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UNDERSTANDING DISCIPLINE AND SUBJECTS

1st SEMESTER • COURSE-V

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Syllabus

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UNDERSTANDING DISCIPLINE AND SUBJECTS

Unit I: Discipline and Subject

Education as Inter-disciplinary Field of Study • Nature and Characteristics of a Discipline • Emergence of Various Disciplines from Education • Merger of Various Disciplines into Education • Interrelation and Interdependence amongst Various School Subjects.

Unit II: Science as a Subject and Discipline

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Unit III: Language as a Subject and Discipline

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Engagement with Field / Practicum

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1

Discipline and Subject

INTRODUCTION

Disciplines are branches of knowledge or categories of teaching, learning and research at the college or university level. They are often called fields of study. A list of academic disciplines will often be presented in tree structure, as some disciples can be further broken down into sub-disciplines. The major Disciplines are Natural sciences, Mathematics, Social sciences, Humanities (often grouped with Linguistics and the Arts), Professional and Applied sciences. Different schools and different parts of the world will group these academic disciplines in their own ways. These are broad categorizations that are more in line with the traditional definition of what constitutes an academic discipline, as was characteristic of early academia around the time of the Renaissance. Today, college and universities have many categories and subcategories of disciplines and the definition has become blurred as to which category a field of study fits into. In many cases, one academic discipline fits into the curriculum of many other disciplines.

The term discipline is not easy to define as it means many things at the same time. It is considered to be the focused study in one academic field or profession. Discipline is referred as branch of knowledge. It is about arrangement of knowledge in a curriculum. The disciplines are taught and researched and are generally associated with higher or university education which is characterized by disciplinary perspective. The term is derived from two

Latin words ***'discipulus'*** meaning pupils and the ***'disciplina'*** or teaching. Discipline is considered as focused study in one academic field of study. The term discipline and field of study are often used interchangeably.

Janice Beyer and ***Thomas Lodahl*** have described disciplinary fields as providing the structure of knowledge in which faculty members are trained and socialized; carry out tasks of teaching, research, and administration; and produce research and educational output. Disciplinary worlds are considered separate and distinct cultures that exert varying influence on scholarly behaviors as well as on the structure of higher education.

According ***Oxford English Dictionary*** discipline is a branch of instruction or education; a department of learning or knowledge; a science or art in its educational aspect. The term discipline also stands for systematic production of new knowledge and for organization of learning. The disciplines are also identified with subjects taught at college or university levels. But not all taught subjects are to be accepted as disciplines. There are well established, well defined disciplines and also nascent ones which are taught as emerging fields of study. The discipline may be explained as a form of specific rigorous scientific training to prepare the practitioners of it and in the process they are being disciplined by their own disciplines for their own good.

The traditional disciplinary perspective of curriculum is now challenged with the advent of global change and knowledge economy. Multiple knowledge perspective has become imperative with the emerging need to promote skill in knowledge creation and innovation. As a result new approaches to organize knowledge have emerged. These are interdisciplinary, multidisciplinary, transdisciplinary and cross disciplinary perspectives of organizing the necessary knowledge.

It is also increasingly being realized that disciplines are not isolated units of knowledge but have permeable

boundaries. So discipline related specialization and categories should not be accepted as absolutely fixed or immovable. With explosion of knowledge it has become necessary to build the bridge where certain aspects knowledge is borrowed from other disciplines to apply in others to solve a particular problem.

Interdisciplinary approach implies blended knowledge from different fields of study. The traditional method of organizing knowledge at the university level has been challenged with the shift in emphasis on application of knowledge and problem solving in different contexts. Rethinking of structuring the curriculum became imperative and new subjects, new curriculum new teaching techniques and new concepts of science and knowledge have developed. It has been termed as 'hybridity' and 'performity' of curriculum signifying connectedness of knowledge and practical usefulness of it. Interdisciplinarity implies interdisciplinary analysis, synthesis and it harmonizes links between disciplines into coordinated and coherent whole. It deals with real world problems which cannot be explained and solved with any single discipline only. Yesterday's subdisciplines have emerged as interdisciplinary subjects like molecular biology, women studies, urban studies and many such branches of knowledge.

In multidisciplinary approach the researchers from different disciplines share knowledge and compare the results but there is no attempt to cross disciplinary boundaries or generate new integrative knowledge. Each discipline contributes professional perspectives of its own on a particular issue. Thus different ideas are gathered in one report of assessment. In multidisciplinary research findings are coordinated but not integrated. The examples of multidisciplinary approaches are health care, urban planning military-industry interface etc.

Transdisciplinarity crosses many disciplinary boundaries to create holistic approach regarding an issue. The prefix 'trans' implies between disciplines, across

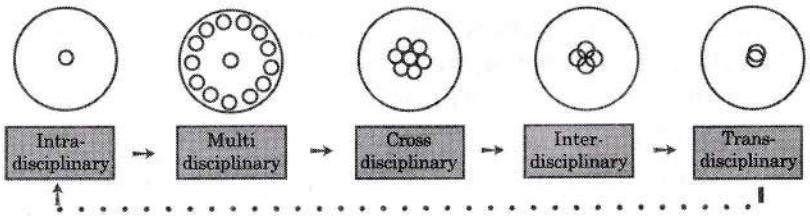
disciplines and beyond each discipline. It is the most desirable approach and also most difficult integrated research work. It seeks to understand the present world which is not possible within the framework of disciplines.

The interdisciplinarity, multidisciplinarity and trandisciplinarity approaches overflow disciplinary boundaries to solve problems or to understand issues in the context of human welfare and pursuit of knowledge. All the three terms refer to involvement of multiple disciplines with varying degree of additive effect, interactivity and holistic approaches on a continuum.

Marilyn Stember (1990) in her paper Advancing the social sciences through the interdisciplinary enterprise, mentioned different levels of disciplinarity.

- Intradisciplinary: This is when contents from different disciplines are combined within a single discipline.
- Crossdisciplinary: It is about viewing one discipline from the perspective of another.
- Multidisciplinary: In this case people from different disciplines work together, each contribute from their disciplinary knowledge.
- Interdisciplinary: It integrates knowledge and methods from different disciplines, using a real synthesis of approaches.
- Transdisciplinary: It is about creating a unity of intellectual frameworks beyond the disciplinary perspectives.

The following diagram proposed by (A.R. Jensenius) may explain the different levels of disciplinarity.



1.1. EDUCATION AS INTERDISCIPLINARY FIELD OF STUDY

The scope of an Education as field of study is wide, though the main theme is teaching and learning. However teaching learning process depends on so many other factors. Therefore, to make this process effective and attain the ultimate objective of developing the personality of a pupil, Education as a subject of study has embraced subject matters from other disciplines.

The three focus areas of the discipline of Education are—

- Learning
- Developmental studies especially during childhood and adolescence and health related issues
- Socio-cultural perspectives of Education as a field of study

Effective learning and teaching process depends on the findings of behavioural science, cognitive science and also on physiology involving the work of brain and other organs of the body. Besides conditions of learning, memory forgetting, attention play important role in this process. In this respect it can be said that difference between Education and Psychology has been bridged. Importance of Psychology in Education was recognized long time back when Pestalozzi pronounced that he wanted to psychologize Education. Today it can be said that Psychology and Education are blended and integrated characterizing the interdisciplinary nature of the latter subject.

Child development as an area of study within the domain of Psychology has become an integral part of Educational studies changing the overall perspective of traditional learning. This synthesis of knowledge going beyond the domain of a particular discipline has also modified the curriculum enhancing its 'performity'.

The development of wholesome personality of the learners and mental health issues are the major concern in education. That is why techniques of psychological

counseling, vocational counseling are integral part of education. The techniques of addressing maladjustment among the students are adopted from psychiatry.

The application of research methodology and quantitative analysis of the education related data requires the use of statistics and other mathematical techniques, which again has enhanced the interdisciplinary nature of education.

Cognitive science too has its tremendous impact on Education thereby ensuring the interdisciplinary nature of Education. The role of neurotransmitters in human cognition is now an important area of research which has great implication for Education as a field of study. Genetics has also contributed in the area of special and inclusive education. This integration of Education with other natural sciences has further strengthened its interdisciplinarity.

The situational view of learning and other socio-cultural contexts of teaching learning process have again demonstrated the importance of study of sociology, ethnography, anthropology, social psychology and women's studies. This development underscores the necessity of incorporating the research findings from these fields to address the issues like equal opportunity in education, universalization of elementary education, bridging the gender gap, correcting the regional imbalances in education. In this respect mention should also be made of another area of social science namely Economics which seeks to integrate educational issues with economic and manpower planning and above all taking correct measures to develop human resources to boost the economic development of a country.

Among the various social sciences which exert profound influence on the discipline of education, anthropology is one. Anthropology is the study of humanity and human diversity around the world. Educationists are interested in cross cultural differences in social institutions, cultural beliefs and communication styles which are the domains of anthropology. The subfields of anthropology are socio

cultural anthropology, archeology, linguistic anthropology and biological anthropology. All these branches are the sources of knowledge to analyse various educational issues. For example Pavlov's theory of learning based on the experiment on dog's salivation and conditioning relates to biological anthropology which studies human physiology and its relation with other animals.

Education as a discipline has accepted input from management science to solve the complex problems like quality education, enhancing leadership quality of the teachers and educational administrators. Quality control, quality assessment, quality assurance, which are the foci of management science, are now increasingly applied in the context of educational institutions.

Education as a discipline has been explained elaborately by ***M Belth*** (1965). According to him education is an independent discipline because it has a unique subject matter. This unique subject matter is the 'act of thinking'. He also maintained that the discipline of education is the study of the modes of thinking practiced by different forms of knowledge. As a process education seeks to develop ability for thinking. Broadly speaking education is the study of all modes of thought and all modes of teaching thought. ***Belth*** (1965) further said that education is discipline of disciplines and a branch of inquiry that inquires into all other branches. It is nurturing of thought. But conventionally education is often equated with schooling.

The above discussion amply shows that Education is essentially an interdisciplinary subject as education related issues are becoming more and more complex and often intractable for which it needs to apply new knowledge from other disciplinary areas. As a process of growth Education as discipline has developed a tree like structure, hierarchically shaped, tightly structured concepts and branches with links to different subject areas.

1.2. NATURE AND CHARACTERISTICS OF DISCIPLINE

Discipline is a branch of learning or scholarly investigation that provides a structure for the students' program of study, especially in the baccalaureate and post-baccalaureate levels. Recognized scholars in the field train students in the thinking and behaviors that are characteristic of the discipline. There is a language idiosyncratic to each academic discipline which socializes its members, trains them in teaching the discipline, researches its strategies and educational, and administers its programs and profession.

1.2.1. Classification of Disciplines

The classification of disciplines was undertaken on the basis of the beliefs held by the members of the different disciplines. Anthony Biglan, the noted psychologist, explained the differences between academic disciplines. Considering the epistemological and cultural dimensions of the disciplines he categorized them into 'hard' or paradigmatic and 'soft' or preparadigmatic disciplines. Besides distinctions were made between natural sciences and humanities or social sciences, pure or primarily theoretical disciplines (e,.g Mathematics) and applied disciplines like engineering. The disciplines were further categorized into bio sciences (engagement with living things) and disciplines belonging to non living system like history. Biglan postulated that epistemology and culture determined the nature of the disciplines and hard natural sciences were more focused and respected than the soft sciences. Thus the taxonomy of disciplines were based on three dimensions namely—

- The degree to which a paradigm exists (paradigmatic or pre paradigmatic)
- The degree to which the subject matters is applied
- The degree of involvement of subject matter with living or organic matters.

Biglan clustered thirty three academic disciplines according to above mentioned three dimensional taxonomy which is termed as Biglan model. So disciples can be categorized in to four groups namely 'hard', 'soft', 'pure' and 'applied'.

1.2.2. History of Development of Disciplines

Education in ancient period flourished in different parts of the world like Egypt, Mesopotamia, China and India. Although there was advancement in knowledge academic disciplines in the modern sense of the term had not emerged. The curriculum in ancient India included the Vedas, Upanishad, Itihasa, Purana all of which comprised Para vidya. Along with these subjects Apara vidya military science, archery, medicines and other practical subjects were taught.

In medieval Europe main three academic disciplines were applied to theology, medicine and law. During the Islamic period, curricula covered a broad range including mathematics (algebra, geometry, and trigonometry), science (chemistry, physics, and astronomy), medicine (anatomy, surgery, pharmacy, and specialized medicine), philosophy (logic, ethics, and metaphysics), literature (philology, grammar, poetry, and prosody), social sciences, history, geography, politics, law, sociology, psychology, jurisprudence, and theology (comparative religions, history of religions etc). Thus categories of subjects were broad and general.

However, as the scientific community started producing new and expanding body of information cataloging them into academic disciplines became necessary. The term disciplinarity which has a modern connotation emerged during 19th century. It is mainly based on Germanic Model arising out of scientific research, publications and graduate education. The explosive growth in disciplines can be linked to the following—

- Evolving of modern natural science
- General scientification of knowledge
- Industrial revolution
- Technical advancement and agrarian agitation.

It is evident that social contexts and overall conditions influence the development of particular disciplines. Political compulsion and historical context determine the evolutionary path of academic disciplines. Quite a number of disciplines are found to be proliferating due to such external factors. For example in recent past the social sciennce was its foreign policy and required specialists in this matter. Similarly computer science and artificial intelligence as emerging disciplines developed due to military funding. Thus the life cycle of a discipline may be traced to its formation, eclipsing and decline. In order to survive an academic discipline must promote marketable new knowledge. It must create new knowledge directly related to application as traditional discipline specific knowledge production within academic departments is becoming obsolete.

1.2.3. Nature of Discipline

Disciplines have a community of scholars with a tradition of inquiry into a particular topic of study. There is a method of research into that topic that outlines data collection and interpretation. New knowledge is added only by strict procedure. Disciplines are classified in many ways. Codification is one way in which the discipline's body of knowledge is unified into theories. Another way is paradigm development in which there is agreement on the defining, ordering, and investigation of knowledge. Physics is an example of this classification.

Besides consistent structure and modeling positive outcomes for the field of study, three major factors of cooperation among colleagues in an academic discipline are: mutual support, shared standards and expectations, and positive educational relationships. The one thing they all

have in common is the connectedness of the relationship between academia and their field of study. Working as partners who communicate effectively and share the same expectations for the discipline in the classroom can offer the right combination of academic integration to bring about success. As always, professors must work as a team, but the academic discipline relationship goes beyond that. In an effective department, follow-up meetings and conferences are common. When a student sees that both his professors and the institution are pulling in the same direction, he or she gains confidence and becomes more reliant on the educational process.

Curriculum developed for a specific academic discipline is often viewed as a necessary process that must be accomplished by the school and its educators in order to provide a foundation for developing education. While it is indeed true that curriculum serves this specific purpose, it appears as if the challenges associated with developing curriculum around a cohesive view of an academic discipline have removed many of the inherent benefits that can be accomplished through this process. Rather the viewing curriculum development as an integrative process that can improve education, curriculum has, in many cases, developed into a mechanistic procedure that provides more headaches than it does benefits for enhancing the discipline.

Although defining any academic discipline and outlining its development is clearly a substantial challenge, researchers argue that, "The curriculum is a sophisticated blend of educational strategies, course content, learning outcomes, educational experiences, assessment the educational environment and the individual students' learning style, personal timetable and program of work". As such, the curriculum is a dynamic tool that can and should be used to both set standards and bolster education in a manner that is both interesting and meaningful for outlining any academic discipline. To facilitate the development of a cohesive definition of an academic discipline, many educators recommend the use of

curriculum mapping. Curriculum mapping would define the elements that are important in achieving the academic goals of the discipline. Influence in the academic profession is derived from disciplinary foundations. A hierarchical structure of authority is not possible in colleges and universities given the autonomy and expert status of faculty with respect to disciplinary activities. Consequently, the structure of higher education is an associational one based on influence and persuasion. Interaction between the professor and the institution is in many ways shaped by the professor's disciplinary affiliation. This condition is not only a historical artifact of the German model of higher education that was built on the "scientific ethos" from which status in the profession has been derived, but it also results from faculty members having their primary allegiance to a discipline, not to an institution.

Thus discipline as an important basis for determining university structure becomes clear. In institutions placing lesser emphasis on research and in institutions more oriented toward teaching, the faculty may adopt more of a local or institutional orientation than a cosmopolitan or disciplinary orientation. In these institutions faculty performance and recognition may be based on institutional as opposed to disciplinary structures. Therefore, the strength of discipline influence on organizational structure in research institutions, liberal arts colleges, and community colleges, for example, can be expected to vary.

1.2.4. Paradigm Shift in the Nature of Disciplines

Paradigms

The term 'paradigm' needs to be explained first before paradigm development and paradigm shift are comprehended. According to American Heritage Dictionary of English Language (2000) paradigm is a set of assumptions, concepts, values, practices that constitute a way of viewing reality for the community that shares them especially in an intellectual discipline. It is often associated with science.

The noted philosopher Thomas Kuhn, said that a paradigm defines the practices that constitute a scientific discipline at a certain point of time. It is discreet and culturally biased. In his famous book The Structure of Scientific Revolutions (1962) he mentioned that the existence of single reigning paradigm is characteristic of natural science whereas the philosophy and social science are characterized by traditional claims, counterclaims and debate over fundamental issues. He observed that scientific research does not progress towards truth and is often subjected to dogma while clinging to old theories.

Paradigm is related to Platonic and Aristotelian concept of knowledge. Aristotle postulated that knowledge could only be based upon what is already known which the basis of scientific nature is. On the other hand Plato believed that knowledge should be judged by what something could become the end result or the final purpose. Thus Plato's ideas were akin to scientific revolution by taking intuitive leaps and Aristotle conceptualized science as patient method of gathering data.

The scientific practices are strongly influenced by paradigm. There are ways in which paradigm dictates the following in the context of a discipline—

- What should be studied and researched within the academic discipline
- The type of questions that are to be asked
- What should be the exact nature and structure of the questions
- How the results of the research are interpreted.

The two other terms are needed to be discussed before paradigm shift is explained ***Thomas Kuhn*** spoke about paradigm development. A well developed paradigm has clear unambiguous ways of defining, ordering and investigating knowledge. At the other end there are preparadigmatic disciplines characterized by high level of disagreement regarding new knowledge, appropriate method of inquiry, criteria for acceptance of the findings and the important

problems related to the study. The discipline of Education and other social sciences are included in this group. Kuhn in this respect held that a student of humanities faces constantly a number of competing solutions to these problems and the solutions for these are to be examined by critiquing them.

Another issue which has a bearing on paradigm is the concept of consensus. It signifies the degree to which the practitioners feel cohesiveness among themselves, absorb the same technical literature, communicate fully among themselves, promote unanimous professional judgments in terms of scientific matters, and share common goals. The consensus within a paradigmatic discipline also ensures how the successors in the field of the discipline should be trained. Obviously high level of consensus is attributed to physical sciences while humanities and social sciences have lower level of paradigmatic consensus.

Paradigm Shift

The scientific paradigm goes through three phases of development. The first phase is the prescience phase when fact gathering process goes on and central paradigm is yet to emerge and take full shape. The second phase is that of 'normal science' when paradigm emerges by the method of puzzle solving and the central paradigm is enlarged. But in the third phase anomalies build up as the results of research or observations fail to solve problems within the paradigm. This is the phase of 'crisis' when rival paradigms emerge and are being accepted. This new paradigms are incommensurable with the previous ones. It means that a paradigm cannot be understood by the conceptual framework and terminology of another rival paradigm. The new paradigms are now accepted by the community and paradigm shift or scientific revolution occurs. For example the Ptolemy's view was replaced by that of Copernicus and Newton. Quantum mechanics replaced classical mechanics. However unlike normal science the rival paradigms may coexist in social science and humanities.

The paradigm shift is continuously occurring with the waves of social change. Toffler's three great historic changes namely development of agriculture, industrial revolution and information revolution have profoundly affected all of society's system and have brought paradigm shift.

Paradigm Shift in the Discipline of Education

The process of teaching learning is as old as human civilization when in primitive period survival skills were taught to the next generation. Since then the system of education has undergone numerous changes. Education as a distinct discipline started developing during 19th century. In our country the subject was first included in the university curriculum after the Sadler commission in 1917 recommended it. Long before that the discipline of education has started incorporating different paradigms. These paradigms were often challenged and new ones were firmly established. During this long period of transformation a number of paradigm shifts have been observed which are given in a tabular form below.

Old Paradigm	New Paradigm
From Teaching paradigm based on algorithm, lower ordered cognitive skills (LOCS)	To Learning paradigm based on higher order cognitive skill (HOCS). Peer interaction, collaboration, mentoring, with reflective teachers as coach.
From reductionist thinking	To Systems thinking
From teacher centric, authoritative frontal instruction, face to face instruction	To student centric, real world, project/research oriented team learning, web based virtual learning, students no longer need a 'place' to learn.
From knowing, recognizing applying of facts for solving exercises	To conceptualize learning for problem solving and transfer.
Education was defined as what teachers teach	Today education is about what the students demonstrate.

Old Paradigm	New Paradigm
From Teacher as sage on the stage, actor on stage	To teacher as guide on the side, interacting coach.
From Faculty as subject experts	To expert in learning styles of the students, developer of modular curriculum, expert in instructional technology, methodology and an effective assessor of students' abilities.
From students listening to teachers, taking notes, reading and taking examinations	To students striving for deep learning and long term retention
From archaic discriminatory examination system	Continuous comprehensive evaluation with concern for abilities of the students.
From elitist caste based education	To mass based education

Apart from the above mentioned changes in education system, this discipline is continuously undergoing metamorphosis within the classroom and the external world like administrative set up with introduction of management by objectives, total quality management decentralization and shared leadership in education.

Challenges to Implement Paradigm Shift in Education

The paradigm shifts in education have thrown grave challenges to teachers and educational administrators. The teachers often fail to meet these challenges. Some of the reasons are—

- Lack of confidence in meeting these challenges.
- Loss of control over class
- Ego of the teachers
- Lack of background training in the use of active learning aproaches.
- Over loaded curriculum.
- The negative mind set etc.

However the teachers cannot be forced to go along with the changes in paradigms in education. Discussions, debates and experimentations and most importantly researches need to be undertaken to accept, reject or integrate paradigms for the improvement of education system.

1.2.5. Characteristics of Discipline

The disciplines develop their own specific methods of research as per its special requirements. Disciplines have institutional manifestation in the form of subjects taught at university and college or academic departments. It is only through these institutions specific knowledge is transmitted from one generation to next. Not all the disciplines show all the above mentioned characteristics as there are many differences among various disciplines. Some disciplines are considered as more useful, more rigorous and students are often attracted by them while others are not so sought after. For example at present Information Technology and Management Science as disciplines are in great demand whereas some traditional disciplines are facing the fate of slow death.

A discipline generally has the following characteristics namely—

- It has theories and concepts on the basis of which specific knowledge is organized. Each discipline has its distinctive knowledge domain. As it develops new theories emerge and old ones are modified and even rejected. A discipline has to do with specific knowledge which is organized, categorized and generally presented in a logical manner.
- Department status, autonomy and formal recognition in academe. A discipline in due course acquires a particular status. It may emerge from a mother discipline but gradually it is given autonomous status as its subject matter becomes more varied and specialized differing more and more from the one it originated. In the process it is recognized as an independent branch of study by the academia.

- A substantial body of knowledge and theory. The discipline is characterized by the specialized knowledge which it professes. The knowledge content is not in isolated form but they are organized in to different theories. The content knowledge is continuously expanded the discipline becomes all the more sophisticated.
- A "common state of mind," including a sense of agreement on areas of inquiry and methods for studying problems, and a common belief that extending the discipline's insights is a worthy endeavor. The people belonging to a particular discipline agree on areas of inquiry within the discipline and there is also agreement regarding its method of study. The pursuit of relevant knowledge within the discipline is considered to be necessary and worthwhile.
- A belief that the continued development of the discipline depends on the generation of basic and applied research. The research, both pure and applied is an integral part of all disciplines. It is obvious that without empirical studies the content knowledge hardly develops. So research work is undertaken in a discipline by its members.
- It is a body of accumulated specialized knowledge. The most salient feature of a discipline is its quantum knowledge which is systematically accumulated and developed throughout its process of expansion. This is why a discipline is defines as body of specialized knowledge.
- A number of people, well known within and outside the discipline, revered as contributors to knowledge, research, and practice. The man is the creator of new knowledge. Any discipline grows and develops because there are erudite scholars who contribute significantly through their research works and relevant practices. This group of people may be directly associated with the particular discipline or even remain outside its circle.

- Support from a learned society. The flourishing of a discipline does not only depend on the contributors within its purview but the learned society too supports a particular discipline.
- A number of people interested in its study. For various reasons a discipline expands and becomes popular as more and number of people start taking interest in it.
- It has a particular object of research. A discipline is a specialized body of knowledge. This is why its research areas are selected on the basis of its objectives of study.
- A recognized area of study. The special area of study of a particular discipline is accepted and recognized by academic world.
- Special terminologies and technical language are used in a particular discipline. The disciplines are specialized body of knowledge distinguished by their own special areas of study. Because of this specialization the disciplines are characterized by their own technical terms, languages and symbols which differentiate them from other disciplines.

Not all the disciplines show all the above mentioned characteristics as there is much difference among various disciplines. Some disciplines are considered as more useful, more rigorous and students are often attracted by them while others are not so sought after. For example at present Information Technology and Management Science as disciplines are in great demand whereas some traditional disciplines are facing the fate of slow death.

Disciplines and school subjects

School subjects are to be differentiated from the disciplines although the two terms are related. The concept of discipline has already been explained. ***Karmon*** (2007) defined school subject as something which gives meaning to curriculum content, teaching and learning activities. ***Deng*** (2015) mentioned that a school subject is an area of

learning within the school curriculum that constitutes an institutionally defined field of knowledge and practice for teaching and learning.

Thus the school subject is knowledge selected from different domains and included in the curriculum. The knowledge base of a particular subject is selected from the related discipline depending on the educational policies of the institutions and the authorities and the relevant teaching learning practices. The selection of the topics of a subject takes into consideration the level of maturity of the students so that they taught matter is appropriate for them. The content of the subject is also arranged keeping in mind the requirements of an effective teaching learning process and pedagogy.

The traditional school subjects are languages, mathematics, science, history geography etc. Most of these are compulsorily taught. However, along with traditional subjects new subjects are introduced in school as aims and objectives of school education change. With the advent of science, technology commerce and other skill related subjects, new fields of study are included in school curriculum. These have originated not from paradigmatic disciplines rather from applied branches of discipline. The examples of such subjects are tourism, hospitality management even fashion designing etc.

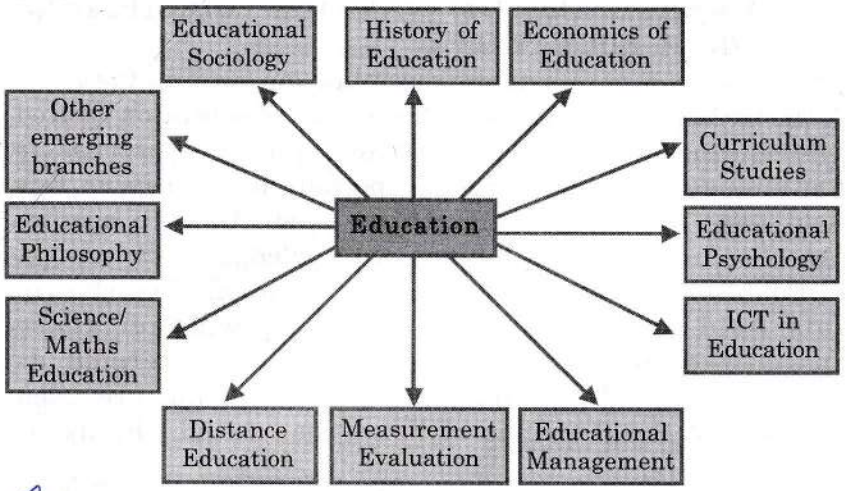
The fundamental difference between school subject and disciplines is the role of research and development. The academic disciplines continue to grow and develop as researches are continuously undertaken to modify and generate new theories. Of course school subjects also continue to develop and change with curriculum revision but in this case the process is slower and conducting research is not the direct purpose of teaching school subjects.

1.3. EMERGENCE OF VARIOUS DISCIPLINES FROM EDUCATION

Education as a paradigmatic discipline emerged in the early 20th century. In recent times the volume of education related information has increased rapidly and the process is continuing. As a result specific specialized interests in this field have become evident. At the same time to acquire expertise in these special areas of knowledge in the context of Education, quite a large number of specific branches in this field have developed. However, whether these specialized fields of knowledge should be termed as discipline is a debatable issue. The following are such offshoots of the discipline of Education, though the list is not exhaustive—

- Educational psychology which may be considered as an independent discipline integrating psychology with education
- Educational Philosophy, Educational Sociology, History of Education
- New emerging fields of Educational Technology, Distance Education, Adult Education
- Education of Children with special Needs
- Science Education, mathematics Education, Teacher Education, Economics of Education, Environmental Education, Public Policy in Education, Educational Management
- Curriculum Studies, Measurement and Evaluation
- Peace Education, Consumer Education.

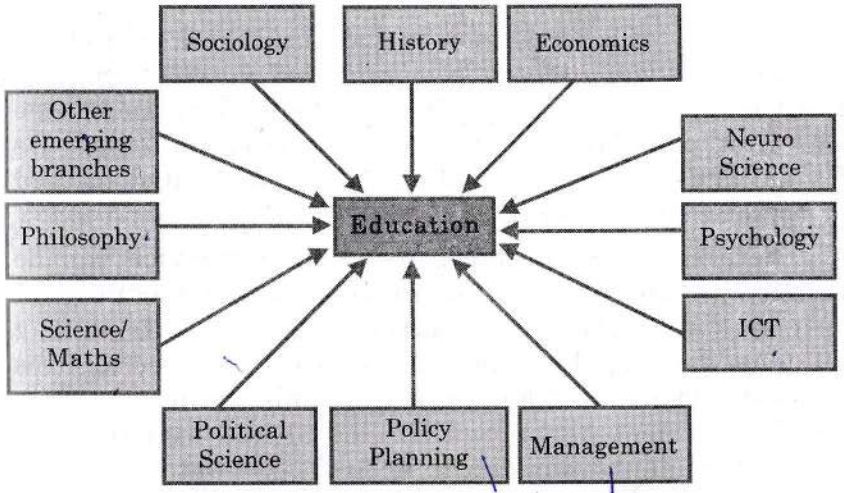
This approach to study of Education is somewhat like infusion model of curriculum development where the ideas, concept and theories studied and developed in Education led to the development of specialized knowledge of Education. These branches of education related specialization may not be considered as paradigmatic discipline. But this points towards the multidisciplinary approach to Education. The figure in next page gives an indication of multidisciplinary nature of Education.



1.4. MERGER OF VARIOUS DISCIPLINES INTO EDUCATION

It has already been mentioned that complex education related problems cannot be solved by the narrow boundary of any single disciplinary knowledge. The subject Education embraced and applied knowledge from other disciplines to attain its aims and objectives. This process is going on for a long time. It can be traced back to the postulates of great philosopher Rousseau who first emphasised on the nature of child the context of education. Since then Education has emerged as a subject of study which has acquired inputs from other areas of knowledge to make teaching learning process effective and at the same time to develop the personality of a child. Therefore the field Education is continuously developing as an interdisciplinary subject of study where boundaries among different subjects have disappeared giving rise to blended knowledge. Inputs from various disciplines like Psychology, Sociology, Political Science, Economics, Technology, Science and Statistics have contributed and have given a unique characteristic to Education. Discarding the traditional garb of strict disciplinarian nature, Education is today a truly interdisciplinary subject embracing the holistic nature of knowledge cutting across the disciplinary division. This

paradigm shift in Education has ensured the total development of personality of students with the concomitant welfare of human society. The interdisciplinary nature of Education is depicted in figure below—



1.5. INTERRELATION AND INTERDEPENDENCE AMONGST VARIOUS SCHOOL SUBJECTS

The division of knowledge in to various compartmentalized disciplines started long time back in ancient time of human civilization. It is obviously an artificial practice as holistic knowledge is more desirable than piecemeal knowledge .Real world problems cannot be solved by the knowledge of only one discipline. If reality is a seamless whole then all disciplines investigating that reality are intimately connected. The holistic view of knowledge implies the knowledge is integral part of inter related whole. Therefore it is increasingly being realized that school subjects are interrelated and interdependent and should be taught in a meaningful way.

Knowledge becomes meaningful when it is not only holistic but also experience based in a real life setting. Problem based learning contextualized within the community of the learners is the best means of making learning meaningful.

Knowledge comes to mind as whole not in isolated bits of information. A child is not able to grasp History, Geography or Mathematics separately but he understands a topic in its holistic form cutting across the boundaries of the subject.

The idea of interrelation of various school subjects is reflected in the concept of method of correlation. The method of correlation signifying unification of knowledge was first postulated by Herbert and later on Zillar, De Garmo and most famously John Dewey advocated method of correlation in teaching.

There are different types of correlation which can be utilized by the teachers to make learning meaningful. Internal or vertical correlation signifies integrating different areas of the same subject so that learner receives a holistic view of it. For example, a history teacher may correlate ancient history with medieval and modern parts to help students develop a holistic concept of human civilization.

External or horizontal correlation occurs when topics from different school subjects are integrated to give a meaningful concept. For example science and mathematics are coordinated to explain the scientific laws and their verifications.

The researches have shown that significant learning occurs only when meaningful class room experiences take place. These meaningful experiences have to be based on interdisciplinary forms of education as experiences cannot be broken according to different subjects. Significant learning based on interrelating the subjects fosters strong foundation of knowledge, helps students to apply knowledge. The students learn to connect ideas, understand social and personal issues and most importantly learn to learn. Moreover, the students are less likely to forget something which is formed as a network of connected meaningful knowledge.

The different school subjects are not only interrelated but also interdependent among themselves when the process of learning occurs. The interrelation signifies the common elements within the subjects while interdependence implies that teacher has take help of other subjects while discussing a particular topic from a particular subject. The kind of interrelationship and interdependence among the school subjects is discussed in brief.

Science, mathematics and languages are the subjects which need to be integrated among themselves and with other subjects like history, geography and other social sciences. Art and craft music can also be practiced with reference to other school subjects. All these subjects are complimentary to each other and taught to achieve the aim of education, that is, the overall development of the learner.

Science is a practical subject but without command over language a student will not be able express and explain scientific principles and laws even though he may understand them. The language teacher can ask the students to write essay on science topics. Science teacher and language teachers take the joint responsibility of helping students express their scientific views orally or in written form.

Even the casual observer can see that there is a link between mathematics and science. But how the two subjects should be related and integrated in the curriculum is far from straight forward. It is admitted that ultimately science is resolved by mathematical models and without mathematics science cannot be explained as there are universal use of mathematical notations in science. The relationship is explained by famous scientist Haldane who said that if someone cannot use something in equation then he does not know the meaning of that thing.

Integration of mathematics and science can be done in terms of content, process and methodology of teaching the two subjects. Regarding content specific integration, some of the topics may be required to be studied in depth before

they are integrated with other disciplinary knowledge. So it is to be noted that not all mathematics and scientific concepts can be integrated. Basic concepts in science and mathematics need to be taught first and separately. But even then the topic may be correlated with science with mathematics or vice versa. For example, study of simple machines can be correlated with the concept of proportion in mathematics.

The process integration means use of real life activities in classroom based on experiment, collection of data, and analysis of data.

The methodology plays important role in integration of teaching science and mathematics. The constructive approach involving inquiry, discovery and learning cycle is effective in the process of integration. Inquiry and discovery learning are known to the teachers. In learning cycle format the students explore the situation, use manipulative and familiar activities to develop concept before symbols, procedure and algorithms are taught.

Thematic approach to integration is also being realized as a potent means of integration of subjects like not only science and mathematics but also other disciplines namely geography and history. For example, "oil spill' is a theme which can be successfully taught with the help of science (physics particularly) effect on marine life (natural science), mathematical calculations of loss and of course economic fall out of it.

The above mentioned principles of integration can be applied while teaching all the school subjects including art and craft. This is the scientific approach to meaningful learning and concept development. It helps the students to develop the ability for critical and reflective thinking. This holistic knowledge also helps them in solving real life problems. The modern trend in this respect is evident in present B Ed curriculum in which the subjects are grouped together to help trainee teachers understand the importance of inter relation and interdependence of various school subjects and teach accordingly in the classrooms.

Questions

☛ Objective type (2 marks)

Q.1. Define the term 'discipline'?

Ans. Disciplines are branches of knowledge or categories of teaching, learning and research at the college or university level. They are often called fields of study. A list of academic disciplines will often be presented in tree structure, as some disciples can be further broken down into sub-discipline The major Disciplines are Natural sciences, Mathematics, Social sciences, Humanities (often grouped with Linguistics and the Arts), Professional and Applied sciences.

Q.2. What are three broad heads under which the disciplines are categorized?

Ans. The broad Disciplines are Natural sciences, Mathematics, Social sciences, Humanities (often grouped with Linguistics and the Arts), Professional and Applied sciences. Different schools and different part of the world will group these academic disciplines. These are broad categorizations that are more in line with the traditional definition of what constitutes an academic discipline, as was characteristic of early academia around the time of the Renaissance. Today, college and universities have many categories and subcategories of disciplines and the definition has become blurred as to which category a field of study fits into. In many cases, one academic discipline fits into the curriculum of many other disciplines.

Q.3. Define 'Performity'.

Ans. The term performity is related with interdisciplinary approach to knowledge. Performity indicates connectedness of subjects and practical usefulness of them.

Q.4. What were the three main disciplines in medieval Europe?

Ans. In medieval Europe three main academic disciplines were theology, medicine and law.

Q.5. What is interdisciplinarity?

Ans. Interdisciplinary approach implies blended knowledge from different fields of study. The traditional method of organizing knowledge at the university level has been challenged with the shift in emphasis on application of knowledge and problem solving in different contexts. Rethinking of structuring the curriculum became imperative and new subjects, new curriculum new teaching techniques and new concepts of science and knowledge have developed

Q.6. Give two reasons for explosive growth of disciplines.

Ans. The traditional disciplinary perspective of curriculum is now challenged with the advent of global change and knowledge economy. This is one reason. Another reason is Multiple knowledge perspective has become imperative with the emerging need to promote skill in knowledge creation and innovation. As a result new approaches to organize knowledge have emerged. These are interdisciplinary, multidisciplinary, transdisciplinary and cross disciplinary perspectives of organizing the necessary knowledge.

Q.7. What is meant by interdisciplinary knowledge?

Ans. Same as Question no. 5

Q.8. What are the three important focus areas of education as discipline?

Ans. The three focus area of the discipline of Education are-

- Learning
- Developmental studies especially during childhood and adolescence and health related issues
- Socio cultural perspectives of Education as a field of study

Q.9. Mention within two sentences how the study of child development has influenced the discipline of education.

Ans. The study of child development has helped the discipline to incorporate teaching strategies in accordance with the development stages. Also it has shown how psychological factors affect the process of learning of a student and management of class

Q.10. What is the role of management science in the field of education?

Ans. Education as a discipline has accepted input from management science to solve the complex problems like quality education, enhancing leadership quality of the teachers and educational administrators. Quality controls, quality control, quality assurance, which are the foci of management science, are now increasingly applied in the context of educational institutions.

Q.11. What do you mean by transdisciplinarity?

Ans. Marilyn Stember (1990) in her paper Advancing the social sciences through the interdisciplinary enterprise, mentioned different levels of disciplinarity. Among these different levels, interdisciplinarty is one.

Intradisciplinary is that level of organizing subjects when contents from different disciplines are combined within a single discipline.

Q.12. What is cross disciplinarity?

Ans. Marilyn Stember (1990) in her paper Advancing the social sciences through the interdisciplinary enterprise, mentioned different levels of disciplinarity. Among these different levels, cross disciplinarity is one.

Cross disciplinarity is that level of organizing subjects when one discipline is viewed from the perspective of another.

Q.13. Indicate the primary needs horizontal correlation in various school subjects.

Ans. Knowledge comes as whole. So division of various school subjects and teaching them separately is artificial process. Therefore there is a need for horizontal correlation while teaching a topic. It means integrating and assimilating knowledge from different perspectives.

Q.14 What is meant by integration of mathematics and science?

Ans. It is admitted that ultimately science is resolved by mathematical models and without mathematics science cannot be explained as there are universal use of mathematical notations in science. The relationship is

explained by famous scientist Haldane who said that if someone cannot use something in equation then he does not know the meaning of that thing. Science can not be explained unless the universal notations of mathematics are known.

Q.15 What is meant by the term external correlation in various school subjects?

Ans. External or horizontal correlation occurs when topics from different school subjects are integrated to give a meaningful concept. For example science and mathematics are coordinated to explain the scientific laws and their verifications.

Q.16 What is the concept of multidisciplinary?

Ans. In multidisciplinary approach the researchers from different disciplines share knowledge and compare the results but there is no attempt to cross disciplinary boundaries or generate new integrative knowledge. Each discipline contributes professional perspectives of its own on a particular issue. Thus different ideas are gathered in one report of assessment. In multidisciplinary research findings are coordinated but not integrated. The examples of multidisciplinary approaches are health care, urban planning military-industry interface etc. Also give the picture of the circle presenting multidisciplinarity.

☛ Short type/Short note (5 marks)

Q.1. Mention how different subjects have been merged in the discipline of education.

Ans. From topic head 1.4 , Page no. 22- 23

Q.2. Discuss how academic subject is related to academic discipline.

Ans. From page 11-12. Starting from the sentence " Although defining any academic discipline.....expected to vary Upto the last line before the beginning of 1.2.4

Q.3. Write a short history of development of academic discipline.

Ans. Page no. 9 topic head 1.2.2

Q.4. Short note on Nature of discipline.

Ans. Page no 10 topic head 1.2.3. However, it is to be made brief as the question is of 5 marks.

Q.5. State how different disciplines have emerged from the discipline of education.

Ans. Sub topic head 1.3 Page No. 21

Q.6. Elucidate the concept of interdisciplinary.

Ans. Page No 3 second paragraph.

Q.7. What are the different characteristics of discipline?

Ans. Page No-17. Sub topic head 1.2.5

Q.8. Describe paragdigmatic and preparadigmatic disciplines with examples.

Ans. See Page 12 sub topic head 1.2.4

Q.9. Write briefly about the cross disciplinarity.

Ans. Elaborate the answer of Q. 12 of short type questions.

Q.10. Differentiate between transdisciplinarity and cross disciplinary.

Ans. Define both the terms. Give examples. Show the pictorial forms of the two.

Q.11. Mention any five characteristics of discipline.

Ans. Same as Q. 7

Q.12. Justify education as an interdisciplinary education.

Ans. See page 5 topic head 1.1

Q.13. Write a short note on inter relationship among different school subjects.

Ans. See page 23 unit head 1.5

Q.14. Explain in brief the history of development of disciplines.

Ans. See page 9 unit head 1.2.2

Q.15. Point out the needs of interdependence amongst various school subjects.

Ans. See page 23. Sub unit head 1.5

Q.16. State the importance of interrelation amongst various school subjects.

Ans. Page 23. Sub unit head1.5

Essay type (10 marks)

Q.1. Explain the interrelation amongst Various School Subjects.

Q.2. "Education as interdisciplinary field of study"-why? Discuss.

Q.3. Write about the nature and characteristics of discipline.

Q.4. Discuss how different subjects merged into the discipline of education and emerged from it.

Q.5. Analyze the content of challenges to implement paradigm shift in education.

Q.6. Indicate the differences between disciplines into and from education.

Q.7. Write a note on interdisciplinary and multidisciplinary approaches to the study of disciplines.

Q.8. Analyze the paradigm shifts in education.

Q.9. Analyze the content of interdependence amongst various school subjects.

Q.10. Describe history of development of disciplines.

Q.11. Analyze the content of merger of various disciplines into education.

(Answers to all the these questions can be obtained from the short answer questions only explain them in detail.)

2

SCIENCE AS A SUBJECT AND DISCIPLINE

The word "science" originates from the Latin word "scientia" (sye en' tee uh), which means "to have knowledge." It can be generally considered as a process dedicated to the accumulation and classification of observable facts in order to formulate general laws about the natural world.

Science is defined as the methodological approach to study natural world. It is also considered as the system enterprise that creats, builds and organizes knowledge in the form of testable explanation and predict about universe. Science requires empirical evidence to logically support the conclusions. It is concerned with the questions like how the world works, what will be the future changes etc. The scientific process is based on observation of phenomena, testing and interpreting them on the basis of logic.

Science has different components and it is subduided into natural science which studies material world, social science, and formal science like mathematics. The applied science includes engineering and medical sciences among many other such branches.

2.1. NATURE AND HISTORY OF TEACHING SCIENCE

The nature and history of science is well developed discipline. It can be conceptualized as the changing concepts of man regarding the world of nature. Science is not about modern inventions or discoveries but commonsense

interpretation of the world around us. This practice developed with the history of human civilization. Only in last century science became sophisticated.

Nature of Science

It is to be noted that the nature of science and method of science are different. According to NSTA (National Science Teachers Association), Standards for Science Teacher Preparation, the researchers have shown that the teachers and students often lack knowledge about the basic assumptions of science although they are aware of scientific methods. So it is necessary that the teachers should understand the nature and assumptions of science the assumptions of science are—

(a) ***Science has limitations:*** Not all problems or natural phenomena can be explained or interpreted by science. Science can not deal with any kind of problem. It mainly addresses natural problems not the supernatural problems. The natural phenomena, subject matter of science should be differentiated from super natural ones. Super natural phenomena can not be definitely or reliably tested by empirical evidence, but natural phenomena are open to approval or disapproval on the basis of empirical verification. Critical testing of scientific knowledge has helped to understand the scientific knowledge in a better way and in the process the quantum scientific knowledge has accumulated over the time.

(b) ***Scientific knowledge is uncertain:*** It is based on a degree of probability and level of confidence. Some scientific knowledge are highly reliable, some are speculative. The tentative nature of science has been recognized as new inventions and discoveries often reinterpret the established facts of science. Established scientific facts have been changed and modified as further observation and experimentations have challenged the veracity of the facts. Thus the scientific facts are tentative yet they are durable and self corrective.

(c) Science has been found to be misused and poorly explained- Pseudoscience and unconfirmed claims are not scientific facts. Falsified data (often in the field of medical science) are propagated as experimentally verified facts.

(d) Science should not be equated with myths, personal beliefs, religious values, mystical inspiration or superstitions. All these may be socially relevant but they are not science. These subjects like politics, religions ethics and aesthetics are beyond the power of science. For example the science has developed the method of cloning but it cannot say whether it is ethically correct to clone humans or desirable.

(e) Science, however, is influenced by social, political and cultural aspects of a country. Because these aspects determine the priorities regarding the types of scientific researchers are to be undertaken.

(f) ***Science is a social process.*** It is based on collaborative work where the team of scientists works together for scientific progress. Science is shared by particular scientific community. The scientists attend conferences, peer review publications for scientific errors, oversight and to expose fraud.

Understanding the nature of science is an attribute of scientific literacy and is required to make informed decisions. This will serve as a defense against unquestioning acceptance of pseudoscience and the prospective teachers and students must be aware about the nature of science.

Basic assumptions of science

The word assumption means something taken for granted. The following are the basic assumptions of science.

1. There are many things that happen around us. The science assumps that these happenings are due to natural causes. For example, when a stone is dropped

from a height it falls downwards. This down ward movement is due to some natural cause and in this case gravity.

2. The science further assums that it is possible learn more about these causes by the help of evidence.
3. Such causes which operate in the natural world are consistent. In other words the universe is orderly, which means that its behavior is regular, consistent and structured. These behaviours are termed as natural laws.
4. Our senses and perceptions often provide us with reliable information about the universe but these perceptions are not always perfect.

Philosophy of Science

The basic assumption of science is that there is an objective reality which is shared by rational observers.This objective reality is governed by the natural laws. These laws are discovered by systematic observation and experimentation. The philosophy of science seeks to explain what these assumptions mean and whether they are valid.

Empiricism is the most popular thought in philosophy of science. It is based on observations and the generalized findings from these observations. The two versions of empiricism are bayesianism and hypothetico deductive method.

Empiricism is contrasted with rationalism. Its chief proponent was Descartes. According to it knowledge is created by human intellect.

The scientific method is the first real step on the road to what is today known as philosophy of science. Many scholars have contributed to the philosophy of science. Among them, ***William Ockham*** (c. 1295-1349) proposed the idea known as Ockham's razor. Though it has been explained in many ways its most popular explanation is "entities should not be multiplied beyond necessity". The world renowned physicist Albert Einstein paraphrased it

by saying "make everything as simple as possible, but not simpler". At present Ockham's razor has been redefined in a quantitative and mathematical manner.

W V Quine, the mid 20th century philosopher, postulated that for any given set of empirical facts, many theories can be suggested to explain them. According to him a theory can not be known to be correct unless more data are accumulated. Karl Popper another philosopher of science rejected this and replaced it with the theory of falsifiability in the 20th century ***Karl Popper*** introduced critical rationalism. Popper replaced the term verifiability with falsifiability. Falsification as empirical method is a land mark philosophical approach in science. Instrumentalization as a philosophical approach in science signifies the utilty of theories as instrument for explanations and predicting phenomena.

P K Feyerabend's idea of epistemological anarchism as an approach of philosophy of science, postulates that no useful or exception free methodological rules govern the progress of science or growth of knowledge. The universal and fixed rules are unrealistic and detrimental to science.

Scientific skepticism requires that distinction between natural and supernatural phenomena should be made. Science should not consider supernatural explanations but neither should it claim them to be wrong. Super natural phenomena and their explanations should be outside the scope of science.

Another significant contribution to the philosophy of science was made by Reverend ***Thomas Bayes***, an 18th century evangelist. This theory was further developed by ***E T Jaynes*** (1922-1998). Jaynes refined the process of hypothesis construction based on precise mathematical foundations. Bayes' rule accepts subjectivism which means that we can never know anything 100%, but only with varying degrees of confidence, which can be precisely updated based on incoming evidence and prior probabilities. This school at present is known as Bayesianism which is very popular among the physical and computer sscience experts.

History of Science

Science is a conglomeration of great ideas. In order to understand science we must study its history and development so that we acquire knowledge about its overall progress and perspective and its effect on human being. It helps us in the following ways—

- It helps us to understand the present
- The knowledge of history of science can guide our course for the future action.
- The study of history of science gives us a perspective on what we know and how we know it.
- It also makes us aware of the limitations of our knowledge.

The term science is a new word and previously it was used to be referred as natural philosophy and those who pursued this knowledge were called natural philosophers. Scientific concepts were developed in Greece where Empedocles (494-434 B.C) first proposed that the world is made up of four elements namely fire, water air and earth. The history of science began when Greek philosophers Plato and Aristotle systematically discussed natural philosophy. The science of observation and its documentation was also carried out in ancient Sumer and Egypt. China and India too were in the forefront of scientific studies which included astronomy, medicines and mathematics.

During 16th and 17th centuries the scientific enquiries and studies progressed rapidly. Ptolemy stated that the Earth was the centre of universe. Copernicus (1473-1543) realized the mistake of such claim. ***Kepler*** and ***Galileo*** were the famous scientists of that era .They made important discoveries and inventions in the field of Astronomy and Physics. In physiology Harvey estimated the flow of blood in human body and how heart functions as pump. Robert Hookes was first to describe cells.

The oldest scientific society in Britain was set up in 1645. In 1662 the King of England granted a charter and it became Royal Society of Science.

Another very important figure of all time scientific discoveries was publication of Philosophiae Naturalis Principia Mathematica in 1687 by Newton. It set out his theory of gravity and his laws of motion. Antonie van Leeuwenhoek (1632-1723) made his own microscopes and through them he made many observations. In 1661 Robert Boyle (1627-1691) laid the foundation of modern chemistry when he published the Skeptical Chemist, which laid the foundations of modern chemistry. Boyle is also famous for Boyle's law (The volume of a gas kept at constant temperature is inversely proportional to its pressure).

Science in 18th century made raid progress. ***Lavoisier*** (1743-1794) discovered the role of oxygen in respiration. ***Musschenbroek*** (1746) invented way of storing electricity. Volta in 1802 invented chemical battery.

The 17th and 18th centuries are considered to be 'Age of Enlightenment' as it was characterized by scientific advancement and innovations. Newton's contribution has already been. He and Leibniz are considered as the creator of new physics. Leibniz used the modern terms like'energy' and 'potential' which were borrowed from Aristotelian terms like 'energia' and 'potentia'. During this time the term 'science' was increasingly used in place of natural philosophy.

During 19th century ***Dalton*** (1803) published atomic theory. ***Mendeleev*** (1834-1907) formulated periodic table. ***Faraday*** (1791-1867) invented dynamo. ***Helmholtz*** (1847) formulated law of conservation of energy.

In the field of natural science an important development was publication of Darwin's Origin of Species which created controversies. In 1866 Mendel discovered the law of hereditary by breeding of peas.

In the field of medicine in 1854 John Snow proved that cholera was transmitted through water ***Pasteur*** (1822-1895) showed that microscopic organism was the cause of disease.

In the field of physics, ***Maxwell*** (1873) discovered that light is an electromagnetic wave. ***Beequerel*** (1896)

discovered radioactivity. In 1898 Pierre Curie and Marie Curie discovered radium.

The 20th century witnessed the great strides in the field of science. In1900 Planck proposed quantum theory which proposed that energy is exchanged in discreet packets called quanta. This was a revolutionary ideaproposed by ***Max Planck***. In order to explain certain experiments that could not be explained in terms of Newton's laws, Planck proposed an ingenious idea: Much like matter exists in tiny packets called atoms, energy exists in tiny packets, which he called quanta. After all, Newton and the scientists who built on his work believed that one can give any amount of energy to an object. If one wants to throw a baseball, he can throw it at any speed he desires, as long the person is strong enough. This is not what Planck thought. He proposed that energy comes in tiny packets. A person can give one packet of energy to an object, or he can give two packets of energy to an object. It implies that one can not give an object any amount of energy in between one and two packets. Thus a revolutionary new way of looking at energy and matter, famously known as quantum mechanics was formed.

He was one of the most famous scientists in quantum mechanics. Einstein used Planck's idea of energy quanta to explain a problem that the scientists failed to understand for years. This problem, called the "photoelectric effect" could not be explained by Newton's laws of motion, but could be easily understood by accepting the fact that Planck was right about energy quanta. Although Planck had produced evidence for his proposition, and Einstein was able to explain a supposedly "unexplainable" problem using the idea of energy quanta, scientists were initially reluctant to believe that Planck was right. Newton's laws had been so successful in explaining concepts of physics which is why the scientists did not want to believe there was something wrong with them.

Einstein postulated a new way of looking at light, matter, and gravity. His special theory of relativity explained how

matter and energy are related. He used this theory to explain the famous equation E = mc2, which proposes that matter can be converted to energy and vice versa. Einstein also developed the general theory of relativity which is an explanation of how gravity works.

More and more evidences gradually accumulated to show that Planck was right. One such important proposal was made by ***Niels Bohr***. Bohr developed a picture of the atom, which is known as the **Bohr Model**. This picture of the atom was based on solid mathematics, and it required the acceptance of the theory that energy comes in small packets. Using the Bohr Model, many of the mysteries of the atom could be explained. In the end the scientists had to accept quantum mechanics as the guiding principles in understanding physical phenomena in place of Newton's laws.

Rutherford (1910) discovered atomic nucleus. ***Hubble*** (1889-1953) discovered that our galaxy is one of many galaxies and it is expanding.

Medicine also made rapid progress. Penicillin was invented by ***Fleming*** (1928). ***Crick*** and ***Watson*** (1953) discovered the double helix structure of DNA. Genetic engineering started during the latter half of 20th century. ***Hawking*** (1942) is considered as the most renowned physicist of present era. He is famous for his postulates on black hole, relativity and cosmology.

History of Science in India

The history of science in India should be traced during the era of Indus valley civilization (4500BCE). Excavations on these sites revealed planned settlement and maritime engineering which required scientific knowledge. During Vedic period scientific studies were pursued. Oldest astronomical text of that period was Vedanga Jyotisha which contained astronomical calculations (1400 -1200BCE). It mentioned the existence of 27 constellation, eclipses, seven planets, and 12 zodiac signs. Sushrata Samhita

(6 thcentury BC) was medical treatise which described cataract surgery. Ayurvedic Text had 184 chapters mentioning 1120 types of illnesses. It also contained the names of 700 medicinal plants. The study of anatomy was included.

In 5th century BCE ***Panini*** studied phonetics, phonology. ***Kautilya's Arthasastra*** (4th century BCE) mentioned dam and bridges. ***Kanad***, an Indian philosopher (200BCE) is said to be the founder of school of atomism, mentioned in Vaisheshika. It was elaborated during Buddhist period.

In the field of mathematics the Indians were in the forefront. In 7th century, the pascal triangle binomial coefficient and concept of negative number were known to them Aryabhata (8th century) used trigonometric formula.

During medieval period mining flourished coins were minted. Metallurgy as a science developed as swords and other weapons were made.

Thus it is evident that India had rich scientific heritage in different areas scientific knowledge namely—

- Civil engineering (Harappan civilization to Iron pillar)
- Water management (Sudarshan lake in te late 4th century BCE)
- Textiles (legendary clothes)
- Iron and steel, Zinc metallurgy
- Shipping and ship manufacturing (compass was used in India long before it was used in Europe)
- Forest management, farming techniques (use of eco friendly pesticides)traditional medicines
- Mathematics
- Rich heritage of folk science.

With the advent of the British and introduction of Western education the indigenous science lost its glory and patronage.

In 21st century the progress of science has been astounding. Never before in its history had science played such a dominant role. In the fields of communication,

medicines, astronomy and technology the humans have made tremendous progress. But problems of energy and environmental pollution are the two issues which mankind has to solve. Many of the scientific inventions have political and sociological implications and ethical issues are also involved. This is why scientific literacy is essential for the future citizens to take the informed decisions regarding science related issues.

2.2. SCIENTIFIC METHOD, A CRITICAL VIEW

As science is concerned with the understanding of truth so it uses methods of observation, testing and logical interpretation of data. It does not claim to understand the absolute truth rather it determines what is most likely to be true at present time with the available evidence. It means that truth is inferred from evidence but the concept might change when different evidence is obtained.

Scientific method is a technique which used to study a phenomenon. The objective is to acquire new knowledge or correct and integrate with previous knowledge. Man is inquisitive by nature so he is curious to know about things and develop ideas.

The step of scientific method is based on rules of reasoning and was first introduced by Rene Descartes in 1619. It is based on critical thinking. Its objective is to eliminate personal or social or unreasonable influences. The number of steps of scientific method may vary and the some essential steps are discussed below—

Observation

The first step in scientific inquiry is observation. A phenomenon or problem is observed or encountered and the individual becomes motivated to learn about it. Sometimes the interest or inner wishes make individual observe something minutely. Even at times the person is given an assignment or his annoyance with something forces him to observe and think about it. It is said that as a boy Einstein wanted to know how it would feel to ride moon

beam. This interest and curiosity made him study physics and led to the proposal of astounding theory of electromagnetism.

Questions

While observing a phenomenon the enquirer raises relevant questions related to it. The questions like this "why sky is blue?" The question can be open ended also. For example what can be done to solve the problem of drop out in elementary education? It is difficult to frame good question Research questions should be framed carefully as questions affect the outcome scientific inquiry. Questions are to be framed on the basis of previous experiences, personal observations or from the works of others.

Hypothesis

Hypothesis is tentative answer to the research questions. It is an educated guess, hunch or conjecture which has to be verified to solve the problem. The scientific method is based on hypothetic deductive model. To frame hypothesis one has to go through related literature. It should be consistent with present knowledge and led to further enquiry. The tow important characteristics of hypothesis are they should be testable and falsifiable. Testable hypothesis is one which can be experimentally proved right or wrong. Falsifiability implies the identification of possible outcome of scientific method that conflicts with prediction deduced from hypothesis. Scientists are more interested in proving a scientific statement wrong as this will led to framing of another hypothesis taking into consideration other important information. Another interesting aspect of hypothesis is that a false hypothesis may be accepted at a later stage of development. For example the famous geophysicist Wegner's idea of continental drift was considered impossible in the 1900s but later scientific inquiry showed that it is most likely to be correct. Super natural phenomena should be excluded from the realm of hypothesis as they cannot be experimentally tested.

Prediction

Hypothesis leads to prediction showing the relation between dependent and independent variables. It implies that something (1) will happen when something (2) is manipulated. Here '1' is dependent variable and '2' is independent variable. It may also refer as logical sequence of hypothesis.

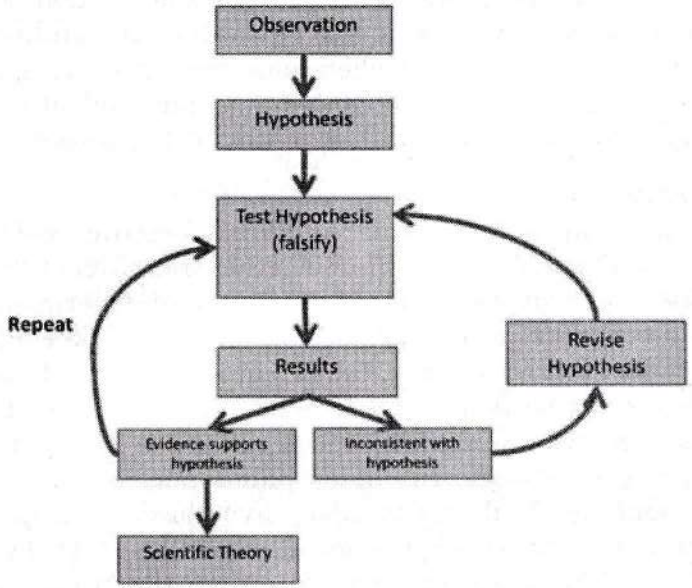
Experiment

The next and important step in scientific method is experimentation. It signifies whether real world behaves in the same way as predicted. Testing and experimentation may be conducted in laboratory, field, and blackboard or in computer even on kitchen table. The experiment to be free of bias must be done in controlled condition. For example in medical science double-blind tests are used as scientific control. Karl Popper, the noted philosopher suggested that the scientists should try to falsify hypothesis, that is search for and test those experiments which seem to be most doubtful. The scientists may interpret the findings from same experiments in different ways. Their conflicts are healthy and they work together in order to find evidence for resolution of such conflicts. The experiments are reproducible and verifiable.

Evaluation

Evaluation is the integral part of scientific method. Evaluation is very comprehensive in the sense that all aspects of scientific methods like experimental procedure, examination of the evidence, identifying the faulty reasoning, examining the statements that go beyond evidence and alternative explanations for same observation are scrutinized and subject to critical analysis. The scientists agree to this peer review. With the development of more scientific knowledge the disagreements are sorted out. The process of evaluation requires the scientists to be accurate, innovative and comprehensible.

The following figure shows the steps of scientific method



The scientific method leads to Scientific Theory. When a hypothesis or groups of hypotheses have been accepted by by various independent groups of researchers during the course of time, the particular hypothesis is accepted as a scientific theory. To experts of the relevant field, the theory is an adequate and precise explanation for a large number of facts and observations about the natural world. A theory has the following characteristics–

- It is internally consistent and compatible with the evidence
- The theory is grounded in and based upon evidence
- It is being tested against a wide range of phenomena
- The theory effectively solves the related problems.

Generally lay public use the term theory to imply mere speculation. However in science, something is not called a theory unless it has been verified over many independent experiments. Theories are more important than hypotheses, but less certain than laws. It is often said that theories are difficult to be proved, but can only be disproved. This is

because there is always the possibility that a new observation or experiment will be compared and contrasted with long-standing theories. This conflict helps in the emergence of paradigm shift which has been referred in Chapter I.

The scientific law is another outcome of scientific method. When strong evidences are obtained over a period of time the theory is transformed into law. A scientific law is a description of a natural phenomenon or principle that almost certainy accepted to be true under specific conditions and will take place under certain circumstances.

Another important term that should be discussed in this respect is scientific revolution. It implies an epoch making scientific invention or discovery. For example, Copernican Revolution should be included in this category when the concept of geocentricism was replaced by heliocentricism.

2.3. KNOWLEDGE, UNDERSTANDING AND SCIENCE

Knowledge means being familiar with something or acquiring of facts, information, skills etc. These are usually gathered by experiences or education. Learning perception and discoveries are the methods of gaining knowledge. Knowledge can be formal or informal, explicit or implicit and can also be practical or theoretical. In philosophy, the study of knowledge is known as epistemology. The tripartite theory of knowledge proposes that an individual knows something when he believes something considers it to be true and justify it or has good reason to believe it. Philosophers classify knowledge in to three categories namely personal knowledge, procedural knowledge and propositional knowledge. Philosophers are mostly interested in propositional knowledge which is knowledge of facts and personal and procedural knowledge contain some forms of propositional knowledge.

Understanding on the other hand is a complex concept. If one is to understand something then he has to go into deeper level and must acquire holistic conception of the phenomenon rather than the merely knowing the superficial characteristics of it.

Understanding signifies making knowledge meaningful and interpreting the existing knowledge. Whereas knowledge is merely recording of fact, understanding is developing insight and a feeling for relationship. It is a challenge to any science teacher to improve the achievement of his students in understanding of science concepts and principles.

The process of learning was explained by many psychologists. Piaget, Ausubel and Vygotsky proposed their theories to analyse how students understand new knowledge including scientific concepts. According to Piaget, the new learning occurs when new schemes are formed developed, integrated and coordinated while the learner internalizes his activities performed in real situation. The process of equilibration and adaptation is important in this respect. Knowledge and skills do not necessary lead to understanding but the central component of science learning is connecting and modifying schemes.

A complimentary theory is of Vygotsky is that of social constructivism. The symbolic rules of scientific concepts are difficult to be grasped by the individual learner. He is unable to master them without the aid and assistance of the more skilled persons. The construction of scientific principles and ideas takes place when learner is engaged socially in talk and activities.

Scientific laws and ideas are not absolute rather they are tentative and socially negotiated. The students do not study the scientific truth but the constructs developed by scientific community. These developed scientific constructs often change with paradigm shift. For example model of atom has changed with change in scientific knowledge. Therefore, scientific knowledge is public knowledge constructed and communicated through culture and social institutions.

To develop understanding in science, the following principles are to be taken into consideration—

- Understanding the pre-instructional knowledge base of the students as new knowledge is built on prior knowledge. The personal social view of the students play important role. This is why inquiry based learning is effective in science education which reveals the students' current level of understanding.
- Importance of science subject related activities. The science teaching encourages students in physical activities which create cognitive conflict. The students want to remove this dissonance for better adaptation and gradually develop deep understanding. This is why student cantered teaching and laboratory cantered method of science teaching is important.
- Importance of contextualization. This concept is based on Dewey's idea of generative knowledge which means that knowledge and understanding have rich ramification in the day to day lives of the learners. The students should learn the implications of the different scientific concepts in different circumstances and develop insights. So science should contain life related topics to motivate the students to learn and contextualize the learning for transfer.
- Collaboration within learning community. Knowledge is co constructed when the students discuss among themselves. This peer learning opportunity not only helps the learner to articulate and justify his scientific ideas but also help to clarify his own conceptions. During this discussion appropriate use of scientific language and symbols are learnt for better understanding.
- Importance of role of teacher in understanding science. In science class the teacher plays two roles. He introduces new ideas and provides support and guidance. In science learning matter the teacher must locate psychological space of the learner which signifies Vygotsky's zone of proximal development (ZPD).

In conclusion it may be said that scientific knowledge is constructed and the teacher should help students to redefine their world views. The teacher has to structure the activities related to science learning and improve communication in the class.

A science teacher in order to help students understand science must remember that

- Knowledge is constructed, not transmitted.
- Prior knowledge impacts the learning process.
- Initial understanding is local, not global.
- Building useful knowledge structures requires effortful and purposeful activity.

2.4. THE SOCIO-CULTURAL PERSPECTIVE AND THE ETHICAL CONSIDERATION

As one grows up he is continuously influenced by social culture and norms. A person' belief, attitude and values are formed as a result of his interaction within his social milieu. The scientists are also influenced by social factors and the decisions they take in the context of science are based on their belief system and values. Therefore science is never value free.

On the other hand society has been transformed as scientific discoveries and inventions have taken place. In fact the modern society has come under the tremendous influence of science. Every day to day activity performed by a man is the result of scientific inventions. Thus science has not only influenced an individual' life but the policies of the government are determined by science. It is evident that individual decisions and collective decisions regarding various aspects of life are influenced by science.

However, science too is shaped by human society. During the beginning of 20th century the large scale warfare in different parts of the world boosted the war industries and scientists were encouraged to develop war machines. The invention of nuclear warheads was the result of this era. A particular area of science progressed rapidly because of administrative patronage.

Later on when the fear of warfare lessened and human civilization entered into a more or less peaceful situation scientists were encouraged to solve the problem of energy crisis, environmental degradation, information technology, and mitigation of diseases. The multinational companies and economic policies determine to a large extent what kinds of scientific researches would receive financial assistance. Resources are now being increasingly invested in researches in biotechnology, agricultures, development of alternative energy sources.

A new concept in science education became evident in 1970s which is known as Science Technology and Society interface. STS goals in the context of science education emerged. STS goals are concerned with Science Technology and Society interface and interaction. It is about how these three interact and what effect it has on human beings. The STS goals in the context of science education are as follows—

- The students will be able to identify STS issues.
- They understand the context of STS issues.
- They learn about the decision makers in this context e.g. genetically modified seeds are allowed in India and who takes decision in this regard.
- The students will be able to investigate these issues themselves.
- They develop their own action plan in relation to STS issues.

A balance has to be struck between science content and science based social issues. The National Curriculum Framework (2005) had discussed the overall system of science education and gave important suggestions. It has also stressed the role of science in social development. Science should be used as a social tool to eradicate poverty, ignorance, superstition class, caste and gender divide .It suggested that the science education in India should have cognitive validity (age appropriate curriculum), Content validity (significant and correct information), Process

validity (generation and validation of scientific knowledge), historic validity (social perspective of science), environmental validity (the STS goals) and ethical validity (honesty, objectivity).

Ethical Consideration

The ethical issues in scientific research are gaining more and more importance in the context of human rights violation and harms inflicted on biotic and abiotic nature. The scientific research is often required to be conducted on human beings. The scientists' intention in this respect is welfare of human society but such research may unintentionally harm the innocent organisms. The types of harm in this respect may be psychological harm to a person, financial harm and social harm. Therefore scientific research should follow ethical principles like—

- Principle of privacy–the results should remain confidential
- Principles of anonymity–the participants' identity must not be disclosed
- Principle of informed consent–the participant should agree to participate in the research after he has been briefed about the research.

The scientific research should be based on human welfare and environmental protection. The ethical codes of conduct in this respect include-

- Justification of the research
- Validity of the research
- The review of the ethical committee
- Risk and benefit analysis
- Compensation for injury during research.

Some of the ethical issues in science research are plagiarism, academic fraud, misrepresentation of research results and allocation of credit for scientific research achievement. Besides, some recent works on science have created ethical controversies. These are genetically modified crops, cloning of embryos, stem cell research.

2.5. SCIENCE AS A DISCIPLINE, PLACE OF SCIENTIFIC KNOWLEDGE IN THE SCHEMA OF SCHOOL CURRICULUM

Science in educational institutions was introduced much later in the 19th century Europe and the USA by the renowned scientists like Huxley, Herbart Spencer, M. Faraday and others. Their task was not easy one as they faced opposition from the scholars of humanities who considered science to be materialistic and without higher virtues.

Today science is an integral and important part of general school curriculum. The objective is to develop scientific literacy among all. The scientific literacy is a broad concept and there is hardly any clear definition of it. The intention is not to prepare students only for science or technology careers but to develop a broad and functional understanding of science for general education. Scientific literacy is not a fundamental tool like 3Rs. According to United States national Center for Education Statistics scientific literacy is knowledge and understanding of scientific concepts and processes required for personal decision making and participation in civic, cultural affairs and economic productivity.

OECD (Organization for Economic Cooperation and Development) (PISA -Programme for International Students Assessment) Framework (2015) defined scientific literacy as an ability to deal with science related issues and ideas of science as a reflective citizen. Such a citizen understands the scientific relevance of environmental and social issues. He can also communicate clearly about science and make informed decisions. Scientific literacy also develops attitude of concern for environment and a feeling of empowerment to use science as a tool to address environmental and social problems.

Scientific literacy has created a problem of 'what', 'why' and 'how' of science teaching. In general science education makes people aware of power and limitation of science and

how to live safely and happily with the help of such knowledge. There are, however, three aspects of science literacy which are—

- Learning science
- Learning about science
- And doing science.

Well informed cultured people should know how natural world works and what the effect of science on society is.

The following may be the objectives of science education in school and the criteria of science literacy—

- Science education prepares one for the world of work. More and more jobs now require people who understand science and use the scientific skills.
- Scientific knowledge can be directly applied to everyday living.
- A scientifically informed citizen and an individual can examine the natural world.
- A scientifically literate person can understand report and discussions of scientific issues that are published in popular media.
- Science education serves aesthetic purpose when an individual satisfies his personal curiosity about flora and fauna.
- One should become sympathetic to science.
- Scientifically literate person understands the nature and importance of technology and the relation between science and technology.
- It admits the traditional examination system which invariably induce stress among the students, does interfere with scientific method of science teaching. It also supported the empowerment.

To keep pace with development and compete in the global market the developing countries like India must produce capable future citizens with adequate knowledge of science.

Science teaching in school is considered to be important for various reasons which are discussed below.

- While learning science the students develop the skill of observation and learn scientific method of inquiry. As a result they learn to reason, acquire clear concepts and form objective judgment. Science disciplines the mind. ***Herbert Spencer***, the noted educationist posed the question "what knowledge is of most worth" and the answer he gave was science.
- Science has cultural value as well as utilitarian value. The students learn development of scientific culture of human civilization and at the same time learnt to use science for material benefit.
- Science gives intellectual pleasure. The students can develop scientific hobbies which they can pursue in their leisure time.
- Science helps students to separate facts from non facts. They also learn authentic sources of knowledge instead of depending simply on heresy.

Ideally science learning in school should aim for the following

- It should help the students to develop scientific concepts and science process in variety of settings.
- It should help students apply the knowledge of science and understanding in their real life.
- It should help them to appreciate the relationship and responsibility between science and society.

2.6. STUDY OF EMERGENCE OF SCHOOL SCIENCE IN RELATION TO THE SOCIAL, POLITICAL AND INTELLECTUAL AND HISTORICAL CONTEXT

It has already been pointed out that social and cultural development of human civilization is very much related to scientific discovery and invention and each has influenced the other. Science has ushered industrial revolution in the

19th and 20th century and this has brought major changes in social system. The society has grown with science. It has not only brought material wealth but also induced great changes in health, living conveniences. It has increased human mobility in time and space enabling people to exchange material things and ideas. The average life span has increased, child mortality has decreased and the world population has increased very rapidly. Science has improved quality of life but it has also damaged the environment irreparably. Science now controls human society. It determines how people learn, work, live and most importantly IT revolution determines how the government interacts with civil society. As a result the issue of individual privacy is now a burning topic. The human society has now realized uncontrolled development of science can harm it and scientific knowledge should be used and applied responsibly. The four concepts for Science in 21st century in this respect were emphasized in this respect by the conference of Declaration on Science and the Use of Scientific Knowledge" and the "Science Agenda - Framework for Action Budapest Conference 1999, UNESCO and International Council for Science. These four concepts are "science for knowledge," as well as the new "science for peace," "science for development," and "science in society, and for society" concepts.

The relationship between politics and science has always been controversial. There is a wide gap in the thought process of the two communities. The scientists by training are objective, logical and rational in their approach. They know the importance of measurement and quantification in analysis of any issue. Scientists are also internationalist in the core of their heart as they realize that science transcends the borders of different countries.

But policy makers are more influenced by the political agenda and political gains from their decisions. As a result the government, business concerns and advocacy groups always put legal and economic pressure to influence the

findings from scientific research to promote their interests. Some of the examples of manipulation of science for political gains are eugenics in Nazi Germany, decisions regarding Global Warming, Tobacco industry, reduction of Carbon foot print and of course manufacturing of war heads including nuclear weapons. Besides, scientific assessment of an issue takes time as it is based on painstaking research. The politicians and public have no patience to know about the result after long trial period. The policy makers often push for quick, popular and expedient solution. They want 'correct' answer from the political point of view.

In public policy making the scientists are marginalized although they are recruited as scientific advisors to government policy makers. The scientists should realize their responsibility and try to influence the policy makers to take those decisions which are beneficial to human welfare and the overall environment of the Earth. The gap between science community and the public policy makers need to be bridged. In this respect the common public also plays important role in a democracy when important science related policies are taken. This is why science education in school is as important as learning science at school will lead to development of scientific literacy. The media too play important role and should report science news based on real facts and experimental evidence.

Science is not only for utilitarian purpose. The nature and natural events inspire people intellectual curiosity. The aesthetic beauty of nature, the flora and fauna has inspired the poets and authors to write immortal literature. This has given pleasure and joy to so many people. Science has the potentiality to remove the superstitious and harmful practices in the society by training rational mind. Most importantly any modern issue related to science is far from simple and deal with such issues one must cultivate logical judgment and insight which can be developed by science education.

2.7. CURRICULUM SYLLABUS AND TEXTBOOKS; THE PARADIGM SHIFTS IN THE DISCIPLINE, THE CHANGING NOTION OF SCIENTIFIC KNOWLEDGE AND THE NEED TO REDEFINE SCHOOL SCIENCE

A debate emerged regarding the curricular objectives of science education. As indicated above, the objectives emphasized more on the relevant aspects of science. But other curriculum developers maintained that thrust area should be understanding of the natural world. The National Society for the Study of Education (1932) in the USA suggested that a balance should be struck between broad intellectual understanding of natural processes, scientific way of thinking and utility of science for effective living. People should learn usefulness of science but at the same time science education must act as powerful force for the search of beauty and truth in this world.

Regarding the curriculum, it proposed that at the primary level the students should explore the surroundings joyfully and science must arouse their curiosity with hands on experiences. At this stage science and social science are to be integrated as environmental science to give a holistic approach.

At the upper primary stage scientific principles will be explained to the students by the help of familiar experiences. Activities and experimentation, group discussion should be components of pedagogy. Continuous evaluation should be mode of assessment. During the secondary stage science as a composite discipline is introduced. Hands on activities, experimentation are part of curricular transaction.

At higher secondary stage, experimentation technology and problem solving methods are to be introduced. Core topics should be selected on the basis of recent advances in science.

The NCF (2005) suggested a paradigm shift in science education in Indian schools. Rote learning should be

replaced by development of inquiry skills. Investigative skills of the students are required to be developed along with nurturing of inventiveness. The role of Science Fair, Children Science Congress are expected to play important role in science education.

At present the science textbooks have also been modified. They are now more interactive and activity oriented. Attempts are being made to make textbooks relevant and learner friendly instead of consisting of massive body of authoritative and unquestionable knowledge. The modern science pedagogy is much more reality oriented to link students' understanding of concepts in classroom with their world outside.

The science textbooks need to be reviewed and modified periodically. The evaluation of the textbook should be based on the following—

- The content emphasis
- Instructional focus and
- Teacher support

The contents of the textbook should match the developmental characteristics of the students. The focus of instruction should be based on the principle of constructivism. The textbook must be framed in such a manner that the teacher finds it effective to teach. The text book and pedagogy of science must be based on inquiry, reflection, critical thinking and problem solving. The activities containing in the text are required to relate with the daily activities of the students. The students often consider science to be demanding and difficult and a subject for elite class. But the teachers and curriculum framers have the responsibility of making science interesting. Instead of encouraging rote learning the teachers should seek to develop deeper meaningful understanding of scientific concepts.

Questions

Objective type (2 marks)

Q.1. Define the term 'science'.

Ans. That is Science is defined as the methodological approach to study natural world. It is also considered as the system enterprise that creats, builds and organizes knowledge in the form of testable explanation and predict about universe. Science requires empirical evidence to logically support the conclusions.

Q.2. Define observation method.

Ans. The first step in scientific inquiry is observation. A phenomenon or problem is observed or encountered and the individual becomes motivated to learn about it. Sometimes the interest or inner wishes make individual observe something minutely. Even at times the person is given an assignment or his annoyance with something forces him to observe and think about it.

Q.3. What is "understanding"?

Ans. Understanding is a complex concept. If one is to understand something then he has to go into deeper level and must acquire holistic conception of the phenomenon rather than the merely knowing the superficial characteristics of it.

Q.4. Mention any two assumptions of science.

Ans. There are many things that happen around us. The science assumes that these happenings are due to natural causes. Foe example, when a stone is dropped from a height it falls downwards. This down ward movement is due to some natural cause and in this case gravity.

The science further assumes that it is possible learn more about these causes by the help of evidence.

Q.5. Why is it said that science is a social process?

Ans. Because it is based on collaborative work where the team of scientists works together for scientific progress. Science is shared by particular scientific community. The scientists

attend conferences, peer review publications for scientific errors, oversight and to expose fraud

Q.6. What was the relation between science and natural philosophy?

Ans. The term science is a new word and previously it was used to be referred as natural philosophy and those who pursued this knowledge were called natural philosophers. Scientific concepts were developed in Greece where Empedocles (494 -434 B.C) first proposed that the world is made up of four elements namely fire, water air and earth. The history of science began when Greek philosophers Plato and Aristotle systematically discussed natural philosophy.

Q.7. What are the aspects of scientific literacy?

Ans. The three aspects of scientific literacy are learning science, learning about science and doing science..Scientifically literate person knows how natural world works and what is the effect of science on society.

Q.8. What is hypothesis?

Ans. Hypothesis is tentative answer to the research questions. It is an educated guess, hunch or conjecture which has to be verified to solve the problem. The scientific method is based on hypothetic deductive model. To frame hypothesis one has to go through related literature.

Q.9. Mention any two objectives of science education.

Ans. Science education prepares one for the world of work. More and more jobs now require people who understand science and use the scientific skills

- Scientific knowledge can be directly applied to everyday living.
- A scientifically informed citizen and an individual can examine the natural world.
- A scientifically literate person can understand report and discussions of scientific issues that are published in popular media.
- Science education serves aesthetic purpose when an individual satisfies his personal curiosity about flora and fauna. (Any Two)

Q.10. What is meant by prediction?

Ans. Hypothesis leads to prediction showing the relation between dependent and independent variables. It implies that something (1) will happen when something (2) is manipulated. Here '1'is dependent variable and '2' is independent variable. It may also refer as logical sequence of hypothesis.

Q.11. Give two examples to show how science was manipulated for political gain.

Ans. Some of the examples of manipulation of science for political gains are eugenics in Nazi Germany, decisions regarding Global Warming, Tobacco industry, reduction of Carbon foot print and of course manufacturing of war heads including nuclear weapons.

Q.12. What is meant by ethical consideration in science?

Ans. The scientific research is often required to be conducted on human beings. The scientists' intention in this respect is welfare of human society but such research may unintentionally harm the innocent organisms. The types of harm in this respect may be psychological harm to a person, financial harm and social harm. Therefore scientific research should follow ethical principles like-

- Principle of privacy- the results should remain confidential
- Principles of anonymity- the participants' identity must not be disclosed
- Principle of informed consent- the participant should agree to participate in the research after he has been briefed about the research.

Q.13. NCF (2005) suggested that science teaching in school should have cognitive validity. What is meant by this statement?

Ans. The NCF (2005) suggested a paradigm shift in science education in Indian schools. Rote learning should be replaced by development of inquiry skills. Investigative skills of the students are required to be developed along with nurturing of inventiveness. The role of Science Fair, Children Science Congress are expected to play important role in science education. This is what is meant by cognitive validity.

Q.14. What is meant by curriculum?

Ans. Curriculum means all the activities , curricular and co curricular , undertaken as teaching learning process. In the context of science education, curriculum should include all types of school activities to develop understanding of scientific concepts.

Q.15. What is meant by textbook?

Ans. Textbooks are the prescribed books used by the teachers to teach different subjects. In the context of science education science text books must be activity based, interactive and related to real life situations of the learners.

Q.16. Indicate the differences between curriculum and syllabus.

Ans. Curriculum is broader in scope whereas syllabus is narrow. Curriculum encompasses all the activities in school but syllabus is mainly concerned with subjects, textbooks etc. In science education syllabus should be related to the develpemntal stages of learner and the curriculum should reflect whole school approach to science education. Discuss iin brief.

Short type/Short note (5 marks)

Q.1. Write a short note on history of science in India.
Ans. Page 38 Sub heading history of science in India.

Q.2. Elucidate the concept of nature of science.
Ans. Page 34. Sub heading nature of science.

Q.3. Short note on Science is a social process.
Ans. Page 50 Sub unit 2.4 Socio cultural perspective of science.

Q.4. What are the steps in scientific method?
Ans. Page 43 sub heading 2.2.

Q.5. Short note on questioning method.
Ans. Discuss lecture discussion method with questions.

Q.6. State the relationship between knowledge understanding and science
Ans. Page 47. Sub heading Q.2.3

Q.7. Mention the important landmarks in the history of development of science in India.
Ans. Same as 1

Q.8. Write a note on socio-cultural perspective of science.
Ans. Same as Q. no 3

Q.9. What is the importance of STS in learning science?
Ans. Page 51 3rd paragraph

Q.10. Write about the aims of teaching science in school.
Ans. page 55. Sub heading 2.5. Last two paragraphs

☛ Essay type (10 marks)

Q.1. Explain the history of science.

Q.2. Analyze the content of scientific method.

Q.3. Discuss the paradigm shift in school science in the context of curriculum and textbook.

Q.4. "Science as a discipline"–discuss.

Q.5. Describe socio-cultural perspective of science.

Q.6. Analyze the content of Knowledge, understanding and science.

Q.7. Discuss with the help of a flow chart the steps in scientific investigation.

Q.8. Write a note on ethical consideration of science.

Q.9. Discuss the place of scientific knowledge in the scheme of school curriculum.

Q.10. Write about the study of emergence of school science in relation to social and political context.

(Answers to all the these questions can be obtained from the short answer questions only explain them in detail.)