experiment showed significant achievements in terms of 37 percent of students receiving out of pocket allowance from the industries, 48 percent getting employment in the same industries where they were placed on attachment, and 60 percent of the students' work output of use to industries. Feedback from teachers, and industries showed students' attitudinal changes in learning, acquiring of better communication skills by the students, favourable attitude of industries, better curriculum feedback through teachers, teaching becoming learning experiences to teachers, and the teachers achieving job satisfaction. The various instructional material developed under this package consisted of a booklet on guidelines for open-ended problem solving, sample open-ended problems collected from 40 industries, instructional manual for conduct of group discussions, seminar, report writing and its presentation, list of standard books and references, and a training diary.

(b) Teaching-learning Package II

In the teaching-learning packages as in II above, curriculum is required to be implemented around open-ended project activities at the institute, industry sponsored projects being one workable method of locating such projects, and the learning of basic concepts and principles forming the pre-requisite to project work. This implies that industry sponsored nature of problems may be sufficient to ensure open-endedness of the project, but is not necessary. In the later case, it would then be the responsibility of the teacher to define such open-ended projects, and this in turn would need training of teacher for this activity. Even today too, such teacher training programmes are not in vogue and the concerned issues vis-a-vis then remain unresearched. It is in this situation that the teaching-learning package as in II above envisages a teacher-work-bench professional team acting as a teacher in the class-room at the institute and accordingly uses instructional material and methods for project-based learning as an integral part of class-room instruction.

Students-teacher interactions with industry are designed to be in the form of group discussions, project guidance and student evaluation. Instructional materials in various formats are designed to help students to learn the subject matter. Extension lectures, group discussions, gap lectures are required to be organised to help students carry out their project work. Thus, this teaching-learning package is also interactive where the students, the industrial experts and the teachers cooperate with each other for the problem solution at the work places. Evaluation of students are designed to assess the total personality traits of the students, using multiple evaluation instruments.

Planning for implementation of this teaching-learning package involved identification of suitable open-ended problems from neighbouring industries and getting them sponsored, allotment of projects to students, preparing students for project activities, involving industries in project guidance and student evaluation.

During implementation of this teaching-learning package, involvement of industrial experts was seen essential, as the teachers were not able to provide all the guidance to students on open-ended problems because of their limited practical experience . Further, time-table had to be made flexible so as to enable student-teacher team visit industries for collection of data and other relevant informations from different sources.

From the results of implementation of this teaching-learning package it was observed that while the students learned to solve open-ended problems through interactions with teacher and the employer, they also understood the subject matter better. This was evidenced from students' improved performance in the post-test as well as in the examination conducted by the State Board of Technical Education. Evaluation method which reflected students' actual abilities in terms of application of knowledge in open-ended problem solving and the method of certification were found more meaningful by the employer than the prevailing system of student evaluation and certification.

Students' perceptions on their own achievements showed significant increase in terms of understanding purpose of studying the subject, seeing practical applications, understanding problems of industry, confidence in problem solving, and demonstrating competence.

Attitude of industry was found favourable as project outputs were directly related to industry's needs. Guiding students in open-ended project activities was indeed motivating and learning experience to the teachers. Interaction with industries provided valuable feedback for curriculum revision. The learning package developed included four video films, experimental kit, demonstration boards, teaching aids, work-book, sample industrial problems, and a universal type trainer.

(c) Teaching-Learning package III

The teaching-learning package as in III above envisage use of teacher made graded exercises in the class room for developing problem-solving competence. A large number of exercises covering the entire course content forms the basis of stdtents' learning activities. The exercises are designed to be of real life like and are graded from simple to complex. Feedback in the form of 'immediate knowledge of results' are made available to students after each unit of activities. Individual guidance, gap lectures, group interactions also form a part of the package design.

Planning for implementation of the package involved analysing the subject in terms of identifying the concepts and principles and their interrelationship which forms the structure of the subject, writing the objectives, preparing exercises and tasks with feedback keeping in view the objectives, grading the exercises and clustering them in the form of modules, preparing remedial study material for use by students who might need them,preparing additional exercises and tasks to be used in between modules,collecting reference material from various sources,and preparing evaluation instruments.

Implementation of the package involved motivating students through use of Advance Organizers,pre-testing students' knowledge,self learning of students through graded exercises, need-based lectures by the teacher,individual guidance, student evaluation and feedback.

Students performance was evaluated by experts drawn from industries as also by the teacher on a continuous basis using evaluation instruments.

Results of evaluation of students by SBTE were also collected.

It was found that all the students gained in terms of acquiring problem solving abilities. The performance of students in the examination conducted by the SBTE showed that this batch of students performed better than the previous batches. One significant finding was that the student of upper group gained more than the lower group. Performance of students in the evaluation conducted by industrial experts was found only satisfactory. Shifting learning responsibilities to students, and providing opportunities for learning showed that the students learned the course content earlier than the time the teacher used to take to 'cover the syllabus' by lecture method, in previous semesters. Further, the number and varieties of exercises and assignments done by students were even more as compared to the earlier batches. The teaching-learning package contained the following material: Learning objectives and the structure of the subject; Modules of Graded exercises with feed-back; Remedial study material; Teaching aids like Models,Charts, Working drawings collected from field; Assignment sheets;and Evaluation tools.

(d) Teaching-learning Package IV

The teaching-learning package mentioned in IV above involve use of functional curriculum in institutional training followed by internship of students in functional areas in relevant industries. Planning for implementation of this package involved development of curriculum through identification of functional areas of diploma holders, development of instructional material on basic concepts and principles, and also covering the functional areas of diploma holders, preparation of guidelines specifying the roles of student interns vis-a-vis the Supervisors, preparation of instructional plan, contacting industries for places of students' internship, developing evaluation instruments, orienting the industrial supervisors, the students, and the teachers about the total plan.

Implementation of the plan was done in two places, viz, at the institute in offering learning opportunities for basic concepts and principles related to the subject of study, and in industry to study the functional aspects while carrying out problem solving assignments under the guidance of supervisors. Learning activities of students included learning by observation, learning by doing, learning by interacting and learning through self study. The work experience of students coupled with interactions with professionals helped students improve their understanding of the related theory. Evaluation of students was done on a continuous basis jointly by the supervisors and the visiting faculty. Towards the end of the training period, evaluation of students was done by a panel of experts drawn from different industries as also through a comprehensive written test covering the basic concepts and principles and the functional aspects. For comparison a group of students who had studied the subject through lecture method was also evaluated simultaneously.

The results of the experiment showed significant achievements made by students in terms of acquisition of all those abilities which are required to work effectively in functional areas. Further, understanding of the concepts and principles was also better as compared to those who studied the curriculum through institution based conventional teaching-learning method. Performance of students in the interview showed better result as compared to other students. The teaching-learning package contained a functional curriculum on the topic, self study type text material covering basic theory, instructional manual for laboratory experiences, reference material in the form of 'Supervisors' Guides' covering four functional areas, guidelines to students for working in industry, and evaluation tools.

Experiences in implementing the above teaching-learning packages have shown that in all the four interactive teaching-learning situations, the outcome has been better than what was possible to achieve through conventional method of teaching-learning.

The results of application of the teaching-learning packages were further analysed to study how each of these teaching-learning packages answered often repeated issues of techncial education i.e. the issues of quality, learner opportunities, relevance of curriculum, teacher preparation, instructional resources, student evaluation, interaction with employers, and overall management of teaching-learning.

Further, cybernetic modelling reflecting the self regulatory feedback system for each of the models were developed to identify factors which gave rise to issues. The requirement and benefit zones of each of the teaching-learning system as analysed through cybernetic modelling summarises as follows:

In model I, the benefits are that students are trained in open-ended problem solving in industries under the guidance of teacher and consultants, get monitory incentives and employment by demonstrating abilities; for industries the benefits are that the project output are of direct use to them and they are able to make better selection of trained students for employment after close observations; for polytechnic teachers, the benefits are that they are able to utilise the industries' resources for student training, as also become future consultants.

Involvement of teachers in industries is, in fact, seen as their on-the-job training, enabling them play multiple roles in terms of organising better teaching, providing feedback for curriculum revision, establishing functional linkage with industries, and using better student evaluation methods.

This model differs from sandwich model in two aspects i.e. its requirement of presence of teacher in industries along with the students; and, industries assigning specific problems to the student-teacher groups.

Model II differs from Model I in the sense that, here, the project activities take place at the institute under the guidance of the teacher and the visiting consultants. Since, the project output are of use to their sponsors, cooperation from industries are available in the form of extension lectures by their experts, as also guidance to students-teacher team.

The requirement for this model is to prepare a problem bank from the neighbouring industries, allowing flexible time-tabling for enabling students-teacher team visit industries, and having flexible rules and regulations. The availability of industrial experts in the class-room is an essential requirement for project guidance, as the teacher, due to his limited practical experience, alone finds it difficult to provide all the required informations and guidance to the student teams. Although, the projects were sponsored by industries and guidance from field experts were available, as in this experiment, projects which had open-endedness could also be formulated by the teachers and guidance to students provided if the teachers had the requisite training for such ability.

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teachers and receive feedback, as also get individual guidance from the teacher. The limitations are that the problems are only real life like and there are no takers for such problem solutions. However, students learn the problem solving methods through individual as well as group efforts, and through student-teacher group discussions organised at regular intervals.

The requirements are to design and develop exercises/tasks which would create enough psychological tensions in students to solve them.

In Model IV, there are more benefits as well as requirements as compared to the other three models. Some of the benefits are: curriculum meeting the needs of industry, experiential learning under expert guidance and in real life situations , viewing student interns as additional human resources by the industries, utilisation of industries' resources for student training, and better quality of student output.

The requirements are: development of a functional curriculum, instructional material preparation covering the basic theory as also the functional aspects, establishing linkage with industries for students' internship, involving teachers for monitoring progress in learning, evaluating students and providing feedback.

Thus it is seen that these four models emerge as viable models with their hierarchy as Model IV, Model I, Model II, and Model III. Choice of a particular model will depend upon the profile of the individual polytechnic which has variables like situational advantages or disadvantages, academic autonomy, human and physical resources, managements' attitude, etc. However, it is submitted that a teacher now has the option of eclectically selecting ideas from different models to frame his teaching-learning design strategy consistent with his specific needs. Thus the thesis suggests eclectic approach to any specific teaching-learning package design using judicious combinations of items under the four models.

Thus the thesis ends with testing and establishing validity of these four models. Of course, this should provide impetus to further work wherein curriculum design approaches could now consider introducing combinations of these models as an integral part of award of diploma. The further issue would be the very management needs of the curriculum thus developed. This can provide directions for further research. TTTIs can play their natural role in this area.

As one brings this thesis to its concusion as above, it is difficult not to express some inherent worries. Reflective or interactive teaching-learning processes are also termed in the literature as having democratic learning character. Thus, the process poses tremendous responsibility on its participants, namely the teacher and the learner, with an additional provisso that the responsibility changes its content and nature every instant, thereby requiring both the participants to be in constant act of adaptation -a continuous process of interacting with the environment and learning to predict and control it to some degree. Educational psychologists consider learning by adaptation equivalent to work, other lower level of learning being accommodation and assimilation. It is the need for constant adaptation or work that provides the source of worry as, the participants may, more often than not demonstrate a lazy mans helplessness in meeting this need, and the environment, generally representing the educational milieu may choose, for its own reasons, to passively look at this helplessness, thereby making the need for adaptation a graveyard of the very effort to ensure it. Of course, in the absence of a strategy and effort to introduce adaptation in learning, it is the act of learning itself that stands to vanish. Thus either way one stands to loose, but the loss, when the act of learning itself vanishes or is killed, is having no chance of bringing education to life, but the loss, while trying to ensure adaptation, can be made to look temporary if side by side to induction of teaching-learning process of interactive nature, a conscious effort is also made to make the environment somewhat receptive and amenable to such teaching-learning objectives. This would call for strategy and policy level innovations in planning and management of researched changes in educational structures for these pedagogic objectives.

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Annexure 4.1

Problem Bank for student as identified by indsstry

A. For Civil Engineering Students

(i) To supervise concrete mixing operation and prepare daily material consumption report.

(ii) To perform quality control tests on crete and keep record of mix proportions, water cement ration, batch number and its placement and cube strength.

(iii) To calculate quantities of materials for a given job with the help of drawings.

(iv) To supervise shuttering and centering operations & ensure safety and stability.

(v) To supervise concreting operations including checking of reinforcement as per specifications.

(vi) Design of simple structural members like beams, columns, lintels etc.

(vii) To carryout site investigations, conduct tests on soils and interpret test results.

(viii) Making measurement of completed work and calculate quantities of raw materials used.

(ix) Preparation of working drawings/tracings for Civil Engg. works.

(x) To conduct surveys for road projects and irrigation projects.

(xi) Estimating and costing for a given job as per drawings.

(xii) To calculate discharge rate and preparation of daily report or discharge measurement.

(xiii) Preparation of bill of raw materials

(xiv) Data collection and its analysis regarding water supply scheme for a town.

(xv) To supervise construction of residential buildings and preparation of daily progress report.

B. <u>For Electrical Engineering Students</u>

(i) Computation of connected load and to draw the load curve for the industry and verification of the energy consumption bill.

(ii) Supervision of laying out of conduit pipes, switch boards and electrical points in a building under construction.

(iii) Preparing layout plan for power wiring in an industry including panel wiring of various machines.

(iv) Estimating and costing of electrical installation in residential building.

(v) Fault finding, repair and maintenance of Electrical appliances such as fans, motors,heaters etc. in a hospital.

(vi) Inspection and calibration of a new energy meter.

(vii) Study of drawings of various control panels & inspection and testing of the panel wiring.

(viii) To conduct market survey and procure orders for control panel jobs.

(ix) To prepare an estimate of temporary electrical installation and get the same executed in a multi-storeyed building for Civil Engineering construction purposes.

(x) Supervision of fabrication of domestic gadgets like Desert coolers, washing machines, geysers etc.

(xi) Testing of electrical motors and fans and preparation of test reports.

(xii) Supervision of repair and maintenance of distribution transformers.

(xiii) Electrical maintenance of power installations.

(xiv) Operation and maintenance of disel generating sets.

(xv) Supervision and testing of control panel wiring of different machines such as lathe,milling and broaching machines.

(xvi) Inspection and quality assurance of industrial cables.

(xvii) Study for optimum utilisation of energy in a plant.

(xviii) Redesign of EM 4 filling machines control circuit into Push button control similar to EM 3 milling machine.

(xix) Flow charts for use of PLC in Broaching machine in place of conventional switchgear.

C. <u>For Mechanical Engineering Students</u>

(i) Analysis of quantity produced, quantity accepted, quantity reworked or rejected for one week of production and preparation of report.

(ii) To carry out a productivity study, namely, study of the utilisation of equipment, machine or men in a particular shop to be identified by the management and workout the percentage utilisation and suggest optimum utilisation of resources.

(iii) To study and report the extent to which the product targets are achieved in a particular shop or division and suggest revised production schedule.

(iv) To study the inventory levels of category A items and suggest measures for optimum utilisation of inventory levels.

(v) To conduct work study on identified critical operations/ processes which call for better methods.

(vi) Studying the in process quality control methods adopted and to suggest improvements required.

(vii) Determining areas of wastage such as improper or under-utilisation of equipment, manpower and materials and energy and to suggest remedial measures.

(viii) To study the existing repair and maintenance schedules, identify the deficiencies if any, and suggest better maintenance schedule.

(ix) Process planning (preparation of route sheet) for a given component taking into consideration the existing equipment and machines available in the industry.

(x) Study of certain operations and processes which call for modernisation with a view to reduce processing time and wastage.

(xi) Study of the pollution and environmental problems in a shop(such as heat treatment, spray paintaing, electroplating, engine testing) and suggest preventice measures.

(xii) Identify items/services required by the indsutry which can be taken by an ancilliary unit.

(xiii) Study the installation drawings required for erection of air conditioning units, ducts etc. and ensuring whether they are provided for during construction.

(xiv) Study of the types and variety of piston ring available and their suitability for different engines manufactured in the region.

(xv) To study the existing safety procedures, identify deficiency and suggest improvements.

(xvi) Fitting of Power chuck with electro clamping arrangement on Lathe machines.

(xvii) Use of Boring bar with cartridges having indexable inserts for boring of components.

D. <u>For Architectural Assistantship Students</u>

(i) To design a Community Centre for Urban Estate, Panchkula with provisions of a multipurpose hall, six double bed rooms with attached toilets, kitchen with pentry provision. For further details, contact Sr.Architect.

(ii) To prepare perspective drawings of a cinema Hall from the detailed plan and elevation drawings.

(iii) To prepare a model of a primary school from the detailed drawings.

(iv) To design the bunglow of Deputy Commission at Patiala comprising of 5 bed rooms with attached toilets a drawing-cum-dining hall, kitchen, and other amenities. For further details, contact Sr.Architect.

Annexure 4.2

Questionnaire to be filled in by polytechnic students on the last day of their industrial attachment period

Name of stduent ______________ Roll No. ___________ Branch ____________

Name of Polytechnic ____

Name of organisation in which placed for Training ____

Duration of Training From _______________ to ___________________

Give your free and frank opinion to the questions listed below:

1. Were you clear about the objectives of your industrial attachment? Yes/No

2. Were you supplied well in advance the following materials?

   (a) Guidelines for undergoing industrial attachment Yes/No

   (b) Problem bank/tasks for indsutrial attachment Yes/No

3. Were the instructional material supplied under item (2) useful to you? Yes/No

4. Who gave you assignment during your industrial attachment?

   a) Given by the organisation

   b) Selected from problem bank in consultation with the organisation

   c) Selected problem on your own

   d) Did not do any problem solving

5. Was the teacher from your polytechnic available to you for guidance? Yes/No

6. What was the frequency of teachers meeting you for project guidance?

   a) Daily

   b) Once in two days

   c) Once a week

   d) Once after 2 weeks

   e) Once a month

7. Was the availability of teachers helpful to you? Yes/No

8. Did the teacher provide you guidance and help in the solution of task/ assignment given to you? Yes/No

9. Were you paid out of pocket allowance by the indsutry during your training?
   a) Yes/No
   b) Rs.____ per month

10. Have you been offered an employment by the organisation? Yes/No

11. Could you achieve the following through this industrial attachment ?

    a) Development of confidence in problem solving — Yes/No

    b) Opportunity for learning new skills — Yes/No

    c) Development of ability to discuss & talk with industrial/field officials on various problems — Yes/No

    d) Skills in reading and interpreting drawings — Yes/No

    e) Exposure to indsutrial environment and factory/ field discipline and opportunity for understanding exact nature of professional life — Yes/No

    f) Understanding of various production/construction/ maintenance and quality control operations — Yes/No

    g) Operation of specialised plant and equipment — Yes/No

    h) Size and scale of operations in industry/field — Yes/No

    i) Understanding regarding the jobs,functions and responsibilities of diploma holders in industry — Yes/No

    j) Understanding regarding value of time, duty,waste reduction, dignity of labour and team functioning — Yes/No

    k) Opportunity for establishing personal relations — Yes/No

12. Did industrial/field supervisors help you in learning or completing your assignment? Yes/No

13. How was their attitude towards you ?

    a) Very favourable

    b) So-so

    c) Indifferent

14. Did they take interest in you ? Yes/No

15. On an average how much time did you take in reaching the place of work? ________minutes

16. Where did you stay during training?
   a) with parents
   b) with relatives
   c) hired a room
   d) company provided accomodation

17. How did you travel to the place of work ?
   a) by walking
   b) by cycling
   c) on scooter
   d) company provided transport facilities

18. How did you manage your food during working hours?
   a) took lunch and tea in the canteen of host organisation at subsidised rates
   b) carried own lunch packet
   c) took lunch and tea outside the host organisation

19. How do you rate the utility of this industrial/field attachment?
   a) very useful experience
   b) will be very useful in future also
   c) Not useful

20. Do you think that such industrial training should be a part of your regular curriculum studies ? Yes/No

21. How do you rate this indsutrial training period?

   a) Excellent b) Very good c) Good d) Fair e) Poor

22. Did you face any difficulty during this training? Yes/No

23. If yes to Q.No.22,,state the difficulties faced very briefly:

____

24. Indicate briefly the work done by you during your Industrial attachment. (Use an additional sheet)

Annexure 4.3

Feedback from polytechnic teachers who supervised and guided indsutrial attachment of polytechnic students.

1. Name______________________ Designation____________________

2. Name of Polytechnic______________________________________

3. Was the objective of Industrial Exposure of students clear to you? Yes/No

4. Do you think that instruction & Instructional material provided to the students before sending them to industrial training were necessary and useful? Yes/No

5. Did you find the students utilizing their time in industry usefully ? Yes/No

6. Did you find students enthusiastic during this training? Yes/No

7. Do you think that this training in future be made a part of the curriculum? Yes/No

8. Could you derive the following benefits by your attachment to industries? Yes/No

   i) Exposure to industrial/field processes & practices Yes/No

   ii) Exposure to industrial/field problems to be tackled by diploma holders Yes/No

   iii) Establishing relationship for improving industry-institute interaction Yes/No

   iv) Development of confidence in teaching Yes/No

   v) Ability to provide better feedback for curriculum revision Yes/No

   vi) Ability to formulate real life problems in the form of projects for the students Yes/No

9. What was the attitude of industry?

   a) Favourable b) Unfavourable

10. Do you consider time spent by students in indsutry better utilised as compared to institutional training ? Yes/No

11. What is your overall rating of this training programme?

   a) Excellent b) Good c) Not satisfactory

12. Was the duration of indsutrial attachment adequate?

a) Yes b) Should have been shorter c) Should have been longer

13. Could the students complete the assignments given to them within the available time?

a) Yes b) No c) To a limited extent

14. Any suggestions for further improvement:

____

____

Annexure 4.4

Feedback from industry regarding industrial attachment of polytechnic students

Note: You perhaps have had experience of industrial training of students on earlier occasions. This time the industrial attachment of students for problem solving experience was planned with your assistance. Kindly give your reactions by answering the following questions, which will help polytechnics evaluate the programme.

Q.1 Was the objective of the experiment known to you before the students arrived? Yes/No

Q.2 Do you consider presence of the teacher in industry for looking after the progress of students and providing regular guidance essential? Yes/No

Q.3 Was the project output received from students useful to you? Yes/No

Q.4 Did you pay any financial incentives to students for their work? If so, please mention the nature of incentives. If not, mention why it was not possible to reward students for their work?

____

____

Q.5 Did you find the students taking interest in the task assigned to them by your industry? Yes/No

Q.6 Was there any discipline problem noticed by you from the stide of students? Yes/No

Q.7 Did you find the student evaluation scheme and evaluation tools relevant and valid? Yes/No

Q.8 What general deficiencies did you find in the students when they came to you for discussion or when you participated in group discussion?

____

____

Q.9 Do you think that during industrial training the students should be given specific assignments rather than leaving them to see the activities going on in industry? Yes/No

Q.10 Do you think that such training are very useful in developing confidence in students in tackling industrial problems? Yes/No

Q.11 Would you like to receive such groups of students on a regular basis? Yes/No

Q.12 Specific suggestions for improvement.

____

____

Annexure 4.5

Problems/Assignments undertaken by Final Year Students

1. Computation of connected load and drawing of load curve for the industry and verification of energy consumption bills.

2. Preparing layout plan for power wiring in an industry including panel wiring of various machines.

3. Estimating and costing of electrical installation in residential buildings.

4. Understanding of drawings of various control panels, inspection and testing of the panel wiring.

5. Supervision and testing of control panel wiring of different machines.

6. Redesigning of existing control circuits for workshop machines.

7. Conduct of market surveys and procurement of orders for control panel jobs.

8. Design of simple structural members.

9. Design of residential buildings as per costumers requirement.

10. Soil Investigation, testing and preparation of investigation report.

11. Computations of quantities of aggregate, cement and steel for structures yet to be constructed with the help of field drawings.

12. Quality control operations for RCC Structures.

13. Preparation of bills/cost estimation of finished structures/works.

14. Analysis of quantity produced, quantity accepted, quantity rejected for one week production.

15. Productivity improvement studies and suggesting methods for raising production capacities.

16. Determining areas of wastage and suggesting remedial measures.

17. Repair and Maintenance of machines.

18. Fitting of power chuck with electro clamping arrangement on lathe machines

19. Use of boring bar with catridges having indexable inserts for boring of components.

Computation of Correlation Coefficients of students evaluation

a) Programme

```
program corr(input,output);
const
     nc=78;
     nv=5;
var
      i,j:integer;
      x,am,sd,s,x1:array[1..5] of real;
      p,r:array[1..5,1..5] of real;
      f1,f2:text;
 begin
      assign(f1,'teaevlnf.dat');
      assign(f2,'teaevlnf.out');
      rewrite(f2);
      reset(f1);
      for i:=1 to nv do
      s[i]:=0;
      for i:=1 to nv do
      for j:=1 to nv do
        p[i,j]:=0;
    writeln(f2,'FINAL YEAR STDNS DATA ');
    writeln(f2,'     QZ         SM        GD         RP          OBS ');
     for i:=1 to nc do
       begin
       readln(f1,x[1],x[2],x[3],x[4],x[5]);
       writeln(f2,x[1]:8:2,x[2]:8:2,x[3]:8:2,x[4]:8:2,x[5]:8:2);
       for i:=1 to nv do
       s[i] :=s[i]+x[i];
       for i:=1 to nv do
       for j:=1 to nv do
         p[i,j] :=p[i,j]+x[i]*x[j];
       end;
       writeln(f2);
       writeln(f2);
       writeln(f2);
       writeln(f2,'   MEAN          STANDARD DEVIATION');
       for i:= 1 to nv do
       begin
         am[i]:=s[i]/nc;
         sd[i]:=sqrt(p[i,i]/nc-am[i]*am[i]);
         writeln(f2,am[i]:8:4,'            ',sd[i]:8:4);
       end;
       writeln(f2);
       writeln(f2);
       writeln(f2);
       writeln(f2,'CORRELATION COEFF.(TEA.EVLN) ARE:-');
       writeln(f2);
       writeln(f2,'     QZ         SM        GD         RP          OBS');
       for i:=1 to nv do
       begin
       for j:=1 to nv do
       begin
       r[i,j]:=(p[i,j]/nc-am[i]*am[j])/(sd[i]*sd[j]);
       write(f2,r[i,j]:8:4);
       end;
       writeln(f2);
       end;
       close(f1);
       close(f2);
       end.
```

2

b) Computations

FINAL YEAR STDNS DATA

QZ	SM	GD	RP	OBS
70.00	80.00	73.00	87.00	88.00
80.00	80.00	73.00	87.00	88.00
70.00	75.00	80.00	83.00	84.00
90.00	75.00	87.00	83.00	92.00
50.00	60.00	67.00	67.00	52.00
60.00	65.00	73.00	70.00	56.00
50.00	60.00	73.00	63.00	52.00
70.00	60.00	80.00	67.00	56.00
50.00	60.00	73.00	63.00	52.00
70.00	75.00	80.00	83.00	84.00
80.00	80.00	87.00	87.00	88.00
70.00	80.00	73.00	87.00	80.00
70.00	80.00	73.00	87.00	80.00
80.00	80.00	73.00	87.00	88.00
70.00	75.00	73.00	87.00	80.00
80.00	75.00	80.00	83.00	80.00
70.00	60.00	67.00	65.00	56.00
80.00	65.00	73.00	37.00	60.00
60.00	55.00	73.00	63.00	52.00
80.00	60.00	67.00	70.00	60.00
80.00	60.00	67.00	70.00	60.00
80.00	50.00	67.00	60.00	56.00
80.00	65.00	67.00	77.00	64.00
80.00	60.00	60.00	70.00	60.00
80.00	70.00	80.00	80.00	60.00
50.00	50.00	53.00	53.00	44.00
50.00	50.00	53.00	53.00	44.00
50.00	45.00	73.00	67.00	76.00
50.00	45.00	73.00	67.00	76.00
50.00	60.00	60.00	67.00	80.00
70.00	65.00	67.00	77.00	76.00
50.00	60.00	67.00	60.00	80.00
50.00	50.00	53.00	53.00	44.00
50.00	50.00	53.00	53.00	44.00
50.00	50.00	53.00	53.00	44.00
70.00	60.00	67.00	60.00	52.00
80.00	80.00	87.00	87.00	88.00
70.00	80.00	73.00	87.00	80.00
80.00	80.00	87.00	83.00	92.00
70.00	65.00	87.00	77.00	76.00
50.00	45.00	73.00	67.00	76.00
70.00	80.00	73.00	87.00	80.00
50.00	50.00	53.00	53.00	44.00
50.00	50.00	53.00	53.00	44.00
60.00	55.00	73.00	63.00	80.00
70.00	60.00	60.00	63.00	80.00
80.00	60.00	67.00	73.00	76.00
80.00	65.00	60.00	70.00	80.00
50.00	95.00	73.00	67.00	76.00
70.00	80.00	73.00	87.00	80.00
80.00	75.00	80.00	83.00	80.00
80.00	65.00	60.00	77.00	64.00
50.00	50.00	53.00	53.00	44.00

80.00	60.00	73.00	70.00	60.00
80.00	60.00	80.00	70.00	60.00
80.00	75.00	73.00	83.00	84.00
90.00	90.00	93.00	90.00	92.00
80.00	60.00	80.00	80.00	84.00
80.00	65.00	73.00	77.00	64.00
80.00	60.00	67.00	70.00	60.00
70.00	70.00	80.00	73.00	64.00
80.00	60.00	73.00	70.00	60.00
50.00	50.00	53.00	50.00	48.00
80.00	80.00	87.00	83.00	92.00
80.00	65.00	67.00	77.00	64.00
80.00	65.00	67.00	77.00	64.00
80.00	70.00	73.00	73.00	68.00
80.00	80.00	67.00	80.00	88.00
80.00	80.00	80.00	73.00	88.00
80.00	80.00	80.00	73.00	88.00
80.00	75.00	87.00	77.00	84.00
80.00	80.00	80.00	73.00	88.00
50.00	40.00	67.00	60.00	72.00
60.00	45.00	73.00	63.00	74.00
80.00	80.00	80.00	73.00	88.00
70.00	75.00	80.00	73.00	88.00
80.00	80.00	87.00	70.00	88.00
80.00	75.00	93.00	73.00	84.00

MEAN	STANDARD DEVIATION
69.7436	12.6059
65.9615	12.2490
71.9103	10.0934
71.6282	11.3681
70.7949	15.1652

CORRELATION COEFF.(TEA.EVLN) ARE:-

QZ	SM	GD	RP	OBS
1.0000	0.5994	0.5661	0.6166	0.5121
0.5994	1.0000	0.6358	0.7483	0.7047
0.5661	0.6358	1.0000	0.6287	0.7010
0.6166	0.7483	0.6287	1.0000	0.7311
0.5121	0.7047	0.7010	0.7311	1.0000

FINAL YEAR STDNS DATA

QZ	SM	GD	RP	OBS
80.00	85.00	80.00	83.00	92.00
80.00	85.00	80.00	83.00	92.00
60.00	55.00	67.00	77.00	84.00
90.00	80.00	87.00	80.00	92.00
50.00	55.00	73.00	70.00	48.00
60.00	60.00	80.00	73.00	52.00
70.00	55.00	87.00	70.00	52.00
70.00	50.00	80.00	67.00	52.00
50.00	60.00	73.00	63.00	52.00
70.00	60.00	80.00	83.00	84.00
80.00	80.00	73.00	87.00	88.00
70.00	80.00	67.00	83.00	88.00
70.00	75.00	60.00	80.00	88.00
70.00	80.00	80.00	87.00	88.00
80.00	80.00	87.00	83.00	92.00
80.00	75.00	80.00	83.00	80.00
80.00	60.00	60.00	70.00	52.00
80.00	65.00	67.00	73.00	52.00
60.00	55.00	73.00	63.00	52.00
80.00	60.00	60.00	70.00	60.00
80.00	60.00	67.00	70.00	60.00
70.00	50.00	73.00	60.00	56.00
80.00	65.00	73.00	77.00	64.00
80.00	60.00	67.00	70.00	60.00
80.00	70.00	73.00	80.00	60.00
50.00	50.00	53.00	53.00	44.00
50.00	50.00	53.00	53.00	44.00
50.00	45.00	73.00	67.00	76.00
50.00	45.00	73.00	67.00	76.00
50.00	60.00	67.00	67.00	80.00
70.00	65.00	67.00	73.00	80.00
50.00	60.00	73.00	63.00	80.00
50.00	50.00	53.00	53.00	44.00
50.00	50.00	53.00	53.00	44.00
50.00	50.00	53.00	53.00	44.00
70.00	60.00	67.00	60.00	52.00
70.00	80.00	73.00	87.00	80.00
70.00	80.00	73.00	87.00	80.00
70.00	75.00	80.00	83.00	84.00
70.00	60.00	87.00	67.00	80.00
70.00	50.00	73.00	60.00	56.00
70.00	65.00	80.00	47.00	76.00
50.00	50.00	53.00	53.00	44.00
50.00	50.00	53.00	53.00	44.00
60.00	55.00	67.00	63.00	80.00
70.00	60.00	67.00	63.00	80.00
80.00	60.00	60.00	63.00	88.00
80.00	65.00	67.00	70.00	80.00
50.00	95.00	73.00	67.00	76.00
70.00	80.00	73.00	87.00	80.00
80.00	75.00	80.00	83.00	80.00
80.00	65.00	67.00	53.00	77.00
50.00	50.00	53.00	53.00	44.00

80.00	60.00	60.00	70.00	60.00
80.00	60.00	60.00	70.00	60.00
80.00	75.00	73.00	83.00	84.00
80.00	80.00	87.00	83.00	92.00
80.00	75.00	80.00	80.00	84.00
80.00	65.00	80.00	77.00	64.00
80.00	60.00	73.00	70.00	60.00
70.00	70.00	80.00	73.00	64.00
80.00	60.00	67.00	70.00	60.00
50.00	50.00	53.00	50.00	48.00
80.00	80.00	87.00	83.00	92.00
80.00	65.00	67.00	77.00	64.00
80.00	65.00	67.00	77.00	64.00
80.00	70.00	73.00	73.00	68.00
80.00	80.00	67.00	80.00	88.00
80.00	80.00	80.00	73.00	88.00
80.00	80.00	80.00	73.00	88.00
80.00	75.00	87.00	77.00	84.00
60.00	80.00	80.00	73.00	88.00
50.00	40.00	67.00	60.00	72.00
60.00	45.00	73.00	63.00	76.00
80.00	80.00	80.00	73.00	88.00
70.00	75.00	80.00	73.00	88.00
80.00	80.00	87.00	70.00	88.00
80.00	75.00	93.00	73.00	84.00

MEAN	STANDARD DEVIATION
69.6154	12.0301
65.1923	12.2590
71.6923	10.0910
70.6410	10.4341
70.8846	15.9647

CORRELATION COEFF.(IND.EVLN) ARE:-

QZ	SM	GD	RP	OBS
1.0000	0.5743	0.4648	0.6066	0.4550
0.5743	1.0000	0.5575	0.7307	0.7099
0.4648	0.5575	1.0000	0.5749	0.6137
0.6066	0.7307	0.5749	1.0000	0.6449
0.4550	0.7099	0.6137	0.6449	1.0000

FINAL YR STDNS DATA IND.EVN

CD	AM	PL	JR
85.00	80.00	80.00	80.00
85.00	75.00	80.00	80.00
84.00	71.00	75.00	80.00
81.00	70.00	75.00	80.00
80.00	70.00	75.00	80.00
75.00	68.00	75.00	75.00
70.00	65.00	72.00	75.00
65.00	65.00	70.00	75.00
65.00	60.00	70.00	70.00
62.00	50.00	60.00	65.00

MEAN	STANDARD DEVIATION
75.2000	8.5767
67.4000	7.8256
73.2000	5.4918
76.0000	4.8990

CORRELATION COEFF.(INTERPOLY) ARE:-

CD	AM	PL	JR
1.0000	0.8928	0.8781	0.8996
0.8928	1.0000	0.9731	0.9286
0.8781	0.9731	1.0000	0.9032
0.8996	0.9286	0.9032	1.0000

c) Correlation Cofficients

(i) Correlation between scores of Quiz, Seminar, Group discussion, Report & Observation

(a) For Teacher evaluation

QZ	SM	GD	RP	OBS
1.00	0.59	0.56	0.61	0.51
0.59	1.00	0.63	0.74	0.70
0.56	0.63	1.00	0.62	0.70
0.61	0.74	0.62	1.00	0.73
0.51	0.70	0.70	0.73	1.00

(b) For Industry evaluation

QZ	SM	GD	RP	OBS
1.00	0.57	0.46	0.60	0.45
0.57	1.00	0.55	0.73	0.71
0.46	0.55	1.00	0.57	0.61
0.60	0.73	0.57	1.00	0.64
0.45	0.71	0.61	0.64	1.00

(ii) Correlation of industry evaluation scores of students of different polytechnics

CD	AM	PL	JR
1.00	0.89	0.87	0.89
0.89	1.00	0.97	0.92
0.87	0.97	1.00	0.90
0.89	0.92	0.90	1.00

Annexure 5.1

Selection of Subject and its Content

The subject of "Electrical Design and Drawing III" taught to the students of Fifth Semester Electrical Engineering in polytechnics of Punjab, Haryana, Chandigarh, Delhi & Himachal Pradesh was selected for developing instruction methodology. The course content as it appears in the curriculum is given below. There was no specific criterion for selecting this subject except that it s an important applied engineering subject.

Course content of Electrical Design and Drawing III

(Fifth Semester Electrical)

1.1 Electrical installations for buildings and ind tries

- 1.1.1 3 phase 4-wire distribution system
- 1.1.2 Protection against overload,short circuit and earth fault
- 1.1.3 Purpose and method of earthing
- 1.1.4 Testing of installations
- 1.1.5 Indian Electricity Rules

* 1.2 Contactor Control Circuits

- 1.2.1 Introduction to three phase induction motors
- 1.2.2 Definitions of equipment used in contactor control circuits
- 1.2.3 motor protection

2.1 Electrical installations

- 2.1.1 Electrical installations for commercial buildings including (a) installation plan (b) single line diagram (c) selection and rating of necessary equipment (d) estimating and costing of material as per given rate schedule
  Note: Atleast two types of building should be taken
- 2.1.2 Electrical installations for small industries including (a) installation plan (b) single line diagram (c)selection and rating of necessary equipment (d) estimating and costing of material as per given rate schedule

* 2.2 Wiring diagrams, schematic diagrams of auxiliary circuits, selection and rating of necessary equipment.The circuits, should incorporate remote control, interlocking, time delay, sequential operation, overload protection etc. applicable to: DOL starters, star-delta starters, slipring induction motor starters, reversing starters, two speed motors, group drives and for similar other applications.

Related Practicals: Wiring, testing and fault detection of contactor control circuits(atleast two exercises).These practicals are to be done under the subject, "Electrical Workshop Practice".

Annexure 5.2

Statements of Problems Identified by the Industries to be given to Fifth Semester students (during Pilot Experimentation)

1. To prepare a competitive tender document for supply of an electrical control panel for a spinning mill as per customers requirement. (Electro-Tech Engineers).

2. Design of a control circuit for automatic stopping of a bunching machine in a cable industry in the event of breaking of any of the strands (Sunhome Cable Industries).

3. Preparation of a customer guide for selection of cable size both copper and aluminium for motors of different HP ratings. (Sunhome Cable Industries).

4. To suggest optimum value of capacitors to be installed in an Oil Mill and their switching arrangement(Khandelia Oil and General Mills).

5. To design & estimate cost of fabricating of a control panel for a customer's requirement (Hanson Enterprises).

6. To trace out fault in the control circuit of a walking beam in heat treatment of spring leaves of automobile spring manufacturing unit. (Jai Parabolic Springs Limited).

7. To design control circuit for an injecting machine with limited operations (International Switch Gears).

Annexure 5.3

Questionnaire for feedback through self assessment

Please give your opinion about the subject(s) you are just completing. Your free and frank opinion will help us a lot. Please tick mark the appropriate answer.

1. Did you understand the objectives and purpose of studying the subject

1	2	3	4	5
Not understood	To a limited extent	To a satisfactory level	To a large extent	Understood fully

2. How do you rate your interest in studying the subject?

1	2	3	4	5
Very low	Low	Satisfactory	High	Very high

3. Were you given opportunity to see and understand practical applications of the subject you are studying?

1	2	3	4	5
Never	Rarely	Occasionally	Often	Always

4. Did you have an understanding of the problem situations you are likely to face in the industry?

1	2	3	4	5
Not understood	To a limited extent	To a satisfactory level	To a large extent	Understood fully

5. Did you get opportunity to demonstrate your real competence (abilities) while studying the subject?

1	2	3	4	5
Never	Rarely	Occasionally	Often	Always

6. Did you get opportunity to develop abilities like communication skill, learning to learn ability, leadership qualities, working cooperatively in groups and sharing ideas in group discussion while studying the subject?

1	2	3	4	5
Never	Rarely	Occasionally	Often	Always

7. Have you developed confidence in solving practical problems to the subject(s) of study?

1	2	3	4	5
Not developed	To a limited extent	To a satisfactory level	To a large extent	Fully developed

Annexure 5.4

Computation of Correlation Coefficients of students scores in various tests.

FIFTH SEM STDNS DATA

FS	PT	BD	CN
56.00	37.00	46.00	40.00
68.00	60.00	43.00	58.00
63.00	30.00	60.00	40.00
66.00	67.00	40.00	52.00
61.00	50.00	40.00	38.00
60.00	53.00	45.00	48.00
64.00	57.00	43.00	59.00
69.00	43.00	59.00	40.00
58.00	50.00	72.00	46.00
81.00	77.00	71.00	80.00
66.00	70.00	62.00	75.00
84.00	53.00	57.00	55.00
69.00	53.00	67.00	50.00
64.00	47.00	41.00	50.00
50.00	53.00	34.00	50.00
70.00	67.00	43.00	60.00
70.00	57.00	50.00	60.00
81.00	77.00	70.00	80.00
43.00	57.00	29.00	60.00
60.00	33.00	40.00	40.00
53.00	53.00	27.00	50.00
60.00	57.00	40.00	58.00
64.00	47.00	47.00	48.00
75.00	73.00	48.00	70.00
81.00	73.00	70.00	75.00
45.00	47.00	18.00	50.00
68.00	63.00	60.00	60.00
75.00	73.00	44.00	75.00
75.00	67.00	59.00	65.00
52.00	53.00	41.00	50.00
51.00	87.00	75.00	90.00
64.00	57.00	72.00	60.00
54.00	70.00	52.00	71.00
76.00	73.00	63.00	80.00
71.00	77.00	52.00	70.00
65.00	77.00	60.00	60.00
71.00	67.00	43.00	50.00
56.00	77.00	73.00	67.00
58.00	37.00	41.00	51.00
78.00	63.00	74.00	55.00
49.00	50.00	65.00	60.00

MEAN	STANDARD DEVIATION
64.4878	10.1648
59.3171	13.4045
52.0976	14.2141
58.4390	12.6318

CORRELATION COEFF. ARE:-

PS	PT	BD	CN
1.0000	0.3742	0.4509	0.3317
0.3742	1.0000	0.4041	0.8643
0.4509	0.4041	1.0000	0.4520
0.3317	0.8643	0.4520	1.0000

Annexure 5.5

Certification of students on the basis of their continuous evaluation in industrial problem solving

Name of Student ____________________ Polytechnic ____________________

Class ____________________ Year ____________________

Statement of Problem of Industry:

Industry & its associated engineer:

Evaluation of Student in Problem Solving

Qualities Assessed	Grades				
	Poor	Satis-factory	Good	Very Good	Commend-able
1. Intellectual Ability	.	.	.	.	.
2. Communication Skill	.	.	.	.	.
3. Skill in Drawing	.	.	.	.	.
4. Initiative	.	.	.	.	.
5. Creativity	.	.	.	.	.
6. Leadership	.	.	.	.	.
7. Professional Judgement	.	.	.	.	.
8. Self Reliance	.	.	.	.	.
9. Regularity	.	.	.	.	.
10. Punctuality	.	.	.	.	.

SPECIAL QUALITY OF THE STUDENT:

IMPROVEMENT NEEDED IN:

Evaluated by:

Date: (Subject Teacher) (Expert from Industry)

Annexure 5.6

Statements of problems identified by the industries to be given to students (during scaled up implementation period)

A. Problems for third Semester students

1. To prepare a design of electrical installation of the flour mill replacing the existing installation which is age old. The design should incorporate modern fittings alongwith necessary protection schemes and the special requirements of control etc. (Sponsored by the Patiala Flour Mill, Chandigarh).

2. To prepare working drawings for certain electrical products as per Indian Standards and also to prepare a suitable leaflet giving specifications and other details for use by the customers for selection of various grades of electrical cables (Sponsored by Pragati Industrial Motors Pvt. Limited, Chandigarh).

3. To renovate the existing electrical installation of the office building of the industry as per the requirements (Sponsored by Bhasin Industrial Corporation, Industrial Area, Chandigarh).

4. To study the electrical fittings of the products Manufactured and to suggest improvements so as to be competitive with similar products manufactured by other industries. The products include coolers,washing machines,geysers, room heaters, etc.(Sponsored by Electricage of India, Industrial Area, Chandigarh).

5. To design a relay operated signal circuit for use in shop cum office building for certain requirements(Sponsored by Bansal Electric Stores, Chandigarh)

6. To design the control circuit for use in a chemical plant . The requirement is that a solenoid value is to open for 5-60 seconds after every 2-6 hours.(Sponsored by Perfect Electrical Controls, Industrial Area, Chandigarh).

7. To suggest reduction of Electricity Consumption in a flour mill(Sponsored by M/s Ram Sarup Babu Ram,Flour Mills No. 2, Grain Market, Chandigarh.

8. The company manufactures quality steel springs and electrical appliances and have over 20 large size induction motor installed in the factory. It is desired that a study is made of the total electrical installations and suggest suitable improvements in the electrical installations including controls, etc.

   Also the company would appreciate design of an attractive product literature.(Sponsored by Mahajan Industrial Corporation,136-140,Industrial Estate,Chandigarh).

9. To give a better design for electrical installations in a residential building including all modern fittings for a customer. (Mr.Tarsem Singla,Contractor,2147,Sector-45,Chandigarh).

B. Problems for fifth Semester students

10. To suggest an economical and reliable control circuit design for control of motors in a pump house of a custoemr. (Sponsored by M/s eekay Electricals, Sector 27,Chandigarh)

11. Renovation of wiring installation of the electrical testing section of an electrical testing indsutry incorporating MCBs, ELCBs, SPPs, etc. and estimation of total cost. (Sponsored by Bhasin Industrial Corporation, Industrial Area, Chandigarh.

12. To design and estimate complete electrical installation for rewiring of one of the hostel blocks of the university. (Assigned by the Construction Wing of Panjab University, Chandigarh)

13. To estimate the cost of Electrical installation of the proposed computer centre of one of the departments of the University.
(Assigned by the Construction Wing of Panjab University, Chandigarh)

14. To investigate the reasons of motors running in opposite directions after restoration of power supply and suggest prevention of such occuring.
(Sponsored by M/s Patiala Flour Mills, Sector 27,Chandigarh)

15. To provide a better design of motor control centre units with given specifications.
(Sponsored by M/s Hanson Enterprise, Industrial Area, Phase I, Chandigarh)

16. To design an Instant Testing Board for testing continuity and short circuit of a manufactured cable.
(Sponsored by M/s Sunhome Cables, Industrial Area, Phase II, Chandigarh)

17. To estimate the total cost of electrical installations of a modern residential house including lighting of tennis court, swimming pool, closed circuit TV, etc.
(Sponsored by M/s Techno Engineering Company Private Limited, Industrial Area II, Chandigarh)

Annexure 5.7

Computation of Correlation Coefficients Scores of Fifth Semester Students in diferent tests

FIFTH SEM STDNS DATA

PR	CN	PS	PT	BD
53.00	71.00	77.00	78.00	77.00
59.00	75.00	60.00	73.00	62.00
44.00	54.00	45.00	2.00	54.00
30.00	28.00	21.00	43.00	54.00
20.00	52.00	20.00	4.00	41.00
60.00	81.00	66.00	82.00	64.00
51.00	57.00	41.00	67.00	55.00
44.00	67.00	39.00	70.00	69.00
4.00	54.00	46.00	47.00	44.00
40.00	67.00	45.00	72.00	79.00
55.00	38.00	32.00	46.00	55.00
50.00	66.00	62.00	66.00	62.00
40.00	69.00	41.00	67.00	59.00
40.00	71.00	67.00	71.00	60.00
25.00	55.00	73.00	55.00	58.00
31.00	54.00	33.00	48.00	53.00
11.00	63.00	23.00	69.00	69.00
60.00	63.00	19.00	57.00	67.00
42.00	69.00	71.00	72.00	70.00
49.00	70.00	66.00	78.00	59.00
40.00	45.00	23.00	14.00	28.00
11.00	54.00	26.00	43.00	23.00
40.00	59.00	63.00	64.00	70.00
45.00	58.00	42.00	10.00	58.00
47.00	61.00	45.00	66.00	67.00
48.00	66.00	69.00	73.00	51.00
59.00	74.00	61.00	75.00	64.00
40.00	56.00	48.00	55.00	63.00
40.00	66.00	61.00	73.00	71.00
40.00	53.00	62.00	6.00	48.00
41.00	70.00	35.00	80.00	65.00
20.00	38.00	42.00	5.00	58.00
45.00	61.00	27.00	60.00	65.00
48.00	71.00	50.00	78.00	77.00
52.00	73.00	53.00	82.00	56.00
49.00	56.00	53.00	62.00	62.00
43.00	66.00	47.00	71.00	58.00
27.00	65.00	60.00	62.00	65.00
18.00	46.00	53.00	33.00	40.00

MEAN	STANDARD DEVIATION
40.0256	13.9164
60.5641	11.0611
47.8718	16.1946
55.8718	23.8824
59.0256	11.8094

CORRELATION COEFF. ARE:-

PR	CN	PS	PT	BD
1.0000	0.4770	0.2971	0.4079	0.4565
0.4770	1.0000	0.5050	0.7208	0.5281
0.2971	0.5050	1.0000	0.3939	0.3499
0.4079	0.7208	0.3939	1.0000	0.6005
0.4565	0.5281	0.3499	0.6005	1.0000

Annexure 5.7 (continued)

Computation of Correlation Coefficients Scores of Fifth Semester Stduents in different tests

VTH SEM STDNS DATA

QZ	SM	GD	RP	OBS
7.50	18.50	12.50	19.50	19.00
6.00	15.00	9.50	14.50	15.00
5.00	7.75	4.50	14.50	13.25
2.00	5.00	2.00	4.50	7.50
2.00	5.00	2.00	5.00	6.00
7.00	17.00	9.00	17.00	16.00
5.00	9.00	4.00	10.00	13.00
3.00	10.00	3.00	9.00	14.00
4.50	11.75	5.25	11.00	13.50
5.00	12.00	4.00	10.00	14.00
3.50	4.50	5.00	9.00	10.00
7.00	13.00	9.00	15.50	17.50
4.50	10.00	4.50	9.50	12.50
8.00	12.00	11.75	17.00	18.25
7.50	18.50	11.50	18.00	17.50
3.50	6.00	4.00	7.00	12.50
3.00	5.00	4.00	6.00	5.00
2.50	4.00	3.00	4.00	5.50
7.50	16.50	12.00	15.25	18.75
8.00	13.50	9.75	17.25	17.50
2.00	3.25	4.00	7.00	6.75
2.00	4.00	3.00	9.00	8.00
5.50	15.50	8.50	16.50	17.00
4.50	5.00\	5.50	12.25	14.75
6.00	9.00	5.00	12.00	13.00
7.50	17.00	11.00	15.50	18.00
6.00	15.00	9.00	16.00	15.00
4.25	10.00	8.00	11.25	14.50
6.25	12.50	9.00	16.25	17.00
6.50	13.25	8.75	17.00	16.50
2.50	9.00	5.00	10.75	14.75
6.25	9.25	4.25	8.00	7.25
3.25	4.25	4.50	6.25	8.75
6.00	12.00	5.00	14.00	13.00
5.00	12.25	6.75	13.50	15.50
5.00	11.00	7.00	15.00	15.00
5.50	10.00	7.50	12.00	12.00
6.50	14.00	7.25	15.50	16.75
3.50	16.50	8.25	10.25	14.25

MEAN	STANDARD DEVIATION
5.0256	1.8308
10.6859	4.4422
6.6026	2.9378
12.0897	4.1624
13.4359	3.9157

CORRELATION COEFF.(PS2) ARE:-

QZ	SM	GD	RP	OBS
1.0000	0.7908	0.8299	0.8667	0.7853
0.7908	1.0000	0.8351	0.8243	0.8308
0.8299	0.8351	1.0000	0.8611	0.8222
0.8667	0.8243	0.8611	1.0000	0.8974
0.7853	0.8308	0.8222	0.8974	1.0000

Annexure 5.8

Computation of Correlation Coefficients of Scores of Third Semester Students in different tests.

THIRD SEM STDNS DATA

CN	PS	PT	BD
65.00	46.00	50.00	56.00
72.00	43.00	50.00	54.00
33.00	52.00	26.50	28.00
62.00	48.25	43.25	52.00
67.00	47.00	50.00	50.00
70.00	29.75	53.25	53.00
70.00	52.00	70.00	58.00
71.00	55.00	60.00	51.00
76.00	67.50	66.50	55.00
65.00	66.25	43.50	53.00
63.00	49.00	46.50	43.00
70.00	48.00	50.00	32.00
61.00	52.75	60.00	46.00
70.00	42.75	43.25	52.00
58.00	37.25	30.00	51.00
73.00	46.50	50.00	43.00
52.00	35.50	40.00	12.00
68.00	36.75	46.50	40.00
70.00	41.50	60.00	54.00
75.00	62.00	60.00	50.00
77.00	53.50	65.00	55.00
64.00	46.25	36.50	44.00
72.00	60.00	50.00	44.00
72.00	43.50	60.00	51.00
70.00	44.00	63.25	51.00
69.00	43.00	60.00	53.00
72.00	51.00	53.25	56.00
65.00	46.50	60.00	56.00
74.00	46.75	43.25	44.00
58.00	42.00	60.00	55.00
78.00	36.00	45.00	30.00
54.00	63.00	68.20	63.00
40.00	33.00	31.50	40.00
82.00	64.00	73.25	60.00
66.00	57.25	56.50	59.00
65.00	55.50	58.25	50.00
72.00	57.50	70.00	51.00
74.00	66.75	55.00	50.00
84.00	70.25	74.00	62.00
64.00	52.75	46.50	51.00
75.00	64.25	63.25	52.00
37.00	44.25	23.25	13.00
75.00	59.50	56.50	50.00
80.00	63.50	70.00	56.00
63.00	52.25	43.25	44.00
74.00	49.75	46.50	54.00
54.00	67.50	46.50	58.00
84.00	69.25	74.00	60.00
66.00	46.00	55.00	60.00
53.00	62.75	33.25	35.00
51.00	34.00	43.25	36.00
51.00	34.00	43.25	36.00

MEAN	STANDARD DEVIATION
66.2692	10.8913
50.7356	10.5740
52.4365	12.2175
48.3077	10.8141

CORRELATION COEFF. ARE:-

CN	PS	PT	BD
1.0000	0.3734	0.7133	0.5655
0.3734	1.0000	0.4810	0.4349
0.7133	0.4810	1.0000	0.6882
0.5655	0.4349	0.6882	1.0000

Annexure 5.8(continued)

Computation of Correlation Coefficients of Scores of Third Semester Students in different tests

IIIRD SEM STDNS DATA

QZ	SM	GD	RP	OBS
5.00	13.00	7.00	11.00	10.00
6.00	12.00	6.00	10.00	9.00
4.00	11.00	7.00	10.00	10.00
3.00	10.00	7.50	11.00	12.00
4.00	10.00	8.00	12.00	13.00
3.00	7.25	4.00	7.50	8.00
4.00	11.00	7.00	14.00	16.00
5.00	13.25	8.00	14.00	15.00
6.50	17.50	11.00	16.50	16.00
7.50	17.25	10.00	16.50	15.00
3.50	11.50	8.00	12.50	13.50
4.00	11.50	7.00	12.50	13.00
4.00	13.50	9.00	13.25	13.00
5.00	11.25	6.00	10.50	10.00
3.00	9.75	6.00	9.50	9.00
5.00	12.50	7.50	11.00	10.50
2.00	8.00	6.00	9.00	10.50
4.75	9.50	5.00	9.00	8.50
4.00	7.00	5.00	10.50	15.00
6.00	14.25	10.00	15.75	16.00
6.50	9.50	11.00	12.25	14.00
3.50	13.75	7.00	12.00	10.00
5.00	14.00	10.00	17.00	14.00
6.00	10.50	6.50	10.00	10.50
6.50	10.00	7.50	10.00	10.00
6.00	8.00	7.50	10.00	11.50
5.25	13.50	9.50	10.25	12.50
6.00	9.00	9.50	13.00	9.00
4.50	10.00	10.00	10.25	12.00
6.00	8.00	10.50	9.50	8.00
4.50	7.75	7.00	8.50	8.50
7.00	13.50	11.00	15.50	16.00
3.00	9.00	6.00	8.00	7.00
7.50	14.50	10.50	15.50	16.00
6.50	14.25	8.00	14.50	14.00
5.00	12.75	9.50	13.25	12.00
5.00	15.50	10.00	14.00	13.00
5.50	16.75	11.50	16.50	16.50
7.50	17.75	11.50	17.00	16.50
4.75	12.00	11.00	11.00	14.00
6.50	14.50	11.00	15.75	16.50
4.00	10.00	8.00	10.25	12.00
7.00	12.50	10.50	14.00	15.50
7.00	14.00	11.50	15.00	16.00
4.50	12.00	10.00	12.75	13.00
4.50	13.75	8.50	12.50	10.50
4.75	13.75	8.00	11.50	9.50
7.50	17.75	10.50	17.00	16.50
5.50	10.00	8.00	12.50	10.00
3.50	8.00	5.00	8.25	8.00
4.25	6.00	5.00	8.75	10.00

MEAN	STANDARD DEVIATION
5.0931	1.3639
11.8284	2.9304
8.3529	2.0467
12.2010	2.6748
12.2647	2.8151

CORRELATION COEFF.(PS2TH) ARE:-

QZ	SM	GD	RP	OBS
1.0000	0.5599	0.6599	0.6331	0.5240
0.5599	1.0000	0.6684	0.8431	0.6556
0.6599	0.6684	1.0000	0.7607	0.6874
0.6331	0.8431	0.7607	1.0000	0.8477
0.5240	0.6556	0.6874	0.8477	1.0000

Annexure 6.1

Electrical Design and Drawing II

(For Fourth Semester Electrical)

Detailed Course Content

1. Estimating and costing for domestic building only

    (i) Various types of wiring as per I.S.S
    (ii) To read and draw diagrams pertaining to service mains, main switch board, and wiring installations
    (iii) To estimate the quantity of material required; and from given rate-schedules, the total cost of material required for the service mains, main switch board, and wiring installations (of house wiring and motor wiring)

    Five drawing sheets (three for house wiring and two for motor wiring)

2. Assembly drawing and detailed working drawings of simple electrical equipment from an actual piece or from a pictorial view like a carbon Brush holder, open knife switch, iron clad switch, motor terminal block, and other similar simple pieces of electrical equipment.

    Four drawing sheets

3. Drawing of squirrel cage induction motor and transformer

    (i) rotor assembly in front and side elevation
    (ii) stator (without end-shields), half in section, front and side elevation
    (iii) end-shield, in section, front and side elevation
    (iv) outside dimension drawing of a complete motor as per I.S.S
    (v) transformer

    Five drawing sheets

4. D.C. Machine elements like pole/coil, commutators, armature, assembly of a d.c. machine

    Two drawing sheets

Annexure 6.2

Electrical Design and Drawing II

(Learning objectives)

Topic-1 Estimating and costing of doemstic buildings

After learning the subject, the students should be able to:

1)define estimating and costing
2)enlist the various types of wiring used,as per I.S.S.
3)compare the different methods or types of wiring
4)draw the diagram of a service mains and main switch and distribution board
5)make a diagram of electric supply arrangement, for a consumer, and
  a)label the various components
  b)install various equipments as per diagram by procuring them from the market
6)make the plan of a house and

  (a) calculate the total electric load of installation using the ratings of different points as per I.S.S.
  (b) find the number of light and fan and power subcircuits as per I.S.S.
  (c) select the correct size of wire/cable to be used for final subcircuit wiring
  (d) select the correct size of wire/cable to be used for mains connections
  (e) select the size of conduit, taking into consideration the number and size of wires to be drawn through it
  (f) select the main switch fuse of correct rating
  (g) select the distribution board of suitable rating
  (h) draw the installation plan showing the main switch fuse, distribution board, switchboards, light and fan and socket outlet points, path of wiring of different subcircuits etc
  (i) draw the electric wiring diagram from the DB to the different outlets
  (j) calculate the length of conduit or teakwood batten required
  (k) calculate the length of wire required
  (l) calculate the length of earth wire required
  (m) write the full specification of each material to be procured from the market
  (n) write the schedule of material and cost as per the given rate schedule

7)design and do estimating and costing as per item number 6 above for a motor wiring installation with small motor

8)make a diagram of wiring installation and

  (a) install the DB and switchboards
  (b) fix the conduits
  (c) draw the wires and do all the related works as per the I.S.S.

Topic-2 Assembly drawing and detailed working drawings of simple electrical equipment

The students should be able to:

1) read, interpret and draw the two views of the assembly drawing of a carbon brush holder
2) read, interpret and draw the assembly drawing and detailed working drawing of a knife-switch.

   (a) single pole single throw type
   (b) single pole double throw type

3) prepare assembly drawing of a busbar post in three views
4) prepare assembly drawing of an iron clad switch
5) prepare front elevation half in section of

   (a) LT pin type insulator
   (b) 11 kV pin type insulator
   (c) disc insulator

Topics-3 Drawings of squirrel cage induction motor and transformers

6) draw the front and side elevation of the rotor assembly of a squirrel cage induction motor
7) draw the front and side elevation,half-in-section of the stator (without end-shield) of an induction motor.
8) draw the front and side elevation, in-section of the end cover of an induction motor.
9) draw the outside dimension drawing of a 3-phase induction motor as per I.S.S.
10) draw the front and side elevation, in-section, of a core and coil assembly of a single phase transformer

Topics-4 Drawings of d.c. machine elements

11) draw the assembly and detail drawing in two views, of a field pole and coil of a d.c. machine
12) draw the front and side elevation half in section of a commutator assembly of a d.c. machine
13) draw the front elevation, half in section of an armature-commutator assembly of a d.c. machine.

Annexure 6.3

Rating scale for evaluation of students on skill in drawing & reading and interpreting of drawings

Name of student________________________ Roll No.______

Ability	Rating: Poor 1	2	3	4	Excellent 5		Score
(a) Drawing skill							
(i) Knowledge of Projections(first angle & third angle)	.	.	.	.	.	x1	
(ii) Quality of line work	.	.	.	.	.	x1	
(iii) Different views(isometric & orthographic)	.	.	.	.	.	x1	
(iv) Dimensioning	.	.	.	.	.	x2	
(v) Lettering	.	.	.	.	.	x1	
(vi) Sectioning & Sectional views	.	.	.	.	.	x1	
(vii) Free hand sketching	.	.	.	.	.	x1	
(viii) Appreciation of neatness & accuracy	.	.	.	.	.	x1	
(ix) Knoweldge of symbols	.	.	.	.	.	x1	
(x) Use of conventions & standards	.	.	.	.	.	x1	
(b) Skill in Reading and Interpreting engineering drawings							
(i) Knowledge of components and their functions in an assembly	.	.	.	.	.	x2	
(ii) Knowledge of dimensions of various components	.	.	.	.	.	x2	
(iii) Identification of components & assembling them	.	.	.	.	.	x2	
(iv) Conception of an object or layout from the orthographic views	.	.	.	.	.	x2	
(v) Conception of the internal details of an object from the sectional views at different planes	.	.	.	.	.	x2	

Total Score

Annexure 6.4

Computation of Correlation Coefficients of Fourth Semester students scores in different tests.

FOURTH SEM STDNS DATA

CN	PT	IN	BD
70.00	74.00	50.00	56.00
66.00	77.00	45.00	52.00
50.00	27.00	40.00	52.00
38.00	34.00	30.00	40.00
37.00	24.00	10.00	54.00
77.00	87.00	70.00	53.00
56.00	74.00	40.00	64.00
54.00	67.00	25.00	40.00
35.00	37.00	25.00	33.00
48.00	50.00	25.00	40.00
60.00	67.00	20.00	55.00
35.00	30.00	18.00	30.00
48.00	64.00	50.00	56.00
49.00	60.00	30.00	52.00
55.00	54.00	30.00	40.00
51.00	57.00	35.00	70.00
40.00	40.00	40.00	25.00
41.00	54.00	30.00	33.00
53.00	70.00	50.00	40.00
36.00	57.00	25.00	40.00
57.00	60.00	45.00	71.00
37.00	23.00	20.00	20.00
32.00	30.00	40.00	12.00
48.00	24.00	22.00	20.00
48.00	47.00	30.00	64.00
57.00	54.00	45.00	70.00
52.00	70.00	30.00	41.00
52.00	80.00	55.00	43.00
74.00	84.00	65.00	41.00
44.00	47.00	40.00	58.00
52.00	70.00	35.00	46.00
39.00	30.00	24.00	42.00
63.00	64.00	30.00	58.00
46.00	28.00	20.00	68.00
39.00	24.00	25.00	30.00
56.00	57.00	40.00	77.00
53.00	74.00	30.00	90.00
61.00	80.00	57.00	60.00
58.00	56.00	40.00	40.00
50.00	58.00	25.00	45.00
51.00	57.00	20.00	58.00
36.00	30.00	10.00	18.00

MEAN	STANDARD DEVIATION
50.0952	10.6878
53.5952	18.8137
34.1905	13.5053
47.7857	16.9123

CORRELATION COEFF.(CLASS4) ARE:-

CN	PT	IN	BD
1.0000	0.7951	0.6676	0.5065
0.7951	1.0000	0.6644	0.4580
0.6676	0.6644	1.0000	0.2578
0.5065	0.4580	0.2578	1.0000

Annexure 6.5

Table values of t for different degrees of freedom and levels of significance

Significance Levels of t*

	Level of significance for one-tailed test				
	0.05	0.025	0.01	0.005	0.0005
	Level of significance for two-tailed test				
df	0.10	0.05	0.02	0.01	0.001
1	6.314	12.706	31.821	63.657	636.619
2	2.920	4.303	6.965	9.925	31.598
3	2.353	3.182	4.541	5.841	12.941
4	2.132	2.776	3.747	4.604	8.610
5	2.015	2.571	3.365	4.032	6.859
6	1.943	2.447	3.143	3.707	5.959
7	1.895	2.365	2.998	3.499	5.405
8	1.860	2.306	2.896	3.355	5.041
9	1.833	2.262	2.821	3.250	4.781
10	1.812	2.228	2.764	3.169	4.587
11	1.796	2.201	2.718	3.106	4.437
12	1.782	2.179	2.681	3.055	4.318
13	1.771	2.160	2.650	3.012	4.221
14	1.761	2.145	2.624	2.977	4.140
15	1.753	2.131	2.602	2.947	4.073
16	1.746	2.120	2.583	2.921	4.015
17	1.740	2.110	2.567	2.898	3.965
18	1.734	2.101	2.552	2.878	3.922
19	1.729	2.093	2.539	2.861	3.883
20	1.725	2.086	2.528	2.845	3.850
21	1.721	2.080	2.518	2.831	3.819
22	1.717	2.074	2.508	2.819	3.792
23	1.714	2.069	2.500	2.807	3.767
24	1.711	2.064	2.492	2.797	3.745
25	1.708	2.060	2.485	2.787	3.725
26	1.706	2.056	2.479	2.779	3.707
27	1.703	2.052	2.473	2.771	3.690
28	1.701	2.048	2.467	2.763	3.674
29	1.699	2.045	2.462	2.756	3.659
30	1.697	2.042	2.457	2.750	3.646
40	1.684	2.021	2.423	2.704	3.551
60	1.671	2.000	2.390	2.060	3.460
120	1.658	1.980	2.358	2.617	3.373
∞	1.645	1.960	2.326	2.576	3.291

*Abridged from Fisher, R. A. and F. Yates. *Statistical tables for biological agricultural, and medical research.* Published by Longman Group Ltd., London, (previously published by Oliver & Boyd, Edinburgh), and by permission of the authors and publishers.

Annexure 7J (a)

HP,Panjab, Haryana, Delhi, Chandigarh Polytechnics
(Developed by TTTI, Chandigarh)

ELECTRICAL MACHINES I

IVTH SEMESTER ELECTRICAL

	L	T	P
Hours/week	4	1	3

1.Generalised Treatment of Electrical Machines

2.DC Machines

3.Transformers (Single phase)

3.1 Definition and principle, Applications
3.2 Constructional features of transformer
3.3 E M F Equation
3.4 Phasor diagram for a transformer on no-load
3.5 Phasor diagram for a loaded transformer, neglecting voltage drop in the windings-Ampere-turn balance
3.6 Mutual and leakage fluxes, Leakage reactance
3.7 Equivalent circuit
3.8 Phasor diagram for a transformer on load
3.9 Voltage regulation
3.10 Testing of transformer as per Indian Standards,Open circuit and short circuit test, calculation of efficiency and regulation
3.11 Efficiency and condition for maximum efficiency. All day efficiency and its significance
3.12 Cooling of transformers, conservator
3.13 Auto transformers construction,working and applications
3.14 Instrument transformers, construction, working and applications
3.15 Difference between power and distribution transformers
3.16 Maintenance schedule of a transformer

Annexure 7.1(b)

Board of Technical Education, U.P. for Polytechnics in U.P.

Electrical Machines I

(Second Year Electrical Engineering)

A. SYNOPSIS AND DISTRIBUTION OF PERIODS:-

Sl.No. Topics	Lecture	Tutorial
1.Energy conversion principle	12	6
2.DC Machines	18	9
3.Transformers	18	9

B. SYLLABUS:-

1.Energy conversion principle
2.DC Machines
3.Transformer

Principle of action of transformer, emf equation, turns ratio. Construction-magnetic circuits-types of cores, primary & secon - dary windings. Terminals, tappings, tapping switches, terminal leads and terminal insulators. Tank-oil cooling devices,conservator, breather. Ideal transformer -No load phasor diagram,leakage flux, transformer on load, phasor diagram,equivalent circuits. Regulation of transformer. Losses and efficiency of transformer. Maximum efficiency, all day efficiency, sumpner's test. Three phase transformers connections, phase grouping.Parallel operation of transformers, load sharing

Special transformer-Auto transformer, welding transformer

Annexure 7.1(c)

Punjab Engineering College & GND Engineering College

Third Semester Bachelor of Engineering(Electrical) Syllabus

Punjab University,Chandigarh

ELECTRICAL MACHINES-I (THEORY)

1. Introduction to different types of electrical machines and their role in generation transformation and utilisation of electrical energy, classification of electrical machines

2. Basic Principles: Concept of flux linkage,self and mutual inductance, speed and transformer voltage, interaction of magnetic fields, production of torque. Blv and Bli concept.

3. DC Machines: Construction, basic principle as generator and motor, armature winding, EMF and torque equations

4. Transformers: Principle of working, construction of single phase transformer, core and shell types.Concept of an ideal transformer and its performance. EMF equation. Distinction between self and leakage inductance. Transformer as a coupled circuit. Equivalent circuit, phasor diagram on no-load and on load, performance calculations -regulations,efficiency.

5. Operation and Testing of Transformers: Effect of saturation on exciting current and voltage, determination of equivalent circuit by O.C. and S.C. tests, back to back test, separation of losses, parallel operation of single phase transformers

6. Auto-Transformers: Principle of operation, advantages, phasor diagram and equivalent circuit.

7. Three Phase Transformers: Different winding connections, their analysis and applications, effect of connections on exciting current harmonics. Inrush current phenomenon,parallel operation of three phase transformers, phase conversion (Scott, 3 to 6, 3 to 12 phase). Three winding transformers-equivalent circuit and applications

Annexure 7.2(a)

Questionnaire for collecting Feedback from Industries

Kindly answer the following questions. Your honest opinion will help us in designing a better system of Teaching-learning for technical students

1. You have received students from polytechnics earlier also. How do you assess this group of students with respect to the students of polytechnics who took training earlier. (Please give points only.

2. What is the preferred method, according to you, of organising industrial attachment of technical students?

   (i) Let students observe only
   (ii) Let students, observe first and then work as assistant to the supervisors and thus develop abilities of facing practical situation/problems
   (iii) Any other method (Please specify below)

3. Would you like to have a regular supply of such trainees who will work as assistants to you?

   Yes/No

4. This group of students have been taught a functional curriculum (copy attached). Based on your past experience of trainees from polytechnics who had studied the normal curriculum (copy attached), do you feel that this group of students were better prepared for the industrial attachment phase?

   Yes/No

5. Give your opinion (based on present experience with this group and your previous experience with students from polytechnics) on the best method of organising teaching-learning for polytechnic students. (Tick the preferred one).

   (i) Normal way of teaching the existing curriculum in polytechnics
   (ii) Teaching of existing curriculum in polytechnic followed by industrial attachment for project work
   (iii) Teaching of a functional curriculum(i.e. a curriculum developed on the basis of functional needs of diploma holders in industry)followed by industrial attachment for project work.
   (iv) Any other method (Please specify)

6. Did the student take interest when asked to do a task?

Yes/No

7. Did the student interact with you regularly to clarify any doubt or make any suggestion?

Yes/No

8. Please study the functional curriculum on transformer and give your specific comments

(i) Satisfies the functional requirement
(ii) Needs revision

Give your specific comment on the topic/aspects to be added/ deleted

____

____

9. Give your rating on the overall performance of the students

(i) Excellent; (ii) Very good; (iii) Good (iv) Just satisfactory; (v) Poor

Annexure 7.2 (b)

Feedback from Teachers (To be taken during the Seminar on 1.8.90 being conducted by students who had returned to polytechnics after their industrial attachment)

You have just listened to the students who had spent one month in different industries/departments doing specific activities assigned to them by the industries. You all had an opportunity to interact with the students. These students were taught a functional curriculum on "Transformer" in the polytechnic and were placed in different industries/departments to work in functional areas as assistants to supervisors. They were also provided with reference study material relevant to the functional areas.

You may kindly give your reaction by answering following questions:-

Q.1 How do you observe the performance of the group of students with respect to similar group of students who have studied the subject but not gone in industry?

(i)	Communication ability	good/poor
(ii)	Knowledge gained	good/poor
(iii)	Self confidence	good/poor

Q.2 These students were evaluated on the basis of day to day observation of their work in industry by the supervisor,group discussion organised periodically, viva-voce, written test, maintenance of training diary, quiz, presentation of technical report, and interview conducted by engineers from industry to evaluate the total personality of a student.

In view of the above do you think the present system of student evaluation as per Board of Technical Education truly reflects the ability of a student?

yes/no

Do you think the evaluation system adopted during the training period is the correct method of student evaluation?

yes/no

Q.3 The existing curriculum as well as the functional curriculum developed through task analysis is attached for your reference. Kindly study both and give your openion regarding their suitability for training of polytechnic students.

(i) We should continue with the existing curriculum
(ii) We whould develop and use a functional curriculum

Q.4 Curriculum material on functional areas have been developed and students used them as reference material during the period of their training. These materials have been displayed in this seminar and you had the opportunity to see them. Do you think such material are most relevant to polytechnic students?

yes/no

Q.5 Would you suggest development of a functional curriculum for a whole discipline and evolve a teaching-learning system similar to the one which this group of students have undergone?

yes/no

Q.6 Are you satisfied with the existing curriculum, the method of teaching and the available instructional material including the present examination system keeping in view the requirements of employers?

yes/no

Q.7 Do you think interaction with indsutry/environment can provide a unique opportunity to bring a change in the system of technical education and training and would satisfy the needs of employers?

yes/no

Q.8 Which according to you, should be the main objective of technical teaching/training?

(i) Pass on information to students as effeciently as possible

(ii) Develop in students abilities of problem solving and thereby learn as to how to acquire relevant informations

Encl: Copy of the syllabus

Annexure 7.2 (c)

Questionnaire for receiving Students' Feedback

1. Give your opinion about the one week contact programme conducted before the industrial training

   Very useful/Just OK/Not required

2. The topics covered during the above programme were

   (i) only theoretical
   (ii) basic theory followed by functional aspects
   (iii) only functional areas

3. The notes and the reference material given to you during this programme were very useful

   Yes/No

4. Were you knowing the training programme in advance giving your date wise training schedule, name of the training supervisor and activities to be taken up in each department

   Yes/No

5. On reporting to the industry on very first day you were having feeling of

   (i) excitement to learn new things
   (ii) being trapped in a difficult situation
   (iii) getting opportunity to relax for 4 weeks time

6. How have you been treated in the industry by your training supervisor and workers?

   (i) neglected
   (ii) supervisors have involved you in the work
   (iii) faced indifferent attitudes of persons of industry

7. By which of the following methods you have learned during the training period ?

   (i) self study
   (ii) observation
   (iii) demonstration
   (iv) group discussion amongst the fellow students
   (v) carrying out tasks
   (vi) interacting with supervisors/engineers
   (vii) all the above

8. Have you received additional information on functional areas from the industry which was not given in the notes provided to you?

   (i) yes, lot of new information
   (ii) yes, but they were also given in the booklets supplied to us
   (iii) no new information was received

9. Through your training which of the following skills you have developed?

(i) reading technical drawing
(ii) supervising assembly of transformer
(iii) measurement techniques
(iv) testing ability
(v) control room operations
(vi) maintenance of transformer
(vii) repairing of a damaged distribution transformer
(viii) installation and commissioning of transformers
(ix) inspection of material
(x) preparation of estimates

10. Name the functional areas in which you have worked specifically during the training

Manufacturing/repairing/operation/maintenance/erection

Can you take up jobs confidently in other areas too?

Yes/No

11. Give your self evaluation with respect to the development of of following abilities during this indsutrial attachment period:-

Abilities	Achievement			
	Above 80%	Between 60% to 80%	Between 40% to 60%	Below 40%
(i) communication skill (ii) ability to analyse a practical problem (iii) ability to participate in group discussion (iv) ability to report the technical matters				

12. If you are appointed supervisor in similar industry, will you be able to take up the job immediately without any difficulty?

Yes/No/Not confident

Annexure 7.3

Comparative Evaluation of Students of experimental group (Group A) and the group who has studied the existing curriculum through institutional training (Group B)

Group A

Sr.No. Name	Written Test: Basic Prin-ciples & Theory	Written Test: Func-tio-nal aspe-cts	Interview by emplo-yers	Interview by Poly. HOD
	(70)	(30)	(100) (Average)	(100)
1st year				
1. Mr. Parveen Kumar	40	9	60	60
2. Mr. Puneet Sharma	51	21	77	80
3. Mr. Gurcharan Sharma	46	12	85	85
4. Miss Rajni Gupta	55	19	70	75
5. Miss Suman Bala Jain	54	20	70	80
6. Mr. Keshav Prashad	48	11	65	70
7. Mr. Narender Singh	51	18	80	95
8. Mr. Anil Kardam	42	11	65	50
9. Mr. Deepak Maheshwari	40	16	60	70
10. Mr. Ajay Dass	42	13	85	95
2nd year				
11. Mr. Neeraj Tandon	62	19	77.5	85
12. Mr. Ajai Jain	61	17	80	85
13. Mr. Suresh Ahlawat	52	13	60	70

Group B (2nd Year Electrical)

1. Mr. Rajinder Kumar	35	3	45	40
2. Mr. Rajesh Kumar	32	3	40	20
3. Mr. Rajesh Kapil	32	5	47.5	30
4. Mr. Yash Pal	34	6	55	15
5. Mr. Satwinder Singh	40	6	45	25
6. Mr. Rajinder Singh	38	7	55	30
7. Mr. Balwant Singh	37	6	40	10
8. Miss Seema Kaushal	30	2	47.5	55
9. Miss Reecha	39	2	50	60
10. Miss Anita	31	4	42.5	45

Annexure 7. 4

Computation of Correlation Coefficients of Students Scores

AMBALA EXPT - STDNS DATA

CON	WTS	EMP	HOD
60.00	49.00	57.50	60.00
71.00	72.00	77.50	85.00
75.00	58.00	85.00	85.00
74.00	74.00	70.00	75.00
73.00	74.00	70.00	80.00
69.00	57.00	65.00	70.00
74.00	69.00	80.00	100.00
59.00	53.00	65.00	50.00
67.00	56.00	60.00	70.00
66.00	55.00	85.00	95.00
82.00	81.00	77.50	85.00
79.00	78.00	80.00	85.00
64.00	65.00	60.00	70.00

MEAN	STANDARD DEVIATION
70.2308	6.6466
64.6923	10.1707
71.7308	9.3225
77.6923	13.2455

CORRELATION COEFF. (AMB.EXPT) ARE:-

	CON	WTS	EMP	HOD
CON	1.0000	0.8283	0.6360	0.6745
WTS	0.8283	1.0000	0.3930	0.4972
EMP	0.6360	0.3930	1.0000	0.8266
HOD	0.6745	0.4972	0.8266	1.0000