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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

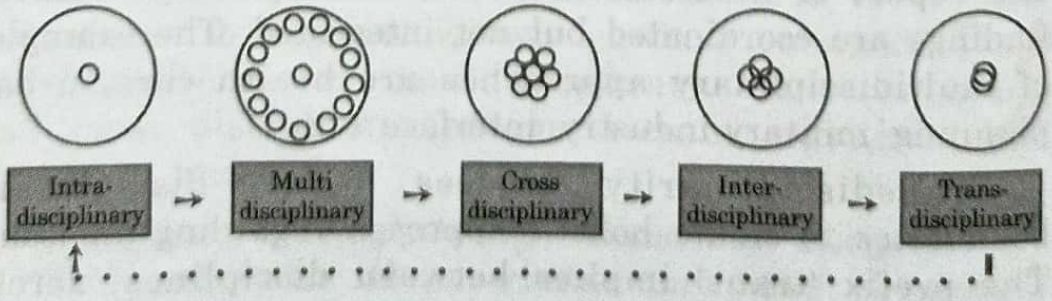
disciplines and beyond each discipline. It is the most desirable approach and also most difficult integrated research work. It seeks to understand the present world which is not possible within the framework of disciplines.

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.

1.2.5. 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.

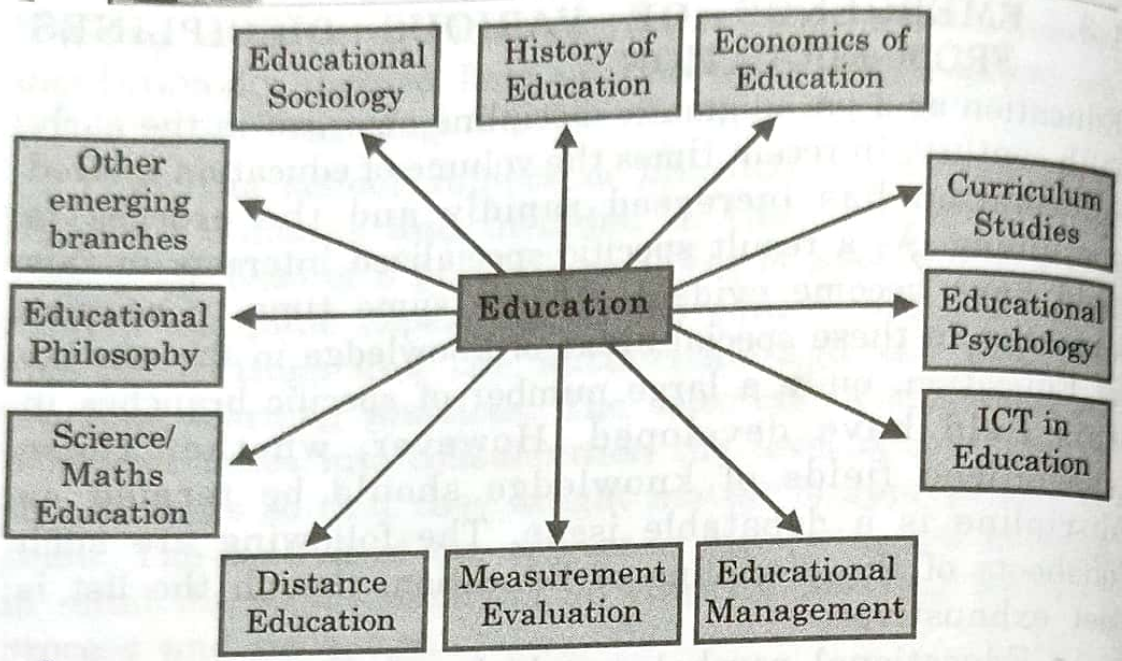
The fundamental difference between school subject and disciplines is the role of research and development. The academic disciplines continue to grow and develop as researches are continuously undertaken to modify and generate new theories. Of course school subjects also continue to develop and change 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.

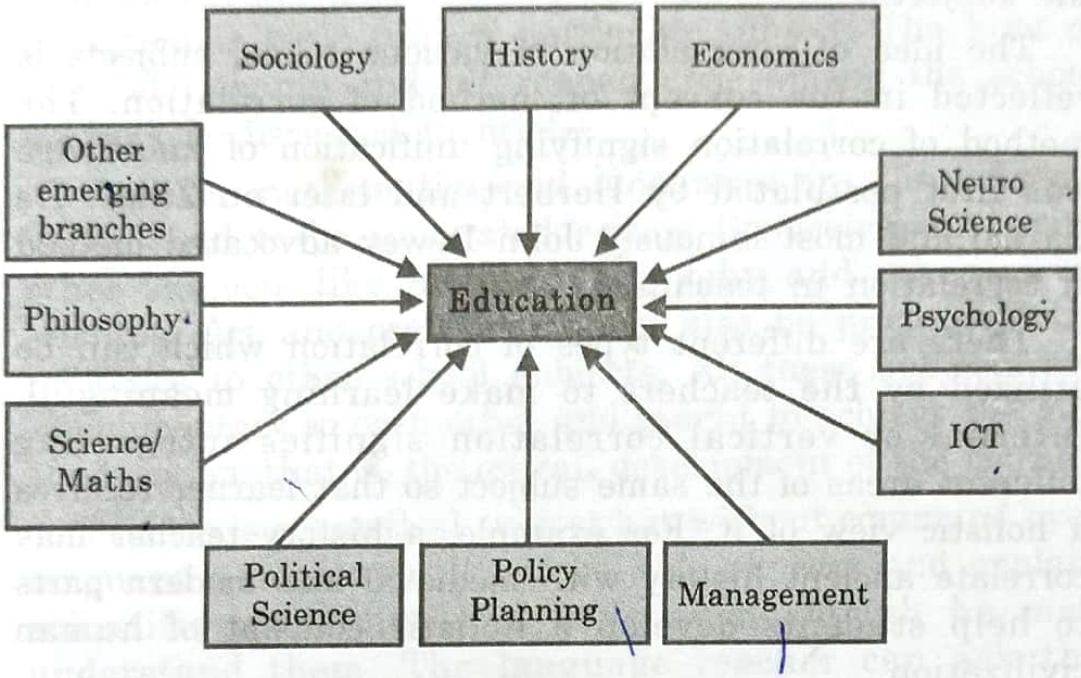
This approach to study of Education is somewhat like infusion model of curriculum development where the ideas, concept and theories studied and developed in Education led to the development of specialized knowledge of Education. These branches of education related specialization may not be considered 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.