CHAPTER - I

INTRODUCTION

1.1. CONCEPT OF SCIENCE

Nothing is comparable to the scientific revolution in its impact on man's material development. It has given him the searching and inquisitive mind to find out cause and effect relationship of every event, to tame the forces of nature, to explore, to verify and to investigate the natural phenomena, to innovate the scientific application in the development of human civilization. Its material benefits are immense and far reaching. Science is liberating and enriching the mind and enlarging the human spirit.

According to Webster¹ 'Science is a branch or department of systematised knowledge that can be made a specific object of study'. In a more precise sense science may be defined as - 'A branch of study that is concerned with observation and classification of facts specially with quantitative formulation of verifiable general laws'.

In the opinion of M.F. Vessel, an eminent scientist² 'Science is an intellectual search involving enquiry, rational thoughts and generation. It represents the descriptive knowledge of our universe - the store house of facts and principles'.

¹ Webster's Dictionary
² M.F. Vessel
Science (Manpower) Project stated\(^3\) - 'Science is a cumulative and endless series of empirical observations which result in the formulation of concepts and theories subject to modification in the light of further empirical observations. Science is both a body of knowledge and the process of acquiring and refining knowledge'.

'Science has thus become constantly more nearly equated with research and has come to connote a process and not a static body of doctrine'.\(^4\)

Einstein says\(^5\) - 'Science is the attempt to make the chaotic diversity of our sense experience to a logically uniform system of thoughts'.

The latest scientific information helps the learner a lot to face new challenges intelligently and boldly to cope with new situation. It also helps the pupils apply and interpret new techniques of science in every day life.

Hence it is not a body of static knowledge. On the contrary it is the fertile skill of acquiring new knowledge and widening the frontiers of knowledge.

Another distinguished science educator, Warren Weaver says\(^6\) - 'Science is an adventure of human spirit. It is an essentially artistic enterprise stimulated largely by curiosity,
served largely by disciplined imaginations and based largely on faith in reasonableness, order and beauty of the universe of which man is a part.

Science helps the students think critically to make unbiased conclusion as a result of logical thinking. It is the continuous and basic search for truths and roots of all discoveries.

Thus in the languages of teaching, science is both a product and a process.

In view of the teaching of science at the school level the curriculum framers have kept in mind their two-fold responsibilities - (i) the product area, i.e. the organised and classified area of already established portion of science and (ii) the process.

1.2. EVOLUTION OF SCIENCE TEACHING AT THE SECONDARY LEVEL

The teaching of science in European Universities started during the middle ages. But in schools teaching of science with attached laboratories is a recent origin - not more than one hundred years. The industrial revolution in Europe gave a momentum to advancement of science education.
In 1858 Michael Faraday urged: "As a branch of teaching men are beginning to recognise the right of science to its own particular place; but now the fitness of University degrees in science is under consideration and many are taking a high view of it as distinguished from literature and think that it may well be studied for its own sake, i.e., as a proper exercise of human intelligence able to bring into action and develop all powers of the mind."

In fact, at present we are living in an age of science. Frontiers of knowledge expand, nature unfolds her mysteries, Astronomy has opened newer vista with the introduction of space rockets, Photon rockets as distance-ceasing vehicles. Bio-chemical engineering achievers, micro-processors, solar batteries, transistors, high yielding hybrid varieties of cereals have been doing miracles in human civilisation. Thus sciences have expanded. All these have set the science-education in the forefront of Education of man.

Education in the past operated within narrow horizons; but in course of time scientific discoveries and industrial development revealed that the strength of modern knowledge depends to a great extent on the industrial development and technology, that is, upon the application of new scientific knowledge. Thus all progresses grow out of man's creative scientific capacities. The most serious explosion of knowledge since the beginning of the twentieth century consequent upon the massive expansion in
science paved the path of progressive movements in Education. In such educational environment the academic scholars have given emphasis on intellectual development. At this crucial juncture "Industrial Revolution" of the West took place and tore apart the boundaries of isolationism. The impact fell upon the countries far away from the heart of the "Revolution".

"The effect of science on human life and thought have become so great and are potentially so much greater that those who have no understanding of them and of the science which has produced them cannot be properly considered educated or truely cultured and are therefore unable to participate in the life of their time. Perhaps scientific-illiteracy is in part due to lack of factual knowledge but is much more the result of a lack of understanding of basic nature and aims of science ... Science should be recognised and taught as a major human activity which explores the realms of human experience, maps it methodically but also imaginatively and by disciplined speculation creates a coherent system of knowledge? .

The policy statement in science education (1961) gave the solid foundation of science education in the secondary school curriculum which so long held a place of secondary importance as a subject, taught in the schools.

India in contact with England developed its system of education after English-pattern. Science-education found its place but maintained a place of secondary importance in school, since under the protection and patronage of the British,
Science never acquired the necessary revolutionary character which it had in the West in terms of challenging the prevalent outlooks and intellectual attitudes generated by them.

India had made serious efforts to upgrade and improve her science-teaching after independence as it was accepted by educationists and national leaders that "Science-education" should be a part and parcel of Secondary Education.

Science-teaching in India during the pre-independence period began in Hindu College (later became the Presidency College) due to the initiative of Raja Rammohan Roy. Later during the 19th century the science-education gradually made its place in Indian Education following the tradition of British Education.

In 1956 All India Science Teachers' Association took initiative to improve the standards of school science instruction to spread scientific information and foster research in the methods of teaching science. In 1961 the Department of Science Education was established under the auspices of National Council of Educational Research and Training with a view to changing the total face of science-education and its teaching in schools in this country.

In West Bengal during the 1st half of the twentieth century science was not given much prominence at the secondary
Matriculation Examination under Calcutta University upto 1960, the School Final Examination under Board of Secondary Education, West Bengal, from 1951 upto 1957. With the introduction of Higher Secondary courses in 1958, science was introduced as a separate stream of Higher Secondary Education under the Board of Secondary Education, West Bengal. This Board introduced "Science" as a compulsory subject in Secondary curriculum (School Final Examination) from 1954. The Secondary Education Commission (1952-53) recommended the establishment of multipurpose school to provide courses at the end of middle school stage (Class - VIII). Accordingly from 1957, "General Science" was introduced in the secondary curriculum in Classes IX and X. Different branches of science i.e. Physics, Chemistry, Biology etc. were taught in classes IX, X and XI as elective subjects in the Higher Secondary Curriculum. This was specially meant for those pupils who possess keen aptitudes, interest and attitude in science education.

In the new syllabus of Secondary Education introduced since 1974 by Board of Secondary Education, West Bengal, "Sciences" were made compulsory thus putting more emphasis on science education in the Secondary curriculum (from Class VI - X). In this curriculum science-education was divided into two broad categories, i.e. Physical Sciences and Life Science. In Physical Sciences taught in Classes VII to X, Physics, Chemistry and glimpses of Astronomy were included. Geology and Soil Sciences were included in Geography. Life sciences taught in Classes VI to X, included Physiology, Zoology, Botany and Nutrition.
It is generally accepted that some knowledge of Physical Science is essential for liberal education. Physical Science trains the pupils to observe and think critically. It develops in the pupils an undaunted spirit of enquiry about the scientific world and the understanding of nature for exploring its secrets. It enables the future citizen to lead happy, well-behaved and useful life as well as to keep themselves abreast of all important developments in the field of science all over the world.

The investigator is rooted to the Indian condition. He has commitments to investigate into the mode of science teaching, its outcome, and he is to suggest remedies for the shortcomings, if any. So he has to dwell upon the objectives of science teaching, laid down by the Board of Secondary Education, West Bengal.

The Board of Secondary Education, West Bengal, introduced Physical Science syllabus in Secondary curriculum since 1974 and it has laid down the following objectives of Physical Science-teaching in Secondary level (VII to X):

(1) to initiate pupils into the realm of play and inter-play of the laws of sciences in life and matter around;

(2) to rouse in the young minds a spirit of enquiry about the nature of matter and forces in nature;
(3) to develop scientific attitudes and enable pupils to understand the important scientific principles involved in the natural phenomena around;

(4) to enable pupils to understand with insight in the application of science to the service of man;

(5) to develop respect for the philosopher scientists, whose contributions have benefitted mankind;

(6) to develop in the pupils of upper forms a spirit of research and experiments to probe into the hidden treasure of the sciences for the enrichment of human life and civilization.

1.3. SCOPE OF GENERAL PHYSICS IN SCIENCE

The term "Physics" originally meant study of the whole nature and hence all the natural sciences like Chemistry, Biology, Astronomy etc. came within the domain of Physics.

The province of "Physics" has now been more restricted. Physics has now been defined as that branch of natural science which deals with -

1) the detailed study of matter, and

11) the natural phenomena that are linked with matter and different forms of energy.
Scientists ascertained that all forms of matter (solid, liquid, gaseous), are composed of some simpler substances known as "Elements". Existence of energy is as true as the existence of matter. But our familiarity with energy grows through its association with material bodies.

(a) Sub-Division of Physics

About a century back "Physics" could not be developed as a separate branch of study. It was simply attached to Applied Mathematics in the Cambridge University.

Glazebrooke was the first teacher of science to organise practical classes in Physics.

Since the middle of nineteenth century nature seems to unfold her secrets throughout a vast range due to the various scientific discoveries all over the world.

Hence manifestations of multifarious physical phenomena led to the primary sub-divisions of Physics for convenience of detailed study.

The sub-divisions of "Physics" are - (i) General Physics; (ii) Sound; (iii) Heat; (iv) Light; (v) Magnetism; (vi) Electricity; (vii) Atomic Physics.
(b) **Scope of General Physics**

General Physics is the basis of all the disciplines of science. Specifically this branch of Physics deals with the properties of matter and the various forms of energy associated with the various forms of matter.

In the opinions of the Physicists and authors of Physics text books the scope of General Physics are restricted to the following domains of Physical phenomena -

1) Different Physical quantities;
2) Units and Measurements;
3) Mechanics : (a) Kinematics; (b) Kinematic Equation;
4) Kinetics and Kinetic equations : Newton's laws of motion;
5) Motion under gravity;
6) Representative, Composition and Resolution of Vectors;
7) Statics;
8) Work, Energy and Power;
9) Friction;
10) Machines;
11) Gravitation;
12) Pendulum;
13) Special properties of solids;
14) Hydrostatics;
15) Floatation of bodies and Archimede's Principle.
The investigator also accepts the above-mentioned domain of the study of General Physics. Since his content area of investigation is General Physics in the Madhyamik syllabus of Class - IX as prescribed by West Bengal Board of Secondary Education, he selected those topics from the syllabus of Physical Science for Class - IX which are directly related to the domain of the study of General Physics as specified in fifteen topics, mentioned earlier.

1.4. OBJECTIVE OF SCIENCE TEACHING (A HISTORICAL PERSPECTIVE) WITH SPECIAL REFERENCE TO TEACHING OF GENERAL PHYSICS

The most important reason for learning science is to develop an attitude of thinking, feeling and acting which is a mixture of curiosity and caution; curiosity leading to correct observation and caution in arguing from the observations.

Science brings about desirable changes in the behaviour of the pupils. The rapid growth and changing nature of scientific knowledge may help to clarify the scientific problems. Hence science teaching must be included in the modern education. The most interested and inquisitive students may thus get scopes for innovative practices.

In the early part of this century the objectives of science teaching were mainly -
(a) to have preliminary knowledge about the laws and theories of science;

(b) to give information about how to improve social status and amenities to ease household activities and comforts.

(c) to provide greater opportunities to the suitable citizens to earn their living with better aptitude like doctors, engineers and scientists etc.

With the change of time in the early 1920's and 1930's the objectives of science teaching were confined in the accumulation of systematized information which help the students solve the problems in day-to-day life situations.

During 1930's and 1940's the objectives of science teaching were (i) to check out the problems of environment; (ii) to correlate among the various problems. Hence emphasis was mainly on the application of principles of science on various natural problems but not on the mastery of facts and principles only.

The objectives of good science teaching after the World War-II were to develop scientific concepts, principles, skills and attitude. Hence objectives were not only based on knowledge
of facts but also on the development of new attitudes, new skills and new ways of thinking.

During and after the Second World War the following categories of objectives were selected -

i) Instructional skills, such as ability to go through the content of science;

ii) Problem solving skills, such as capacity or ability to detect the problems to find out probable hypotheses and to verify these hypotheses by suitable experiments;

iii) Functional information of facts, such as the whole polar system, living and non-living elements;

iv) Functional concepts, such as vastness of space and the mastery of the whole world;

v) Functional understanding of principles, such as the reproductive systems of living beings, and transformation of energy from one form to another;

vi) Attitudes, such as attitude towards learning must be broad and open-hearted;
vii) Appreciation, such as the contribution of scientists should be properly appreciated and the power to understand the cause and effect relationship;

viii) Interest, such as interest in scientific discoveries.

Miller and others explained scientific attitudes as a condition of mind involving imagination and emotional states which are the results of previous experiences.

According to Gagne, at the earliest level of instruction the individual needs to learn how to observe, how to figure, how to measure, how to orient things in space, how to classify objects and events, how to infer and how to make conceptual models. The above mentioned capabilities he will use throughout his life.

Nuffield science project suggests the following objectives of teaching science:

1) to observe the natural phenomena critically and scientifically;

ii) proper reasoning for the phenomena;

iii) finding out the real cause and developing basic concepts;
iv) after convincing the problem forming questions and designing experiments to answer the questions properly;

v) after scientific and proper observations coming to a logical conclusion;

vi) having acquaintance with the problem to command over their solutions;

vii) manipulating skills after acquiring proper knowledge;

viii) communicating;

ix) creating interest and attitudes and aesthetic awareness;

x) formulating the findings after critical systematic observations;

xi) developing patterns of relationship logically.

On the basis of the objectives selected in Nuffield project the UNESCO also suggests the integrated science teaching. The complex problems of revising science curricula in keeping with the nature of modern scientific knowledge have very recently been recognised by the scientists, science
educators and science teachers. Therefore, the science educators suggested integrated science courses.

According to Heiss and others, adjustments to the situations encountered in modern living are not made on the basis of cold factual applications alone but also with feeling and emotion. Each adjustment situation is a complex of feeling, attitudes and understandings. Thus it is evident that a background of appreciations which is peculiar to science should become one of the desired outcomes of instruction in this area.

Development of scientific system within the individual leads the path of science-teaching. So the students should be helped to live in modern world properly and to develop such proper attitudes as expected in a highly scientific and technologically advanced society.

Science teaching helps the students appreciate and enjoy the nature and life. It facilitates proper use of leisure and encourages to take an active and intelligent part in the development of social environment. It helps the pupils think clearly, critically and carefully and foster the scientific method and discipline. It introduces the pupils to lead happy, well-balanced and useful life. It also helps the pupils distinguish between scientific information and popular information and beliefs.
So science teaching should be concerned with - (a) functional understanding of - (i) Scientific Vocabulary; (ii) Scientific facts; (iii) Scientific Concepts, (iv) Scientific abstractions, and (v) Scientific application in new phenomena; (b) Scientific skill; (c) Scientific attitude; (d) Scientific Interest; and (e) Scientific appreciations.

Accordingly an individual who has developed scientific literacy will emphatically -

(a) follow essential characteristics of the processes of discovery in science, i.e. the use of imagination and abstraction;

(b) Understand the theoretical structure of science which is responsible for the relevance and validity of the scientific constructs;

(c) know how an area of science is influenced by the man's beliefs in religion, logic and technology etc.;

(d) be aware of the contribution of common sense in the theories of science;

(e) assess the validity of the theory and confirm the theory; and

(f) understand the essential characteristics of the processes of discovery in science.
The main objectives of science teaching are to encourage the pupil to think critically and draw unbiased conclusions. Hence science education should include the appropriate affective, cognitive, Psychomotor learnings so that it may fulfil the basic human needs.

General Physics is such a branch of Physics the knowledge of which is basic of all sciences and thus plays its role in the study of all other branches of sciences.

Besides its specific scope of course-content on matter, its properties, physical phenomena and energy related with matter, general physics deals with a vital course-content - "Units and Dimensions", the measurement of physical quantities which has its grass root in all sciences. Thus the knowledge of general physics is a must for every pupil in the secondary level to lead a well-behaved happy life in the society as well as to solve the problems of day to day life satisfactorily.

1.5. THE PROBLEM

The objectives are specific goals towards which attempts are directed. The teachers are directly responsible for the success or failure of realising these objectives. The present investigator believes that unless teaching is improved, all attempts of realising the objectives are bound to fail. Therefore, the first and most important task is to establish the fact -
whether the students have adequately mastered the course-content. He feels the need to develop an "Achievement Test", covering all different aspects of the syllabus. He is not blind of the reality of the fact that there is virtually no scope for practical work or demonstration of scientific principles. He is therefore, forced to depend on testing only the cognitive achievement areas of learning which include chiefly: Knowledge; Understanding; Application and Skill.

The common belief is that the science-teaching is not different from the teaching of Geography or History or language etc. This is a narrow view of science-education. And our syllabus of science in Secondary Schools is based on this view.

Therefore, the problem comes to the testing of cognitive achievements of learning outcome only. The investigator intends to analyse critically the students' achievement in General Physics.

1.6. DELIMITATIONS OF THE STUDY

As the investigator has limited time and resources he had to cut down the total syllabus of Physics under Physical Science course and took only "General Physics" portion of Physical Science syllabus of Class - IX (as prescribed by West Bengal Board of Secondary Education in 1974), as his area of investigation.
Since this area of course-content also forms the foundation of Physics and all other branches of sciences it has been chosen by the investigator.

The investigator selected Class - X students who had been just promoted from Class-IX, for the investigation of his problem, since these students had to study classified topics under course content of General Physics and were not heavily burdened with the entire course of Madhyamik Examination.

The present study was a descriptive one. The main objectives of the study were - (i) determination of the extent of achievement of the student in General Physics with the help of an 'Achievement Test in General Physics' developed by the present investigator; (ii) determination of the significance of difference in Academic Motivation and General Intelligence separately between the High achievement group and Low achievement group; (iii) determination of the inter-correlation among Intelligence, Academic Motivation and Achievement in General Physics.

The investigator took his "Data" from three distinct social strata of schools as representative of West Bengal. He selected five schools from Calcutta (Urban area), five schools from semi-urban area and three from rural area.
The schools can therefore represent fairly the various types of schools of West Bengal.

In fine, the limitations are in - (a) the area of course-content, (b) a sample of schools which can represent the total secondary schools in West Bengal, (c) the students of Class - X (Boys and Girls) just promoted from Class - IX, during the earlier months of the academic session of Class-X.

1.7. SIGNIFICANCE OF THE STUDY

The 'Achievement Test' prepared by the investigator in General Physics is a battery of objective tests. The items are all multiple choice-type. The investigator generally depended upon Dr. Bloom's Taxonomy of Educational Objectives. As the battery of Tests had been attempted to make it a standardized one, it was based on thorough content-analysis. It left no content within its limit untouched. Due emphasis had been given on all the areas of cognitive learning, viz. Knowledge, Understanding, Application and Skill.

The 'Achievement Test', thus prepared will help the teacher to lead his teaching-learning activities to perfection.

The school examination papers are generally of recall-type. Little attempts are made to test the ability of understanding or application. Hence this 'Achievement Test' deve-
loped by the investigator on various cognitive objectives of learning General Physics will serve as a guide for future techniques to be adopted by the educators to make the learning perfect.

Since Test-items were carefully prepared chapter-wise, each area received its due weights. Moreover, as the knowledge of fundamentals were tested here the objective of the course was fulfilled.

1.8. STATEMENT OF HYPOTHESES

Assumptions Behind the Hypotheses

Every investigation aims at establishing or rejecting unverified beliefs.

Investigation can also break new grounds, i.e., some proofs or facts, hitherto unknown to others.

But the investigator had some a priori intelligent "Guesses". He might want to check his "Guesses" through investigation. But these "Guesses" should stem out, from the problems of this research project.
The present investigator has formulated the following Hypotheses on the basis of which the design of study had been chalked out:

\( H_1 \): Differentiation in performance of the students in major cognitive objectives of "General Physics" would be evident from the analyses of the responses.

\( H_2 \): The cognitive objectives might be arranged in an "Hierarchical - order", in respect to the performances of the students, as evidenced from their scores.

\( H_3 \): In respect of "Total Scores" in the Achievement Test in General Physics, the "High" and "Low" achievers do not significantly differ in "General Intelligence".

\( H_4 \): There is no significant correlation between the scores in the "Academic Motivation Test" and the scores in "Achievement Test in General Physics of the students.

\( H_5 \): There is no significant difference in scores of "Academic Motivation Test" between the high and low groups of students as determined by their Academic Achievements in "General Physics".
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