CHAPTER - I

INTRODUCTION

"Curriculum for the ten year school-An Approach paper" prepared by the National Council of Educational Research & Training (NCERT) (1975), has made the following observations about Science Education in India.

" There is hardly any need today to justify the place of science in a scheme of general education for school children. Science is all pervasive. Modern societies exist on the basis of science. Science is intimately related to the means of production and means of communication, including transport. Even economics and politics have to depend on scientific factors such as productivity from land or from industry, power of modern weapons or the speed of transportation of ground and air forces. In the present situation anyone, therefore, in any walk of life must be aware of certain quantum of science and technology. Secondaly the scientific method extends far beyond science. All disciplines are becoming scientific. The method of observation, of making symbolic, graphical or linguistic models, designing experiments, of applying reason as well as imagination to draw conclusion from data to formulate theories, the method

of keeping an objective view while theories are tested is a method which prevades every discipline, Facts of today may not be facts of tomorrow and theories may also undergo change, but there can be no going away from the method of Science".

(A)' SCIENCE EDUCATION IN INDIA & ABROAD

Science policy resolution, Government of India (1958) visualised training of men in scientific and technical skills, so that they will solve the national problems of hunger, disease, scarcity and under development.

Third Education Commission (1964) made the following recommendations:-

a) Modernisation of curricula, stress on experimental and field work.

b) Proper balance should be maintained between experimental work and theoretical aspects.

c) The experimental work of under-graduate and post graduate students needs special attention to improve quality of practical work and to integrate it with the learning of theory.

UNESCO Planning Mission (1964) also made a detailed and critical survey of the state of science, education in India. It made a strong recommendation that a practical

and investigatory orientation be given to school science, teaching in India. Many follow up measures were taken up to implement the recommendation.

Some of the major recommendations of the UNESCO Planning Mission regarding practical work were:

1) To provide for one combined laboratory for teaching general science in classes VI-VIII and separate laboratories (Physics/Chemistry & biology) for Teaching Science in senior classes IX-XI.

2) To follow certain specific lay-outs and general equipment of lecture rooms, laboratories in Physics/Chemistry and Biology.

3) The work place of a teacher in a study room should be equipped in such a way as to create therein all necessary conditions for covering all type of activities by the teacher and the pupil's.

4) The work place for pupils should be two seater table where he can carry out all types of work.

5) Provision of the laboratory Assistant's room.

The follow up measures of the mission were:

1) Russian text books were adopted/adapted and translated in English/Hindi.

2) Manufacture of science kits for the primary stage (demonstration only) and for the middle stage (demonstration as well as pupil's Kit.

3) Preparation of teachers guide, test items and audio visual material to support science teaching.

4) Out of school activities like Science exhibitions, field trips, surveys and science club activities, popular science lectures, science magazines relevant to school children etc. Earlier such activities existed only in name but now they are organised on a large scale and on a substantive basis.

5) Rigorous pre-service/Inservice training for science teachers wherein content and methodology were suitably blended. New type of teacher training courses were initiated wherein students were taught the content and methodology.

In order to raise the level of teaching science and mathematics in Indian Schools the following measures were suggested to be taken in the light of the recommendations made by UNESCO Planning Mission (1964-66):-

1) To finalise the preparation of pilot syllabi (prototypes for states) of science and mathematics as compulsory subjects in classes I-VIII.

2) To prepare pilot syllabi (prototypes for states) of science and mathematics in classes IX-XI.

3) To review curricula for the primary and middle levels and of high/higher secondary schools in a phased manner.

4) To start introducing new syllabi and curricula in the schools of all states of India.

5)(i) To prepare the prospective plan and to start preparing the text books, teaching aids and methods guides for teachers in science and mathematics which can ensure the introduction of new syllabi once these are finalised.

(ii) To hold a wide scale discussion on text books prospectus and teaching aids.

(iii) To prepare the plan and start preparing and studying the popular literature for school children using the experience of the USSR and other countries.

6. To increase considerably the enrolment of students studying science in higher secondary schools.

7. To carry out measures regarding research and development of talents in science and mathematics (special curricula and syllabus for summer schools to be established in universities).

8. To prepare, finalise the standard lists of teaching equipment for teaching science & mathematics for Various stages of secondary education.

9. To prepare the prospective plan for the third and fourth five year plans for designing and manufacture of prototypes of teaching equipment and to start their production by 1964-67 having provided budget allocation for this purpose.

10. To finalise work on establishing the central science workshop of the National Institute of Education by 1964.

11. To allocate in 1964 and 1965 special funds to Schools for the purchase of teaching equipment for providing physical, chemical and biological study rooms there with.

12. To organise research work on science and mathematics education in secondary schools.

Sanyal (1969) mentions the various steps taken by NCERT as follow up measures of various commissions/ reports and recommendations regarding improvement and updating of science education. The problem of numbers, ever increasing content, ever changing methodology, newer instructional materials, uneven school structure,

lack of training of teachers and shortage and inadequacy of physical facilities were identified. NCERT devised the solutions by preparing instructional material in science and mathematics by launching curriculum projects in the department of science education and in study groups located in 20 centres, 5 in each subject and by appointment of text book panels or editorial boards. Other measures adopted included launching of the National Science Talent search scheme for identifying talented students, establishment of four regional colleges of education to impart a new type of pre-service and in-service training for teachers, establishment of summer science institutes for training of teachers in the new curriculum projects.

The other measures adopted were the provision of funds to secondary schools for equipment, establishment of state institutes of science, long term and short term training programmes for science teachers. A nine month content course at post-graduate level at universities or state institutes of science for B.Sc. teachers to improve their academic competence.

A major step in the new direction was the launching of project for reorganisation and expansion

of science teaching throughout the school stage with the help of UNESCO & UNICEF. The main components of the project were :

i) Development of new syllabi for science courses for the whole school stage and for teacher training programmes.

ii) Development of instructional materials (text books, laboratory manuals, teacher guides and pre-service training materials).

iii) Training of science educators and science teachers through short term orientation cum refresher courses.

iv) Equiping key institutions and selected schools with necessary science & workshop equipment.

v) Introducing revised syllabi and instructional materials in a phased manner in schools.

Mahalanobis (1964 & 1982) has advocated that science education for underdeveloped countries should evolve through experimentation and research, a system which would be available in time for all the people on a country wide basis, within the means of a nation. The foundation of the science oriented education and research should be to promote the modernisation of a society in a

peaceful way and make conditions favourable for economic development.

Puri (1967) has advocated a science education policy for African countries which is in harmony with the cultural and social ethos of the land.

Subarsky (1965) has mentioned that in East Africa Science education is examination dominated and students are certificate minded. He has further stated that the African student is a serious science learner and means business.

The papers presented by the Nigerian and Ghanian delegations at the commonwealth conference on the teaching of science in schools held at peradeniya, Ceylon (December 1963) complained that science education in these countries was too theoretical leaving little scope for imagination. The purpose of laboratory work was to acquire manipulative skills rather than develop a spirit of scientific inquiry. The schools are short of trained science teachers and well equipped laboratories. Science text books are European in outlook and unrelated to the experiences and surroundings of the children. In Nigeria general science is taught in schools with poorly equipped laboratories and disciplinary science in schools with well equipped laboratories. The medium of instruction of science teaching

being foreign is also a major problem to the African Child. A lot of infrastructure is being created in African states which will help in the development of science education which will be in tune with their needs.

The paper presented by the Newzealand delegation at the same conference claimed that science education in Newzealand was being organised on the same lines as in advanced countries of the West. The country has abundant resources of men and material for the proper implementation of science teaching in schools. Teachers have been oriented in the American curriculum projects in various subjects but they are slowly developing their own curriculum material suited to the national needs.

In a paper contributed by Australian High Commission in Delhi to School Science (NCERT - 1962) it is mentioned that Australian efforts in improving science education in schools has been on the pattern of advanced countries of the West. They have organised summer science institutes to improve science teaching in schools. In these summer schools distinguished university professors (from within the country & abroad) eminent scientists, and school teachers participated. The television was used for reinforcing the training programmes. Some of the

publications of these summer schools had international acknowledgement. The private companies provided financial support for these programmes.

The National Science Teachers Association of America in a position statement (1982) has suggested "a renewed commitment to the aim of scientific literacy for the year 1980's" and that in order to produce scientifically literate individuals, science education, for this decade should focus on the following fundamental goals:

a) To develop scientific and technological process and inquiry skills.

b) To provide scientific & technological knowledge.

c) To use the skills and knowledge of science and technology as they apply to personnel & social decisions.

d) To enhance the development of attitudes, values and appreciation of science and technology.

e) To study the interactions among science, technology, and society in the context of science and related societal issues.

The objectives of Science teaching in communist countries like the U.S.S.R., China and G.D.R. have been identical. The common objectives of science education in all communist countries is to provide polytechnical

education where there is great interaction between theory and practice. Science education at the school level has been so designed that there are enough opportunities for observing and participating in the technological application of scientific theories. The practical experiences encountered in industry are related back to natural science class room where they are explained in a theoretical context. This educational method reinforces the knowledge and skill which pupils obtain in deeper study of sciences.

(Prokofyev) (1972), Swetz (1979) Siebert, (1979) and Bingham (1964) have argued that in all countries of the world Developed, Developing or Under-developed science education is looked as an instrument of national resurgence and change.

In his study of Science Education in the Peoples Republic of China, Swetz (1979) states that every one as early in the childhood as possible learns "Not only politics but also science & technology". Commenting on science education in Nigeria, Asum (1978) observes that "Science graduates are ill equipped to find the relevance of scientific laws and theories outside the school nor can recognise scientific elements in old cultural and

traditional practices. The recommendation of the study is that "curriculum designers, school teachers, and examination councils need to get together and evolve a school science programme that will provide, promote and ensure application of learning to situational problems".

Lee (1978) in his study on the Impact of Science curriculum on American Society concluded that "The quantitative projections based on the data compiled here suggest that a particular societal impact on the university curriculum last approximately ten years and therefore either the impact diminishes or other factors of new significance become dominant".

Bringing out the virtues of the system of Natural Science Education in the German Democractic Republic Siebert (1979) says that "The theoretical learning is strongly interfused with practical or laboratory experience and that the practical experiences encountered by youth in industry are related back to the natural science class room where they are explained in a theoritical context".

The primary task of Science Education in the GDR is to contribute to the major objective of compulsory education to educate and train youth for effective

participation in the socio-economic development of a socialist society and its further development towards communism. The science education in GDR has been geared to have high level of scientific and technical competence through polytechnical education. It is also aimed to have great interaction between theory and practice and relating it to daily life of an individual. It has been strongly influenced by the national requirement of educating and training a cadre of workers with sufficient scientific and technological expertise to permit them to function efficiently in the GDR's skilled work intensive and science intensive industries.

Compulsory education in the United States and the countries of western Europe is showing signs of becoming increasingly incapable of preparing youth for effective and productive adult lives. In contemporary industrial society the quality of science education which is a part of compulsory education in these countries is not of much practical utility. These countrees are also keen to have some type of science education which is of practical and applied in nature. They want students to have training in the skills of science so that enrollment in schools increases, job opportunities for students brighten and students are able to find better general adjustment in life.

Discussing the situation in Thailand says Suchareekul (1979) that "the most significant implication reported is that the rigrous teacher training and new curricula were significantly influencing teacher behaviour in the desired direction which suggests the need for intensifying the emphisis upon developing inquiry teaching skills among all teachers".

Al. Hajji Yacoub (1982) in his study on Science laboratory work in Kuwait concludes that :

a) Middle school students in Kuwait find science laboratory work to be necessary, interesting and helpful to them in learning science. They however seem to be unsure of their ability to do the required experiments properly. They can not decide also which is the better method of learning science, watching the science teachers demonstrations or actually doing the experiments themselves.

b) Girls expressed as much interest in science laboratory work as did boys. Moreover they showed more willingness to actually involve themselves in doing experiments than did boys.

c) Students living in Kuwait city and the residential areas around it indicated more interest in laboratory work than did students in the Coastal towns of Kuwait or inland towns.

d) The middle school science teachers in general seem to agree that their students are sufficiently interested in and are able to perform satisfactorily in the laboratory.

e) The science teachers in Kuwait city and the residential areas around it indicated better attitude towards science laboratory and their student performance in the laboratory than did those in the coastal and inland towns.

B) PRACTICAL LEBORATORY WORK IN SCIENCE

Prokofyev (1972) observed "The success of a school chemistry course depends not only upon the content of the course but also on the teaching methods employed. Chemistry is a science that deals with matter - with what can be seen. During the chemistry course the pupil gains a first hand knowledge of a considerable number of substances. Much can be demonstrated in the classroom. Even in higher educational institution highly qualified professors, whose students are much more advanced than school pupils consider it important that their demonstrations should be of the highest possible standard. This principle is even the more important in school chemistry teaching. The syllabus provides for a comparatively large number of laboratory experiments and plenty of

practical work and schools must have a chemistry room equipped for this. A good experienced teacher will grudge neither trouble nor time to prepare an interesting demonstration, for without laboratory experiments it is impossible to get the most of the study of chemistry". Thus pupils should have opportunities for observation and should acquire the desire to understand why a particular phenomenon occurs.

There is one another very important side to the teaching of chemistry, and that is the link between the chemistry studied at school and that used in industry. As is generally known, modern industrial practice derives a great benefit for advances in chemistry. The chemical industry has become a vital branch of industry, and chemical methods of processing materials are employed in many other industries. Chemical technology is studied at specialized educational establishments, but school pupils should be shown a number of examples of the transititon from laboratory apparatus to production in modern conditions. It is essential to arouse the pupils interest in the ways in which scientific knowledge can be put to practical use".

Paraagh (1972) in his paper "Relevance of Nuffield Chemistry in developing countries" has described the objectives as the acquisition by the pupils of mental and

manipulative skills (rather than as in the past, the memorising of facts) and the attainment of some understanding of the scientific approach to problem solving i.e. arousing the curiousity about a problem, the speculation about explanations and the testing of the suggested explanations by experiment leading to further exploration".

In a paper (Hamblin(1972)) argues that the Nullifield system provides

- a broad outlook on the natural sciences.
- development of the ability to propose hypothesis and to draw conclusions.
- Discussion of difficult problems and methods for solving them.

The National Science Teachers' Association of America (NSTA) in a position statement (1982) has defined the goals of laboratory as under". "The laboratory is the place where students design and perform experiments, manipulate equipment and use the process of science - ask questions, formulate hypothesis, interpret data, and so on. It is the place where they use higher cognitive skills such as analysis and synthesis.

Laboratory outcomes are concerned not only with the cognitive and affective domains but also the psychomotor domain, the third major area of Objectives categorised by Krathwhol, Bloom & Masia (1964). The psychomotor domain is very relevant to science, since laboratory activities require students to perform certain tasks such as manipulating equipment, bending a glass rod, mixing solutions etc. The list is endless ".

C) PRESENT STATUS OF CHEMISTRY TEACHING IN INDIA :

The launching of sputnik by the Soviet Union made the strong impression in the western countries that their science teaching programmes were out of date. One of the outcome of al this concern was three curriculum programmes in Chemistry, i.e., Chemical Bond Appraoch (U.S.A, 1957), Chemical Education Material Study (U.S.A.) (1959) and Nuffield Chemistry (1965) (U.K.) . All these programmes were highly experimental in nature. All the three curriculum programmes were a total package of text books, teacher's guide, laboratory Manuals, supplementary reading material, films etc. Some of the other chemistry curriculum projects of International importance were "Interdisciplinary approaches to chemistry (IAC) (1968). (U.S.A.), the UNESCO pilot project for chemistry teaching in Asia* (1965-66) Bankok (Thailand).

* The countries covered under this project were Afghanistan, Burma, Ceylon, India, Iran, Israel, Japan, Korea, Malaysia, Nepal, Pakistan, Philipines, Taiwan & Thailand.

The other chemistry curriculum projects were launched in Czechoslovakia, Ghana, Nigeria, Hungary, Italy, Japan, Switzerland and Scotland. The materials associated with most of these projects included text books, laboratory manuals, student work books, teacher, manuals and guides as well as many other teaching aids. (Charts, films stips, films, Radio & Television). All these projects laid great stress on experimental approach of Chemistry. These materials had many suggestions for laboratory activities, demonstrations, field trips and projects. Two of these programmes made a strong impact on chemistry teaching in India i.e. Chemical Educations Material Study (U.S.A.) & Nuffield Chemistry (U.K.) 2986 teachers were trained in 79 summer institutes since 1963 run with the help of U.S. AID consultants in case of chemical Education Material study and British Council experts in case of Nuffield Chemistry upto 1969. These curriculum programmes had a deep impact on the teaching of chemistry. The new pattern of education (10 + 2) introduced in 1975 started with new curriculum materials produced by NCERT. To implement these curriculum programmes in Kendriya Vidyalayas, Delhi Administration Schools and other schools

affiliated to Central Board of Secondary Education, New Delhi, a Rigorous training programme was held for teachers throughout India in 1976.

These changes had considerable effect on the chemistry practical syllabus. In 1978 NCERT framed a new practical syllabus for Central Board of Secondary Education New Delhi which, for the first time introduced practicals related to theory and some optional/investigatory projects. The syllabus also toned down the traditional experiments like salt analysis, gas preparation, volumeteric analysis. This syllabus has been in operation ever since 1977*.

Education is a state subject under the Indian Constitution. Every state has a board of secondary education which prepares the practical syllabus in various science subjects. Therefore the position of Chemistry practicals is widely different in different states. The state board of secondary education in Maharashtra has the most advanced syllabus in chemistry practicals. Some of the unique features of the Maharashtra state board of secondary and higher secondary Education, Pune (Maharashtra) are as following:-

- Use of thin layer chromatography for seperation.
- Separating cations by ascending paper chromatography.

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* (Report of the orientation programmes of key personnel of states and union territories published by NCERT New Delhi(1982).

- Preparation of indicators from flower.
- Osmotic pressure - study the property of some natural and artificially prepared semipermeable membranes.
- Determination of rate expression, rate constant, reaction order and half life period in a chemical reaction.

All these experiments are not covered in any other syllabus of any board of secondary education in India. All these experiments are highly advanced in theoretical concepts and experimental techniques. All these experiments are of an applied nature and find many useful applications in industry. While the states of Tamil Nadu, Uttar Pradesh, Rajasthan, Andhra Pradesh fall in the middle rung party new* and partly classical.** While all other states have classical chemistry practical syllabus.

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* New pattern syllabus is usually one which contains experiments related to theory, projects, experiments, related to industrial applications, apart from the traditional experiments of volumeteric & salt analysis (which have been considerably tonned down in terms of time allocation and importance).

** Classical syllabus is usually one which contains traditional experiments, like, laboratory techniques, gas preparation, purification of chemical substances, gravametric analysis, volumeteric analysis and salt analysis.

The practicals included in the various syllabi* range from simple laboratory operations (i.e. cutting, bending, boring etc.) to thin layer or paper chromatography. The usual experiments which find place in all syllabi are volumeteric analysis, salt analysis, Inorganic preparations. Some Syllabi have organic element detection, functional group detection, equivalent weight determination, Avagadros constant determination, preparation of some natural indicators etc.

D) POSITION OF CHEMISTRY LABORATORY IN INDIA & ABROAD

The Indian educationists and educational planners right from the beginning of the post independence era felt that if science education in this country had to improve, the laboratory facilities and laboratory instruction should improve. In fact the reform in science education in this country started with the modernisation of science laboratory and laboratory instruction.

Kothari (1962) had advocated the development of simple apparatus and equipment of good instructional value.

The Taradevi(Simla) Seminar on Science education worked out the details of the laboratories for training

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* Report of the Orientation programmes of key personnel of states and Union territories - published by NCERT, New Delhi-16 (1982)

schools to be equipped. All India Council of Secondary Education (1957) also worked out the details of laboratories and science class rooms.

United National Development Programmes (UNDP) Under the science teaching project prepared a list of equipment to be supplied to all training colleges/ training schools/state Institutes of Science Education throughout the country.

National Seminar on Science consultants at Nainital (1964) also worked out the details of Laboratory equipment and skills in the form of a detailed report. UNESCO planning Mission (1964) made a critical and detailed study of science teaching in Indian schools. The outcome was a report which emphasized the experimental Investigatory approach to science teaching. The members of the mission were the distinguished science educationists of the U.S.S.R. & U.S.A., Directorate of Education Delhi Administration (1964) also worked out the requirements of school laboratories for new approach to teaching science. Bose & Atmaprakash (1976) finalised the requirements of secondary school science laboratories. There are many other scientific committees which investigated the reasons as to why the schools are facing difficulties in equipping the laboratories.

A scientific instruments committee set up by planning Commission (Government of India) (1958) made a detailed study of the requirements of Scientific instruments/equipment required for Science teaching upto class XI. It prepared two sets of equipments *.

In March 1964 the Planning Commission also set up a working group on equipment and scientific instruments. It made the following recommendations, "The educational institutions should be encouraged to fabricate their own equipment. For this purpose the teaching load should be reduced, finances required for the purpose should be made available and teachers should be given suitable incentives. There was a need for an agency to undertake the responsibility of bringing the developed instruments into market. The existing facilities for post graduate education in design engineering and instrument technology should be expanded as well as extended in depth ".

A committee was set up by Planning Commission (Government of India) on science education in schools in 1966. The Committee discussed the need for effective quality control in regard to supply of science apparatus to schools and strongly supported the suggestion that NCERT should undertake on a high priority basis the work of laying down the norms and standards for science apparatus.

* Appendix-IV of the study contained a list of apparatus required for school teaching science upto class XI. Appendex-XVI contained a list of school instruments which were common with the UNESCO list of instruments for science teaching.

The committee also supported the recommendation for the appointment in the state directorates of Education of a senior officer with requsite qualifications and experience in the teaching of science to take chagge of the programme for promotion of science education in schools. The officer should ensure that grants for science equipment were sanctioned in time and that the science apparatus purchased by schools was of standard quality. The committee commended the work done by the recently established science education units in some of the States.

The committee considered the difficulties of the science apparatus industry in maintaining adequate supplies of science apparatus of good quality and recommended that the Central Government should give facilities to the manufacturers for importing sufficient quantities of needed raw materials. The committee also recommended that facilities should be given to the industry to import prototype samples of latest equipment to serve as models as well as testing equipment needed to maintain precision and quality of science apparatus.

The report identified 177 pieces of equipment in physics, 90 pieces of equipment in Chemistry, and 126 pieces of equipment in Biology. Apart from equipment, chemicals, glassware, tools, audio visual aids & misscellaneous items were identified. Tools for science workshop numbering 72 were also identified.

A panel constituted by the committee on plan projects (Government of India) (1962) made a thorough study of the science laboratories and equipment in high/higher secondary schools of India. The panel made a detailed study of the basic requirements, location, space, lighting services, furniture, ancillary acomodation, and height of the laboratories. All these aspects were studied subject wise (Physics/chemistry/biology/home science etc.). The panel drew detailed lists of equipment for Physics, Chemistry, biology and home science laboratories. The panel also made a detailed study of the cost involved in equipping the laboratories. The panel further made an effort to classify items as essential, desirable and supplementary to reconcile the apparently conflicting aims of economy and efficiency in equipping science laboratories. The panel also laid down specifications and standards for equipment and apparatus and procedure for quality control, procedure for allotment of funds and procurement of equipment. It also identified the possibility of having a centralised agency for the manufacture and procurement of scientific equipment,

simplification of methods of work in the laboratories. The panel prepared the lists of equipment/apparatus/chemicals (subjectwise) i.e. physics/chemistry/biology/home science etc).

The panel also prepared the drawing design of the laboratories and furniture/subject wise(physics/chemistry/ biology/home science)

Another panel constituted by the committee on Plan Projects/ Government of India (1964) made a detailed study of the various aspects of laboratory instruction in science at the high school stage. The panel made a detailed study of the financial procedure for grant, purchase etc. of the science equipments/chemicals/and the establishment of science laboratories. It also identified apparatus and equipment. It also made a detailed study of the planning of science laboratories (Basic requirements, laboratory space, laboratory furniture, laboratory lighting, laboratory services, and materials and methods of construction). The other recommendations of the panel were estimating the total requirements of science apparatus, and the need for a special officer to look after science education. The panel also made a survey of the procedure for recurring and non-recurring grants, procedure for financial sanctions for purchase of science equipment and apparatus in schools. The panel also identified equipment (subject wise) for high school and middle schools laboratories. It also

identified items of appratus to be improvised locally by science teachers, tools and implements required for workshops attached to high schools. The panel also prepared a list of tools and implements required for workshops attached to teachers training institutions. The panel also prepared drawing design of science laboratories & laboratory equipment at high school stage. This concern was not felt at the secondary stage alone, the process percolated down to middle and primary stage. In a paper Tamarin & Bhattacharya (1971) mention that NCERT designed and produced science kits (Demonstration kits & pupils kits) for various science subjects and supplied them on a mass scale to various schools, teacher training schools/teacher training college throughout India. At the primary stage NCERT designed and produced a Science kit as a part of total programme "Science is Doing". The middle stage kits in physics chemistry 'Biology and Mathematics were part of the curriculum packages at that stage. Recently (1981) NCERT has designed, fabricated and produced an "Integrated Science kit for secondary stage suitable for Integrated science course syllabus of the Central Board of Secondary Education, New Delhi'.

In a paper Paragh (1969) mentions that Nuffeild project implies that more practical work would be done than had been customary in most schools. The equipment of

school chemistry laboratories is such that most teachers could adopt the Nuffield approach without much difficulty. The main problem is to reduce the amount of time spent on routine operations. The various United National Agencies * (UNESCO,UNICEF) etc. have been helping all developing countries to modernise their science teaching programmes so that they are of experimental Investigatory nature rather than traditional chalk & talk method.

E) THE POSITION OF CHEMISTRY LABORATORY INSTRUCTION IN SENIOR SECONDARY SCHOOLS OF INDIA & ABROAD

In the Indian educational set up, senior secondary stage in most states is the first stage when students can perform the experiments themselves. In most cases this is the first opportunity when the need for higher order chemistry laboratory skills arises. This is the stage when the laboratory instruction is really meaningful. Compared to advanced countries the laboratory instruction is still classical, unimaginative and verification oriented. The chemistry practical syllabi of various Indian states vary greatly and hence the development of chemistry laboratory ** skills acquired by students also vary considerably. In most of the states chemistry practical syllabus is dictated by the demands of the industry and employment market.

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* New trends in chemistry teaching Vol.I (Section 11) UNESCO, paris (1967).

**Report of the orientation programmes of key personnel from states and union territories - NCEFT, New Delhi-16(1982)

The position of chemistry laboratory in some of the developing and underdeveloped countries is still in a poor state on account of lack of trained manpower, lack of initiative from the government, poor working conditions and lack of finances.* In most of such countries the stress is on the confirmatory nature rather than the investigative and innovative nature of laboratory instruction. In order to gear up the national economies of these countries, the laboratory instruction has also to improve. The students should have the fullest opportunity to utilise their talent to acquire the skills and understanding of chemistry laboratory so that they become creative and innovative chemists of future.

Hearle (1974) has identified some of the chemistry laboratory skills at the high school level in America as follows :-

a) Recognition of colour, odour, size and shape

b) Assemble laboratory equipment from picture of model, from verbal or written instructions, from previous experience.

c) Read dials and scales (linear & vernier).

d) Perform complex manipulations/properties.

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* New trends in chemistry teaching (vol III) UNESCO, Paris (1972).

i) Measure volume, temperature, weight, solubality melting point, boiling point, pH and other physical properties.

ii) Build model.

iii) Perform titrations.

e) Make observations and record data.

f) Summarize data & observations by:-

i) Calculations from direct observations.

ii) Calculation from associated formula.

iii) Graph, histogram, table or chart using a provided form.

iv) graph, histogram, table or chart using self developed form.

g) Interpret data and or draw conclusion.

i) from summarized data or observations

ii) extrapolate or predict from summarised data or observations.

h) Design and execute New experiments.

i) Define problems.

ii) Select appropriate path to follow.

iii) Select appropriate equipment and supplies.

iv) Outline the sequence of steps to be followed.

(B) RATIONALE OF THE STUDY

Gibbons (1977) in his study has concluded that "The operational definition of scientific literacy includes six categories, i.e. 13 process skills, 21 attitudes, 58 life science concepts, 56 physical science concepts, 20 ecological and other concepts".

Tietze (1972) in his report has mentioned that "In order for experimental work in chemistry to be productive, it should include several currently accepted objectives of laboratory instruction. Some of the objectives are

1) To develop observational, manipulative preparative and instrumental skills.
2) To acquire illustrate and amplify chemical knowledge.
3) To stimulate thought through experimental investigation.
4) To recognise the precision and limitation of laboratory work.
5) To record accurately and communicate results clearly.
6) To develop personal responsibility and reliability in conducting experiments.
7) To plan and carry out further laboratory work by the effective use of available laboratory resources.

NSTA (1982) in a position statement mentions that students abilities and skills in the laboratory can be assessed through tests composed of series of items related to a task or tasks. Teachers prefer to assess laboratory skills through laboratory performance tests or practicals. These tests can also be used not only to assess practical psychomotor skills but for other cognitive outcomes such as the ability to design experments,make quantitative and qualitative observations,handle certain calculations, analyse and interpret, predict,formulate hypothesis, and apply techniques to new situations.

Laboratory learning is a very costly method of instruction. The cost conciousness is even more relevant in developing and under developed countries. Educational planners and administrators are always worried about the cost effectiveness of Laboratory instruction.* One of the main purposes of this study was to know whether some gain in laboratory skills is achieved during a full academic session. India being a developing country, there is a strong need to find if the students make a good gain during a full academic session. If yes, how much gain do they make? The purpose of this.....

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* The Teaching of science in secondary schools published by John Murray.

study is not only to identify chemistry laboratory skills and measure them but also to find the rationable why students are good at certain skills and poor at other skills. The study is also concerned what are the other areas in the chemistry laboratory skills which can be explored and investigated.

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