Chapter – I

INTRODUCTION

1.1 Introduction to Science

Every citizen of the modern world sees the countless manifestations of science all around him. There is no aspect of man's life today which has not been influences by science one way or the other. The modern science is no longer confined to the surface of this globe, its sphere of achievements reached beyond the earth.

Each and every student needs to achieve optimally in Science. Each part of the science curriculum such as physics, chemistry and Biology needs careful planning. The objectives determine what students are to achieve. In addition to reading and Mathematics which is presently being emphasized in testing student achievement.

It believes, the teacher to choose carefully which objectives students are to achieve. The objectives are to be selected need to emphasize knowledge and skills ends which are useful to the student presently as well as in the future.

Which content, objectives, and then student achieve in any Science unit of study? Vital Science facts, concepts and generalizations need identification and implementation in the classroom with the help of various and different types of media like internet, Science equipment for experiments, video tapes, filmstrips and illustrations as they form the heart of science in hands on approach to leaving.

Within the frame work of problem solving students need to develop needed skills in thinking critically. To think critically the student needs to be
able to analyze subject matter in terms of being factual v/s opinion, accurate v/s inaccurate and relevant v/s irrelevant.

In addition to critical thought, the student also needs to think creatively. Unique ideas are necessary in many cases to solve problems. The 'Tried and True' may not work as solutions. Thus novelty and Originality of decisions must be made. Flexibility of ideas is then needed in the decision making arena.

Quality attitudes should be an end result of all learning opportunities in an on going Science units of study. The attitudes may be wanting to learn more about the world of Science, wanting to get along well and be actively involved in doing Science experiments and demonstrations, become proficient in problem solving use flexibility in thinking skills. To do enrichment works in Science and units of study and to increase proficiency in using science equipment.

In addition to choosing proper objectives and aligned learning opportunities. The science teacher should obtain the interest of students, learner to assimilate old learning with new learning's encountered and with a good motivation. The student may reach out and accomplish. The sky is the limit for the student, if he or she is motivated to learn more in science discipline, hence high expectations and challenge are the key ideas to move on and finally, a variety of evaluation of devices need to be used to assess students achievement. The teacher written tests with high validity and reliability should be used.

Students achievement in science is an important area of personal development. The world of science surrounds the individual with technological
improvements, innovations in ideas and the natural environment. Thus in medical practices and human health in agriculture, in transportation, in communication, the individual perceives what science has accomplished for the individual.

1.2 Concept of Science

Educational opportunities though open to all do not seem to engage to any reasonable extent, the capacities of those who seek to avail themselves of them. An external question baffling parent's educators and planners is – why do students of demonstrated ability flop in their academic efforts at examinations? Academic under-achievement, more than academic failure, constitutes a grave problem as it amounts to wastage of manual and material resources which is constructed as an irreparable loss to the society. This stimulated a number of researchers to undertake studies on factors influencing academic achievement.

A rapidly advancing technology was calling for a large number of highly trained man power. Individuals who posses science potential can come only from our schools and colleges. It takes time and experience to educate them. We must identify student with science potential at least at the secondary school stage, encourage need stimulate them to continue their education. So as to become trained scientists and technologists of tomorrow.

The term ‘science’ (scientia) is etymologically synonymous with knowledge. Modern science consists of a great deal of systematical knowledge which is integrated with conceptual scheme. The definition given by Pearson is “Science leads us to classification and system independent of
the individual, therefore to sequencers thinker to and laws admitting of no
playroom for individual fancy”.

1.3 Nature and Importance of Science

Science is the product of man's conscious effort to understand and
control his environment. Since earliest times, man has been carefully
observing the several natural phenomena taking place on him, studying their
effect and trying to understand the causes of such phenomena.

Philosophers, scientists and experts have attempted for centuries to
describe the nature of science. Scientist Fitzpatrick gave one of the important
descriptions about science. The described science as a cumulative and
endless science of empirical observations, which result in the formation of
concepts, facts and theories in the light of future empirical observations.
Science is both body of knowledge and acquiring and refining knowledge.

Since the industrial era of 20th century the importance of science is
understood by common man and today in the era of globalization,
privatization and liberalization science has become important to all.

Science has contributed to bringing about changes in our ways of
thinking, attitude, aptitude, creativity, interest and out look. Hence the science
education imparted in our school plays a vital role in the development of
individual and in turn the nation. Now a days it has become very difficult to
impart meaningful science education due to explosion of scientific knowledge.
So it will become worse, if we fail to take into account the explosion of
knowledge in this age.
If science is poorly taught and badly learnt, it will become worse by burdening the mind with dead information and it could generate new vistas of superstition.

Science is a great human enterprise, not only endless and faceless but also stable and fluid. It is a self-accumulating self-growing, self-accelerating and self-correcting enterprise, which originated in the collective curiosity of man since time immemorial. It attempts to provide a body of knowledge through procedures and techniques. It is very much as objective as the prevailing conditions make it, that is do not challenge it. It moves forward on the wheels of dynamism, dogmatism and discovery at the same time. Open mindedness, curiosity, demand for verification and proofs, suspended judgements, statistical reasoning and willingness to change one's opinion in the light of new evidence which characterize the scientific phenomena.

1.4 Meaning of Science

Science is a systematized store of human knowledge gained after generalizing and interrelating the various isolated facts and opinion which is supported by formal proofs or by observational evidence through systematic approach.

John Woodburn and E.O. Ogbourn consider "science as that human endeavour that seeks to describe with even increasing accuracy. The events and circumstances which occur or exist within our natural environment". According to the report on policies for science education is "science is a cumulative and endless series of empirical observations which results in the formation concepts of and theories with both being subject to modification in
light of further empirical observations. Science is both a body of knowledge and the process of acquiring and refining knowledge.

Thus science is simultaneously a body of knowledge and also a self-evaluative process of enquiry. Science has two important approaches.

a) Science as a Product
b) Science as a Process

Columbia Encyclopedia (1963) defined "science as an accumulated and systemized learning in general usage, restricted to natural phenomena". The progress of science is marked not only by an accumulation effect, but by the emergence of scientific method and scientific aptitude.

According to Gagne (1965) "science is what the scientists do" — It is a process by which we increase and refine understanding of ourselves and of the universe through continuous observation, experimentation, application and verification.

Inherent in these definitions is the implication that science is at the same time a body of knowledge and an ongoing self-testing process. Thus it may be stated that "science is both a process and a product". This view is supported by the definitions of science given by Fitzpatrick (1960) UNESCO (1971).

a) Science as a Product

Although the importance of science both as a product and a process is undisputedly accepted, but in actual classroom practices today the emphasis is still on 'acquisition of knowledge' which forms the product side of science. Science is being taught in Sainik School as well as either school as a body of established facts obtained by individual using infallible.
The reality of science knowledge includes not only facts which are truths and therefore indisputable but also generalizations and theories that are subject to error and prone to change.

Scientific method is the procedure followed by scientists to conduct scientific investigations, as to find solutions to the problems.

Ritchie (1980) remarks that scientific method basically involves confronting ideas experience that is designing experiments to test ideas or hypotheses and predictions based on them.

b) Science as a Process

The most distinguishing characteristic of science is its method. It is an activity that takes place in the minds of individuals which is the result of certain intellectual processes that made discovery possible.

The processes of science are the means by which one can examine, explore and investigate the unknown. They are the procedures researchers use to investigate the natural world.

'Acquiring process of science' implies that students are exposed to possess the ability such as - tc observe, to classify, to infer to make and test hypotheses and to conduct experiments about the neural phenomena.

The following were identified 'as processes in science' by the American Association for Advanced of Science (AAAS)

I. Observation
II. Classification
III. Number relations
IV. Measurements
V. Space/time relations
American Association of the Advancement in Science used a process skill approach to teach science. Further it defines these skills as a set of broadly transferable abilities appropriate to many science disciplines and reflective of their true behavior of scientists. It divides process skills into two types—Basic and integrated. The basic science processes are observing, classifying, communicating, measuring, using space/time relations, using numbers, inferring and predicting. These skills provide a foundation for learning the more complex integrated skills. The integrated science process skills are controlling Variables interpreting data, formulating hypotheses, defining operationally and experimenting.

"There is of course, one thing about which we feel no doubt or hesitation: education, Science based and incoherence with Indian culture and values, can alone provide the foundation as also the instrument for the Nations progress, Security and Welfare" – Indian Education Commission (1964-66), this sums up the importance of Science. Science is one of the potent weapons created and grafted by man to the mankind to achieve his needs and aspirations. Besides these Science and technology helps us to
impart "Scientific attitude" by training the younger generations through "Scientific Method" These cultivated Scientific attitude gets transferred to other real life situations and is valuable.

Science and Technology has become compulsory subject in the school curriculum because of its multifarious value to the individual as well as to the Society. Intellectually it helps us to develop consciousness, sharpens our intellect and makes us to develop critical observation and reasoning. It teaches to arrive at conclusions without any emotional prejudice.

The utilitarian value of Science need not be emphasized as it has become a necessity right from birth till death. Whatever luxuries that we enjoy are the benevolence of Science. We are prepared and geared up to fight all kinds of pathogens, external calamities and conserve Natural resources. In the present day of "Atomic age", we harness "atomic power" to various uses and to defend ourselves from forces of Destruction. The Nation progresses when the people of the country are healthy. Much credit must be given to Science in this regard as it made many diseases disappear. It's also helping us to have self-sufficiency through Second green revolution, operation flood, afforestation etc.

Vocational Value of Science is ever increasing as it throws open the gates of medical, agricultural, genetical, veterinary, bio-chemical, pharmaceutical and many other professions.

Science has played an important role in determining the culture and civilization of a Country from time to time. It has a direct influence in dispelling many traditional beliefs and food habits. The report of Indian Education Commission (1968) thus sums up the cultural value of Science. "If Science is
to be pursued with full vigour and zest and is to become a mighty force in the Indian renaissance, it must drive its 'nourishment' from our cultural and spiritual heritage and not bypass it. Science must become an integral part of our cultural and spiritual heritage".

Man by virtue of his scientific learning will be morally bound to whatever he does. He lives with Goodness, Beauty and Truth. Science makes man to do Good for others and be truthful to himself and others.

"Truth is Beauty" Aesthetically Science aspires to get truth of every discovery and the process of discovery is an Art with lot of skills. Hence Art and Science belong to beauty. Thus Science discovers "Pre - established harmonies" that are always beautiful.

Thus Science has multfarious values and help children to develop Scientific attitudes that help them in day to day life and also in different areas of National development. Science has reached a stage where it can create virtually anything including a whole Human being from a cloned cell. A day is sooner approaching where Science can make Humans to live on other planets such as The Mars and The Moon.

1.5 Objectives of Teaching Science

The broad objectives of teaching of Science and Technology at Secondary Stage are to help the learner to :

a. Understand the Nature of Science and Technology

b. Understand the basic concepts, principles and laws of Science

c. Apply basic scientific principles in finding solutions to problems related to agriculture, energy, health, nutrition etc.

d. Develop problem solving and decision making skills
e. Inculcate values that underline Science and technology
f. Import to his pupils some inlight into the meaning and value of Science
g. Inject in them the scientific spirit, and
h. Train them in a manner appropriate to their particular stage of mental development in the methods of cognitive styles and thinking

1.6 Origin of Concept Mapping (Constructivism)

Concept maps were used by Joseph D. Novak of Cornell University in the 1960's. Concept maps have their origin in the learning movement called 'Constructivism'. In particular, constructivists hold that prior knowledge is used as a framework to learn new knowledge. In essence, how we think influences how and what we learn. Concept Maps can thus illustrate faulty views individual may have and help us in better understanding how students may construct meaning from subject matter. Thus concept mapping originally developed as a way of 'determining how changes in conceptual understanding were occurring in the students'.

Constructivism is derived from the field of Cognitive psychology. The constructivist paradigm is based on the work of Jean Piaget, Lev Vygotsky, Jerom Bruner, Howard Gardner and Nelson Goodman (Fosnet, 1996). The main assumption of constructivism is that knowledge does not exist out there in an objective reality. Knowledge is actively constructed from within by the learner (Hendry and King, 1994). Facts become facts because it is knowledge that is agreed upon by communities of learners. The learner comes into any new situation with prior knowledge based on past experience. New knowledge is learned through integration with prior knowledge. The
educational principles, which have been derived from constructivism, are given below:

1. Concept development and deep understanding are the goals of instruction, not behavioral skills.

2. Learning is a constructive activity that students have to carry out. Students are active learners. The educator’s task is to provide students with opportunities to construct knowledge.

3. The teacher must provide meaningful, authentic activities to help students construct understanding relevant to solving problems.

4. Reflection of both content and the learning process is paramount.

5. Collaborative group should be used sc that student can set their understanding of particular issues.

6. Teacher’s need to ‘establish explicit linkages for students between new information taught in class and students past and future experiences. Teachers summarize, review and link main concept at critical points throughout and at the conclusion of units and lessons’.

7. Conceptual understanding is influenced by the prior knowledge brought by students to learning situations. This prior knowledge is labeled as ‘preconceptions’. Naive theories’, ‘alternative frameworks’ or ‘misconception’.

8. Teacher must challenge the learners thinking (alternative framework, preconceptions). Concept Mapping fits well with the constructivist approach that learner construct their own idiosyncratic understanding of concepts. The teachers can use a map as a basis for which to challenge student assumptions of how concepts are related. Russo, Scheurman, Heneed and Leubke (1995) maintain that most college faculty that
students would not remember specific facts from a course. What is more important is that students take away may or themes or concepts and an understanding of how these concept are related. Using a Concept Maps to design a course can aid the teacher in guiding the student to learn relevant concepts rather than trivial facts. Also, in knowing that students may perceive instruction differently from the way an educator intended. It can be helpful for the teacher to ‘Construct a hypothetical model of particular conceptual world of the students they are facing’.

1.7 Psychological Foundations of Concept Maps

The question sometimes arises as to the origin of a child’s concept. These are acquired during the ages of birth to three years, when they recognize regularities in the world around them and begin to identify language labels or symbols for these regularities. This early learning of concepts is primarily a discovery learning process, where the individual discerns pattern of regularities in events or objects and recognizes these as the same regularities labeled by older persons with words or symbols. This is a phenomenal ability that is part of the evolutionary heritage of all normal human beings. After the age 3, new concept and prepositional learning is mediated heavily by language, and takes place primarily by a reception learning process where new meanings are obtained by asking questions and getting clarification of relationship between old concepts and propositions and new concepts and propositions. This acquisition is mediated in a very important way when concrete experiences or props are available: hence the important of “hands on” activity for science learning with young children, but this is also true with learners of any age and ir any subject matter domain.
In addition to the distinction between the discoveries learning process, where the attributes of concepts are identified autonomously by the learner, and the reception learning process, where attributes of concepts are described using language and transmitted to the learner, Ausubel made the very important distinction between rote learning and meaningful learning.

Meaningful learning requires three conditions:

1. The material to be learned must be conceptually clear and presented with language and examples relatable to the learner's prior knowledge. Concept maps can be helpful to meet this condition, both by identifying large general concept held by the learner prior to instruction of more specific concepts. And by assisting in the sequencing of learning tasks though progressively more explicit knowledge that can be anchored into developing conceptual frameworks.

2. The learner must possess relevant prior knowledge. This condition can be met after age 3 for virtually any domain of subject matter, but it is necessary to be careful and explicit in building concept frameworks if one hopes to present detailed specific knowledge in any field in subsequent lessons. Therefore, condition (1) and (2) are interrelated and both are important.

3. The learner must choose to learn meaningfully. The one condition over which the teacher or mentor has only indirect control is the motivation of students to choose to learn by attempting to incorporate new meanings into their prior knowledge, rather than simply memorizing concept definitions or propositional statements or computational procedures. The indirect control over this choice is primarily instructional strategies used
and the evaluation strategies used. Instructional strategies that emphasize relating new knowledge to the learner's existing knowledge foster meaningful learning. Typical objective tests seldom require more than rote learning. In fact, the worst forms of objective tests, or short answers test, require verbatim recall of statements and this may be impeded by meaningful learning where new knowledge is assimilated into existing frameworks, making it difficult to recall specific, verbatim definitions or descriptions. This kind of problem was recognized years ago in Hoffman's (1962) *The Tyranny of Testing*.

As noted above, it is important to recognize that because individuals vary in the quantity and quality of the relevant knowledge they possess, and in the strength of their motivation to seek ways to incorporate new knowledge into relevant knowledge they already possess, the rote meaningful distinction is not a simple dichotomy but rather a continuum. Creativity can be seen as a very high level of meaningful learning.

One of the powerful uses of concept maps is not only as a learning tool but also as an evaluation tool, thus encouraging students to use meaningful mode learning patterns (Novak & Gowin, 1984).

Another important advance in the understanding of learning is that the human memory is not a single "vessel" to be filled, but rather a complex set of interrelated memory systems.

While all memory systems are interdependent (and have information going in both directions), the most critical memory systems for incorporating knowledge into long term memory are the short term and "working memory". All incoming information is organized and processed in the working memory
by interaction with knowledge in long term memory. The limiting feature here is that working memory can process only a relatively small number of psychological units (five to nine) at any one moment.

This means that relationships among two or three concepts are about the limit of working memory's processing capacity. For example, if a person is presented with a list of 10 to 12 letters or numbers to memorize in a few seconds, most will recall only 5 to 9 of these. However, if the letters can be grouped to form a known word, or word like unit, or the numbers can be related to a phone number or something known, then 10 or more letters or numbers can be recalled. In a related test, if we give learners 10 to 12 familiar but unrelated words to memorize in a few seconds, most will recall only 5 to 9 words. If the words are unfamiliar, such as technical terms introduced for the first time, the learner may do well to recall correctly two or three of these. Conversely, if the words are familiar and can be related to knowledge the learner has in her/his cognitive structure, e.g. months of the year, 12 or more may be easily recalled.

It should be noted that retention of information learned by rote still takes place in long term memory, as does information learned meaningfully; the difference is that in rote learning, there is little or no integration of new knowledge with existing knowledge resulting in two negative consequences. First knowledge learned by rote tends to be quickly forgotten, unless much rehearsed. Second, the knowledge structure or cognitive structure of the learner is not enhanced or modified to clear up faulty ideas. Thus misconceptions will persist, and knowledge learned has little or no potential for use in further learning and/or problem solving.
Therefore, to structure large bodies of knowledge requires an orderly sequence of iterations between working memory and long term memory as new knowledge is being received. Therefore, one of the reasons concept mapping is so powerful for the facilitation of meaningful learning is that it serves as kind of template or scaffold to help to organize knowledge and to structure it, even though the structure must be built up piece with small units of interacting concept and prepositional frameworks. Many learners and teachers are surprised to see how this simple tool facilitates meaningful learning and the creation of powerful knowledge frameworks that not only permit utilization of the knowledge in new contexts, but also the retention of the knowledge for long periods of time (Novak, 1990; Novak & Wanderse, 1991). There is still relatively little known about memory processes and how knowledge finally gets incorporated into our brain, but it seems evident from diverse sources of research that the brain works to organize knowledge in hierarchical frameworks and that learning approaches that facilitate this process significantly enhance the learning capability of all earners.

While it is true that some students have difficulty building concept maps and using these, at least early in their experience, this appears to result primarily from years of rote mode learning practice in school settings rather than as a result of brain structure differences per second. So called "learning style" differences are, to a large extent, derivative from differences in the pattern of learning that students have employed varying from high commitment to continuous rote mode learning to almost exclusive commitment to meaningful mode learning. It is not easy to help students in the former condition move to pattern of learning of the latter type. While
concept maps can help, students also need to be taught something about brain mechanisms and knowledge organization, and this instruction should accompany the use of concept maps. The information in the above paragraphs should become part on the instructional program for skillful use of concept maps. The information provided in this document could be part of this instruction. Other ideas for improving instruction to achieve understanding of the subject are available elsewhere.

1.8 Concept of Concept Mapping

Concept map is a device for representing the conceptual structure of a subject/discipline in a two-dimensional form, which is analogous to the road map. A concept, as defined by Novak, is regularity in objects or events designated by a specific label. Concept maps are diagrammatic representations, which show meaningful relationships between concepts in the form of propositions.

Propositions are two or more concept labels linked by words, which provide information on relationships or describe connections between concepts.

Concepts are generally isolated by circles and connected by lines. Lines are labeled with lining words, which describe how the connected concepts are related to each other. Two connected concepts make up a prepositional linkage or a statement about how some piece of the world looks or works.

Concepts are arranged hierarchically, that is the most general concept (super ordinate) are less inclusive than higher ones. 'Cross links' are prepositional linkages that connect different segments of the concepts.
hierarchy. They may indicate syntheses of related concepts, a new interpretation of old ideas and some degree of creative thinking.

Concept mapping is seen as a useful strategy for helping students learn about the structure of knowledge and the process of knowledge production. Learning about the nature and structure of knowledge helps students to understand how they learn. Knowledge about learning helps to show them how humans construct new knowledge. In contrast to students who learn by rote, students who employ meaningful learning are expected to retain knowledge over an extensive time span and find new related learning progressively easier.

Concept maps use three types of knowledge: facts, concepts and generalization. It is a learning strategy that was developed first as a research tool to represent learner's prior relevant knowledge and later as a tool to enhance meaningful learning.

1.9 Concept Mapping - It's Meaning

Concept mapping is a technique for representing knowledge in graphs. Knowledge graphs are networks of concepts. Networks consist of nodes (points/vertices) and links (arcs/edges). Nodes represent concepts and links represent the relations between concepts.

Concepts and sometimes links are labeled. Links can be non-uni- or bi-directional. Concepts and links may be categorized; they can be simply associative, specified or divided in categories such as casual or temporal relations.

Concept mapping can be done for several purposes:

- To generate ideas (brain storming, etc.);
• To design a complex structure (long texts, hypermedia large web sites, etc.);
• To communicate complex ideas;
• To aid learning by explicitly integrating new and old knowledge;
• To assess understanding or diagnose misunderstanding.

The concept mapping technique was developed by Joseph D. Novak at Cornell University in the 1960s. This work was based on the theories of David Ausubel, who stressed the importance of prior knowledge in being able to learn about new concepts. Novak concluded that, "Meaningful learning involves the assimilation of new concepts and propositions into existing cognitive structures".

Mind Mapping is a popular related technique, invented (and copyrighted) by Tony Buzan in the UK. He describes mind maps as: "a mind map consists of a central word or concept, around the central word you draw the 5 to 10 main ideas that relate to that word. You then take each of those child words and again draw the 5 to 10 main ideas that relate to each of those words."

The difference between concept maps and mind maps is that a mind map has only one main concept, while a concept map may have several. This comes down to the point that a mind map can be represented as a tree, while a concept map may need a network representation.

Theoretical Framework of Concept Mapping

It is essential that one has to have through knowledge of the theoretical framework of Concept Mapping Techniques and its related aspects like origin of Concept Mapping, its nature and characteristics, steps in
the Construction of Concept Mapping, if he wants to apply that strategy in the teaching learning situation.

1.10 Concept Mapping in Its Meta-Cognitive Context

Novak and Gowin have been exploring factors that influence students understanding of scientific subject matter. Their early work focused on acquisition of concept meanings and more recently their work has been turned to problem in epistemological foundation and assumptions underlying both instructional materials and learner's perceptions on subject matter. Gowin's (Gowin, 1970) early work on the structure of knowledge led to latter development of a heuristic device, Gowin's Vee (Gowin 1981). Novak's research problem led to development of cognitive learning theory and techniques for representing concept/prepositional frameworks that Novak refers to as a Concept Mapping. A number of studies have been completed utilizing the Vee Heuristic and Concept Mapping. These studies have found a fundamental underlying problem: Students failure to understand the nature of meaningful learning most of their learning being primarily role memorization in character. However, these studies have shown that Concept Mapping and Vee diagram can help students; help them 'learn how to learn (Novak and Gowin, 1984).

The fundamental of Concept Mapping is based on the theory of meaningful learning by David Ausubel which in itself is based on the assumption that meaningful learning occurs when new concept are linked to familiar existing in the learner's cognitive structure and can be applied to all subject matter.
How does Concept Mapping Facilitate Meaningful Learning?

First, concepts are not isolated, but rather connected together, showing inter-relationships.

Cross-links are particularly powerful connections, which form a 'web' of relevant concepts, probably enhancing their anchorage and stability in cognitive structure. They not only connect general concepts to specific concepts, but also tend to connect different sub-domains of conceptual structure. Linkages that are made only vertically would be likely to be forgotten than those that are also made laterally since vertical linkage are somewhat more specific instances of concepts whereas cross links relate together concepts in different domains of a concept.

Concept mapping demands clarity of meaning and integration of crucial details. The process of constructing a concept map requires one to think in multiple directions and to switch back and forth between different levels of abstraction. In attempting to identify the key and associated concepts of a particular topic or sub-topic, one will usually acquire a deeper understanding of the topic and clarification of any prior misconceptions.

1.11 Importance of Concept Mapping

The map is to construct a bounded graphic representation that corresponds to a perceived reality, it is not possible to map that area. Mapping follows knowing. Thus "to map" requires "knowing". Map represents one's knowledge.

As stated earlier concept is a generalized idea which results from categorization of a number of observations.
Dececco (1968) defined a concept as a class of stimuli which have common characteristics.

Concept, according to Wanderse (1990), is regularities in objects or events designated by some label, usually a term.

Novak (1984) defines concept as "perceived regularities or relationships and that refers to the name of the concept. Concept name represents the concept in symbolic form.

So it is understood that a name given to identify the categorized regularities and that refers to the name of the concept. Concept name represents the concept in symbolic form.

A concept can be learnt by different methods. In concept formation method, learner categorized the objects into groups based on certain criteria of commodity and difference (community within the category and difference among those which all out of the category).

In another approach, the meeting of the term representing a concept is presented to the learner.

Concepts are classified into three categories based on how they are related to other concepts. The most general concept is a super ordinate concept. Among the examples of this general concept subcategories can be formed, which a subordinate concepts to the super ordinate concept. The subordinate concepts so formed, are co-ordinate concepts among themselves.

Concept mapping is a technique that allows understanding the relationships between ideas by creating a visual map of the connections.
The maps generated by a learner report his or her conceptual organization of the topic (Schmid and Telaro, 1990).

However it has been through the later work of Novak and his Coworkers that concept mapping has emerged as an exemplary learning teaching strategy.

Concept maps are also effective in identifying both valid and invalid idea held by students. In every general terms the teacher may identify for a given hierarchy concept that are omitted or valid relationships that ate neither justified in the light of current understanding or are missing.

Concept map can be used by the classroom teacher to determine the extent meaningful learning has taken place for a particular topic. In a study by Heinz-fry and Jane Ann (1997) to evaluate the concept mapping as a tool for meaningful education, students felt mapping increased their integration of knowledge, helped to make sense of the material, clarified conned ions among concepts and helped them spend less time in memorizing.

The evaluation scheme is based on Ausubelian Learning principles. The propositions that link concepts are seen as a measure of the degree of differentiation of constituent concepts. Hierarchical differentiation, provides an indication of a student's ability to distinguish between exclusiveness and inclusiveness of a particular concept. Grouping of concepts on a map is a further way of demonstrating relationships and inter-relationships between concepts and can be seen as a measure of integrative reconciliation of meanings.
1.12 Characteristics of Maps

Concept maps are relational representation of concepts. Concepts are, as said earlier, related with super ordinate and subordinate relationship. In a concept map, super ordinate concepts are placed at the top.

Since a concept can be super ordinate with respect to one set of concepts but can be a subordinate to another concept, a concept has been raised for a subordinate to super ordinate level relatively. Also a concept can be represented simultaneously acting as a super ordinate concept and subordinate concept in same concept map.

Concept mapping provides a framework for organizing conceptual information in the process of designing a word. The Concept map also supports vocabulary and concept learning by helping.

Students internalize a strategy for defining and clarifying the meaning of unknown words. Students write the concept word or target word being studied in the center, and then work.

Outward into the boxes writing words that describes the target word. The framework of the concept map contains category/class the concept or target word belongs, properties if the concept word or target, and examples of the concept or target word.

A concept map presents the relationships among a set of connected concepts and ideas. It is a tangible way to display how one's mind "sees" a particular topic. By constructing a concept map, one reflection what one knows and what you don't know. In a Concept Map, the concepts, usually represented by single words enclosed in a rectangle (box), are connected to other concept boxes by arrows. A word or brief phrase, written by the arrow,
defines the relationship between the connected concepts. Major concept boxes will have lines to and from several other concept boxes generating a network.

"Concept Mapping" is a tool for assisting and enhancing many of the types of thinking and learning. To do a Map, write the main idea in the centre of the page. It may be a word, a phrase, or a couple of juxtaposed ideas, then place related ideas on branches that radiate from this central idea.

Concept maps are graphical tools for organizing and representing knowledge. They include concepts, usually enclosed in circles or boxes of some type, and relationships between concepts indicated by a connecting line linking, two concepts. Words on line referred to, as linking words or linking phrases, specify the relationship between the two concepts. A concept can be defined as a perceived regularity in events or objects, or records of events or objects, designated by a label. The label for most concepts in a world, although sometimes symbols such as + or %, and sometimes more than one word is used. Propositions are statements about some object or event in the universe, either naturally occurring or constructed. Propositions contain two or more concepts connected using linking words or phrases to form a meaningful statement. Sometimes these are called semantic units, or units of meaning. Following figure shows an example of a concept map that describes the structure of concept maps and illustrates the above characteristics.
Another characteristic of concept maps is that the concepts are represented in a hierarchical fashion with the most inclusive, most general concepts at the top of the map and the more specific, less general concepts arranged hierarchically below. The hierarchical structure for a particular domain of knowledge also depends on the context in which that knowledge is being applied or considered.

Another important characteristic of concept maps in the inclusion of cross links. These are relationships or links between concepts in different segments or to domains of the concept map. Cross-links help to see how a concept in one domain of knowledge represented on the map is related to a concept in another domain shown on the map. In the creation of new knowledge, cross-links often represent creative leaps on the part of the knowledge producer. There are two features of concept maps that are important in the facilitation of creative thinking: the hierarchical structure that...
is represented in a good map and the ability to search for and characterize new cross-links.

A final feature that may be added to concept maps in specific examples of events or objects that help to clarify the meaning of a given concept. Normally these are not included in ovals or boxes, since they are specific events or objects and do not represent concepts.

Concept maps were developed in 1972 in the course of Novak's research program at Cornell where he sought to follow and understand changes in children's knowledge of science (Novak & Musonda, 1991). During the course of this study the researchers interviewed many children, and they found it difficult to identify specific changes in the children's understanding of science concepts by examination of interview transcripts. This program was based on the learning takes place by the assimilation of new concepts and propositions into existing concept and prepositional frameworks held by the learner. This knowledge structure as held by a learner is also referred to as the individual's cognitive structure. Out of the necessity to find a better way to represent children's conceptual understanding emerged the idea of representing children's knowledge in the form of a concept map. Thus was born a new tool not only for use in research, but also for many other uses.

Concept mapping is a type of structured conceptualization, which can be used by groups to develop a conceptual framework, which can guide evaluation or planning.

Concept mapping encourages the group to stay on task results relatively quickly entirely in the language of the participants; yields a graphic.
or pictorial product, which simultaneously shows all major ideas and their interrelationships; often improves group or organizational cohesiveness and morale.

The key principle behind this strategy is to "relate new knowledge first to the things that students, already know and second, to the things that they are currently learning in the classroom". Concept mapping relates directly to such theoretical principles of previous knowledge, consumption, progressive differentiation, integrative reconciliation and cognitive bridging.

Also concept map parallels human cognitive structure, in that they show concepts organized hierarchically. That representation along with showing logical structure of subject reflects the psychological structure of knowledge.

The mapping process has its justifiers in cartography, the science of mapmaking. Wanderss (1990) draws following generalizations from cartography to justify concept mapping.

1. Mapping and knowing are closely intertwined.

2. Maps are excellent heuristic devices.

3. Both map maker and map-reader has important responsibilities to fulfill if communication is to occur.

4. Every map reflects both its data and its designer.

5. Changes in the maps reflect changes in the understanding.

6. The prior knowledge of the mapmaker can have a great influence on the maps he or she makes.

7. Maps have great cognitive, integrative, summative and generative power.
Concept mapping for psychological structure of knowledge facilities meaningful learning? First concepts are not isolated, but rather connected together, showing interrelationship. Crosslinks in the concept maps from a 'web' of relevant concepts, enhance the stability in the cognitive structure. Rather than just connecting general concepts to specific concepts, they tend to connect different sub domains of conceptual structure. What this does in effect is inverse the number of relevant concepts that connect to new material very powerful connections might relate previously isolated chapters or even areas together. Rote learning would be just a series of propositions that are memorized but not related to each other. With mapping, new concepts and propositions are connected into a whole existing relevant framework. This pattern of subsumption, progressive differentiation and super ordinate learning leads in times, to both a quantitative and qualitative increase in the learner's knowledge structure.

1.13 Pedagogy for Concept Mapping

Brainstorming Phase: From the memory, (which one can jog by going through the notes and related course material) facts, terms and ideas that in anyway associated with the topic should be identified. A list of these items and prints them neatly on small notes, one per note, in very brief form, i.e. a single word or short phase. In this brainstorming process, so everything is important should be written down. The objective here is to generate the largest possible list.

Organizing Phase: Spread out the concepts (small notes) on a flat surface so that all can be read easily and, together, create groups and subgroups of related items. Items should be grouped to emphasize
hierarchies. Terms that represent those higher categories should be identified and added and new items can be introduced. Some of the concepts may fall multiple groupings. This will become important later.

Layout Phase: On a large sheet of paper, an arrangement (layout) that best represents the collective understanding of the interrelationships and connections among groupings can be brought out. Items can be analyzed at any time during this phase. A consistent hierarchy must be used in which the most important concepts are in the center or at the top. Within sub grouping, closely related items should be placed near to each other. The items in a simple sentence that shows the relationship between them. It may be advisable to meet outside of class to work on this assignment and plan for its completion.

Linking Phase: Lines with arrows can be used to connect and show the relationship between connected items. A word or short phrase can be written by each arrow to specify the relationship. Many arrows can originate or terminate on particularly important concepts.

Finalizing the Concept Map: After arranging one need to convert the concept map into a permanent form that others can view and discuss. One can be creative in a constructive way through the use of colors, fonts, shapes, border thickness, etc. to communicate one’s understanding of the concept. A title to the concept map. In reviewing the concept map, the following attributes are considered:

- Accuracy and Thoroughness. Are the concepts and relationships correct? Are important concepts missing? Are any misconceptions apparent?
- Organization: Was the concept map laid out in a way that higher order relationships are apparent and easy to follow? Does it have a title?
• Appearance: Was the assignment done with care showing attention to details such as spelling and penmanship? Is it neat and orderly or is it chaotic and messy?

• Creativity: Are there unusual elements that aid communication or stimulate interest without being distracting?

1.14 Kinds of Concept Maps

There are four major categories of concept maps. These are distinguished by their different format for representing information. Examples of the various types of concept maps are presented on the following pages.

1. Trees (hierarchical map): These are arrangements of concepts of some type of classification, starting at the top of the page with the broadest and the subdividing progressively down the page.

2. Webs: These are non-hierarchical arrangements in which as many interconnecting propositions as possible are shown.

3. Wheels: These maps have a central "hub" concept with propositions radiating out like spokes. Secondary spokes are also possible.

4. Strings: The arrangement of concepts are in the forms of strings.

1.15 Steps of Construction of Concept Mapping

The steps followed in constructing the concept maps are as follows:

(i) The students are given the material pertaining to the lesson/unit and given instructions to read the material and select the key concepts. The concepts are listed on the blackboard as they are identified. Discussion is held with the students as to which concept is more important and most inclusive in the lesson/unit.
(ii) The most inclusive or super ordinate concept is placed at the top. The most general and inclusive concepts are listed next, working through the first list until all concepts are rank ordered.

(iii) Students are asked to help in choosing good linking words to form the propositions shown by the lines on the map.

(iv) Cross links between concepts in one section of the map and concepts in another part of the concept tree are made with the. The concepts are either circles or put in small boxes.

(v) Maps are reconstructed if they have poor symmetry or are poorly clustered.

Textbook chapters or lectures are excellent materials for concept mapping because they offer short and concise descriptions of important subjects or issues. Often in Bio-Science the map will be hierarchical (the more inclusive/general concepts and relationships usually are located closer to the bottom) with lines indicating subordinacy or flows, or cause effect links.

1.16 Points to be Remembered While Preparing Concept Maps

Step 1. Selecting and reading a chapter in a textbook or a set of lecture notes on a particular topic, highlighting the important points and ideas. After having finished reading and highlighting, the key concepts necessary for understanding the topic to be identified and a list of their names can be made.

Step 2. Deciding which concept (or concepts there may be more than one) is the most important or more exclusive idea, and making a list with this concept at the top. The next most general concept should be found and be written next. Now remainder of the concepts can be concluded from "most inclusive" or "most general" to "least inclusive" or "most specific".
Step 3. Constructing a concept map should begin with placing the name of the broadest, most inclusive concept's at the top of a piece of paper. Work down, adding more specific concepts. Sometimes these may be located a long side each other like brands of detergent on a supermarket shelve. Sometimes it is more sensible to have them in descending order, one above the other. Enclose each term in a box or a circle.

Step 4. Joining the concepts with lines and label the lines with linking words that show meaningful connections between the concepts. As a first step, the word or words that accurately describes according to your text reading, the relationship between the super ordinate concept and the subordinate concept related to it must be formulated. These are called the "linking words." The learner (mappers) should try to be "economical" is formulating these links. Linking concepts is the most important aspect of concept mapping. Here are a few examples of linking words use to describe relationships: "Composed of, 'includes', 'depends on', 'is influenced by', causes', if effected by.

Step 5. Finishing of mapping in all concepts in the list and continuing to make the map grow by relating additional concepts from list to concepts already on the map. The more "inclusive" terms has to be taken first, working the way down to the most specific terms until all the concepts are "mapped in".

Step 6. Map to studied to see if there are any other relevant relationships that should be illustrated between terms on the map. Such relationships, if they exist, may take the form of cross-links. Cross-links are relationships that exist between two concepts or two propositions indifferent
vertical segments of the concept map. Cross-links helps to integrate a concept map into a cohesive whole. Cross-links can be constructed at any point in the mapping process. In fact, the learner will often “see” cross-links when only some of the terms have been mapped. Such cross links may be forgotten if not mapped in at that point.

Step 7. When the concepts which are linked together to form a cause effect relationship, an arrow is used to show the direction of the relationship. Not all links need be one-way. Examples of two-way interdependency can be looked for.

1.17 General Methods of Drawing Concept Maps

- Gather Your Writing and Drawing Materials

  Having to get up to find a tool or notebook is more than an inconvenience, it can completely break your concentration. Have plenty of paper on hand, colored markers, a ruler, and even a shape template. You may wish to dedicate a notebook just to making and refining visuals for your classes.

- Gather Your Research Materials

  These materials can include: books, class notes, related newspaper and magazine articles, notes of independent observations, data/statistics, and visual materials. Such as photos and diagrams. This is your “database” for making concept maps. You scan such materials to keep relevant information in mind as you are making maps.

- Select One of the Concept Map Formats

  Get to know the different formats. Try them out when you have an opportunity. See how different formats are appropriate for different kinds of
information. For example, if you want to depict the organizational structure of the College of Agricultural, Consumer and Environmental Sciences, a hierarchy map is best (the Dean goes in the top box).

- **Making your First Map**

  For example, for the question "should there be logging in old growth forests?" make a spider map to represent the pro's and con's of this issue. On one side of this issue, there are topics like biodiversity and spotted owls that should be depicted on the map. On the other side of the issue, there are topics related to the towns and families that rely on logging income that should be on the map. There are also issues of logging and foreign trade, logging and recreation and so on. Try to come up with a map that represents the whole issue.

- **Revising Maps**

  Revise your maps to refine them: Are they clear? Logical? Attractive? Good maps are like good writing: they are usually the products of several drafts. Show a map to your teacher and friends to get feedback.

- **Using Maps as Preparation for Discussion Section**

  After lecture and before your discussion section, make a map to represent the information presented in lecture. And be sure to always master the concept maps that are in your Discovery Manual at the beginning of each of the five system sections. They provide a convenient overview of some very complex information.

1.18 **Creative Tips for Making Meaningful Maps**

1. Available visual materials such as photos, sketches, graphs, etc. should be reviewed.
2. A visual language approach to communication must be pressured upon.
3. Possible formats for visual structuring can be considered.
4. Allow the mind to "free associate" with the concepts.
5. Informal, thumbnail sketches of the visual impressions can be drawn.
6. A variety of visual layout formats should be experienced with color, shapes, arrows or words can be used emphasis.
7. A bird's eye overview of the subject matter to be presented is to be imagined.
8. Verify whether the visual presentation attractive?
9. Verify these visuals compelling? Do they help convince the viewer that the subject matter is important and inviting?
10. The visuals are to be intended with the text, verify if it works to the best advantage?
11. A record of the maps done should be kept.

Concept map made by a pupil corresponds to a representation of the hierarchical organization of her/his cognitive structure (Wandersee, 1990). Allowing the exteriorization of the singularities of that structure, this is very important in the day-to-day functioning of the classroom. In fact the conceptions with which the pupil begins a learning task become more explicit. It reveals his more or less intuitive and erroneous thought, and when it is again constructed by the same pupil it allows him/her to schematically illustrate what was learnt, how it was learnt and to what extension the pupil's concepts were enriched. The disclosure of the pupil "secrets of the mind" that "externalization" of her/his cognitive structure with the concept map, allows the teacher to make sense of the pupil how differentiates, relates,
discriminates and integrates them. Therefore, "the construction of concept
maps is a way of helping learners and educators penetrate the structure and
meaning of the knowledge that they are trying to understand" (Novak and

1.19 Advantages of Mapping

• It clearly defines the central idea, by positioning it in the centre or at the
top of the page.
• It allows to indicate clearly the relative importance of each idea.
• It allows to figure out the links among the key ideas more easily. This is
particularly important for creative work such as essay writing.
• It allows to see all year basic information on one page.
• As a result of the above, and because each map will look different, it
makes recall and review more efficient.
• It allows to add in new information without messy scratching out or
squeezing in.
• It makes it easier to see information in different ways, from different
viewpoints, because it does not lock it into specific positions.
• It allows it easier to see complex relationships among ideas, such as self
perpetuating systems with feedback loops.
• It allows to see contradictions, paradoxes, and gaps in the material more
easily, and in this way provides a foundation for questioning, which in turn
encourages discovery and creativity.

1.20 Uses of Concept Maps

In constructing concept maps, difficult concepts can be clarified and
they can be arranged in a systematic order. Using concept maps in teaching
helps teachers to be more aware of the key concepts and relationships among them. It helps in deciding what to include in a curricular unit or lesson plan. Taking time to identify concepts yields clarity about topics and helps to determine which topics are worth learning. Mapping concepts suggest specific objectives that teachers must plan for pupils. It also helps to seek the breadth and depth of a topic, see logic of relationships and choose proper activities and teaching aids. This understanding improves teachers planning and instruction.

Since knowledge is vast, and most of the teachers have acquired it in pieces at different stages, there is a possibility of not seeing important connections between different ideas. As an exercise, concept mapping provides an opportunity to express one's understanding about various concepts and to show relationships with other similar and dissimilar concepts.

There is evidence that concept maps can help teachers, become more effective (Beyerkach and Smith, 1990; Hozetal, 1990) and can serve as a heuristic for curriculum development (Starr and Krajicik, 1990). They are essential tools for planning and teaching and can help improve student's concept constructions.

Concept mapping is a more recent development that is widely used as a constructivist learning model. It has been used as an advance organizer to focus pupil's attention and guide them along to seeing the bigger picture and for use as mental scaffolding for organizing their thoughts and discoveries.

Concept mapping can be used for several purposes like (a) to generate ideas (brain storming); (b) to design complex structures (long texts, hyper media, large web sites); (c) communicate complex ideas; (d) to aid
learning by explicitly integrating new and old learning; and (e) to assess understanding or diagnose misunderstanding of a concept.

By assessing the concept maps developed by the students, the teacher can:

i) Gain insight into the way students view a concept or a topic;

ii) Examine the valid understandings and misconceptions students hold; and

iii) Assess the structural complexity of the relationships students depict.

Apart from assessing the student’s understanding of concept, the teachers can also use concept maps to organize their ideas in preparation for instruction, as a graphic organizer during class and as a way to encourage students to reflect on their own knowledge and to work together and share their understanding in collaborative group settings.

Concept maps can also be used for pupil evaluations. They may be used as formative and summative evaluation tools to see whether pupils have understood the concepts, relationships between concepts and the topic as a whole.

Besides the cognitive abilities that have been stated, concept maps are not the only ways to represent meanings. Flow charts are often used to represent sequences of activities. Organizational charts, cycles such as water cycle in science, semantic networks and predictability trees that are used in some psychological and linguistic writings are some sort of maps. But they are not based on the theory of learning and theory of knowledge that underlie the concept mapping strategies and their application to education.

Concept mapping done in groups also develops certain social skills, and values like tolerance, respect for others, views, group spirit, cooperation, discussion abilities, open mindedness and so on.
Novak and Gowin (1984) had mentioned some of the uses of concept mapping which are:

1) To explore the understanding of a limited aspect of the topic.
2) To check whether learners understand the purpose of instruction.
3) To see whether learners can make links between concepts.
4) To identify changes that learners make in relationships between concepts.
5) To find out which concept are regarded as key ones.
   i) The material to be learned must be conceptually clear and presented with language and examples related to the learner's prior knowledge.
   ii) The learner must possess relevant prior knowledge.
   iii) The learner must chose to learn meaningfully.

Conclusion

In the present study the researcher has considered some of the psychological factors such as cognitive ability, problem solving ability and scientific aptitude and teaching pedagogy that may effect the achievement in science of secondary students Hence the present study is undertaken with a view to examine various psychological factors effecting on science achievement.

In the modern class room situation, the influence of science teaching is given vital importance and innovative instructional technology. Hence teaching science is a challenging task on the part of science teacher. These new innovative practices especially new pedagogies, strategies, self instructional materials, in individualized instructional materials and new electronic gadgets in teaching science brought significant changes in the process of teaching and learning science subjects to motivate the students for better performance in turn total academic achievement. Hence the present study is undertaken with a view to study the effect of concept mapping on science achievement of secondary school students and to identify the relative effectiveness of both conventional instruction and concept mapping in relation to cognitive ability, problem solving ability and scientific aptitude.