CHAPTER – I
INTRODUCTION

In order to improve instructional methods carried out in the classroom for improvement of students’ learning, there has always been a search for more potential ways of instruction. One of the strategies that have evolved as a useful tool in leading students towards meaningful learning is ‘Concept Mapping’. In recent years, along with the various innovative methods, constructivism in the classroom as an interpretative process involving individual’s construction of meanings in science is being suggested. New constructions are built through their relations to prior knowledge and it is a pedagogic challenge for teacher to focus on students’ learning with understanding. To learn science from a constructivistic philosophy implies direct experience with science as a process of knowledge generation in which prior knowledge is elaborated and changed on the basis of fresh meaning negotiated with peers and teacher. Concept mapping stimulates this process by making it explicit.

1.1 CONCEPT MAPPING

Concept mapping is a teaching and learning strategy that establishes a bridge between how people learn knowledge and sensible learning. Students need to have sufficient foundation and a critical thinking about concept mapping and the relations between different concepts. Concept mapping promises to be useful in enhancing meaningful learning and students’ conceptual understanding in Science (Novak and Gowin, 1984). Concept mapping is seen as a useful tool for helping students learn about the structure of knowledge and the process of knowledge production or Meta 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 mapping consists of Concepts maps, which are diagrammatic representations made to show meaningful relationships between concepts in the form of propositions
which are linked together by words, circles, and cross-links. Concepts are arranged hierarchically, with the superordinate concepts at the top, of the map and subordinate which are less inclusive than higher ones at the bottom. Cross-links are used to connect different segments of the concepts hierarchy, which indicate syntheses of related concepts, a new interpretation of old ideas, and some degree of creative thinking.

1.1.1 Theoretical Basis of Concept Mapping

Joseph D. Novak of Cornell University was the one who, in the 1960s, started the systematic use of concept mapping for learning (Novak, 1993). His work was based on two important ideas in Ausubel’s (1968) assimilation theory of cognitive learning:

- Most new learning occurs through derivative and correlative subassumption of new concept meanings under existing concept or propositional frameworks. Learning that is meaningful involves reorganization of existing beliefs or integration of new information with existing information.

- Cognitive structure is organized hierarchically, with new concepts or concept meanings being subsumed under broader, more inclusive concepts.

The theoretical framework that supports the use of concept mapping is consistent with constructivist epistemology and cognitive psychology. Constructivism is a major influence in current science education. Concept mapping is a method to visualize the structure of knowledge. Since the knowledge expressed in the maps is mostly semantic, concept maps are sometimes called as semantic networks. Often it is claimed that concept mapping bears a similarity to the structure of long-term memory. Instead of describing all concepts and their relations in text, one may choose to draw a map indicating concepts and relations in a graph or network. Visual representation has several advantages. Visual symbols being quickly and easily recognized can be demonstrated by considering the large amount of logos, maps, arrows, road signs, and icons that most of us can recall with
little effort. Visual representation also allows the development of a holistic understanding that words alone cannot convey, because the graphical form allows representations of parts and whole in a way that is not available in sequential structure of text.

1.1.2 History

The technique of concept mapping was developed by Joseph D. Novak and his research team at Cornell University in the 1970s as a means of representing the emerging science knowledge of students. It has subsequently been used as a tool to increase meaningful learning in the sciences and other subjects as well as to represent the expert knowledge of individuals and teams in education, government, and business. Concept maps have their origin in the learning movement called constructivism. In particular, constructivists hold that learners actively construct knowledge.

Novak's work is based on the cognitive theories of David Ausubel (assimilation theory), who stressed the importance of prior knowledge in being able to learn new concepts: "The most important single factor influencing learning is what the learner already knows. Ascertain this and teach accordingly. Novak taught students as young as six years old to make concept maps to represent their response to focus questions such as "What is water?" "What causes the seasons?" In his book *Learning How to Learn*, Novak states that a "meaningful learning involves the assimilation of new concepts and propositions into existing cognitive structures."

Various attempts have been made to conceptualize the process of creating concept maps. Ray McAleese, in a series of articles, has suggested that mapping is a process of off-loading. In this 1998 paper, McAleese draws on the work of Sowa and a paper by Sweller & Chandler. In essence, McAleese suggests that the process of making knowledge explicit, using *nodes* and *relationships*, allows the individual to become aware of what they know and as a result to be able to modify what they know. Maria Birbili applies that same idea in helping young children learn to think about what they know. The concept of the Knowledge Arena is suggestive of a
virtual space where learners may explore what they know and what they do not know.

1.1.3 Meaning of Concept mapping

Essentially, concept mapping is a structured process, focused on a topic or construct of interest, involving input from one or more participants, that produces an interpretable pictorial view (concept map) of their ideas and concepts and how these are interrelated. Concept mapping has concept maps to its core. Concept maps are spatial representations of concepts and their interrelationships that are intended to represent the knowledge structures that humans store in their minds (Jonassen, Beissner, & Yacci, 1993).

The concept map is a tool or device that was developed by Ausubel, Novak, and Gowin as a convenient and concise representation of the learner’s concept/ propositional framework of a domain specific knowledge. The simplest concept map would consist of two concepts linked by “logical connectives” as in Figure 1.1.

![Figure 1.1 The simplest concept map](image)

The terms in the boxes are concepts and the verb or logical connective constitutes a “proposition”.

The word concept may be defined as:

1. Something conceived in the mind
2. An abstract idea generalized from particular instances

And has been defined by Ausubel, who’s cognitive learning theory has been a guide to research on concept mapping, as:

“... (Any) objects, events, situations or properties that possess common critical attributes and are designated in any given culture by some accepted sign or symbol.”
A concept map that consists of new concepts that are connected by propositions to previously learned concepts could be looked at as demonstrating meaningful learning. Furthermore, as concepts are associated with other concepts and propositions the nature of the persons understanding of that concept will change. The propositions in this map called as links and they have been emphasized as a most important component in the concept mapping. They provide an indication of what learning exists and the depth of that understanding. A concept map is a way of representing relation between ideas, images or words, in the same way that a sentence diagram represents the grammar of a sentence, a road map represents the locations of highways and towns, and a circuit diagram represents the workings of an electrical appliance. In a concept map, each word or phrase is connected to another and linked back to the original idea, word or phrase. Concept maps are a way to develop logical thinking and study skills, by revealing connections and helping students see how individual ideas form a larger whole. An example of a more Complex map is presented in Figure 1.2.

![A complex concept map](image)

**Figure-1.2  A complex concept map**

Concept maps were developed to enhance meaningful learning in the
There is research evidence that the knowledge is stored in the brain in the form of productions that act on declarative memory content which is also referred to as chunks or propositions. Because concept maps are constructed to reflect the organization of the declarative memory system, they facilitate sense-making and meaningful learning on the part of individuals who make concept maps and those who use them.

Among the various schema and techniques for visualizing ideas, processes, organizations, concept mapping, as developed by Joseph Novak is unique in philosophical basis, which makes concepts, and proposition composed of concepts, the central elements in the structure of knowledge and construction of meaning. Concept maps are freer from, multiple hubs and clusters can be created, unlike mind maps which fix on a single conceptual center.

As babies, we begin to build up schema, which enable us to distinguish a human face from its background. More abstract conceptualization involves the same process of constructing meaning and pattern from a jumble of sensory information. These schemas then enable us to function with confidence in a complex environment (Bruillard & Baron, 2000). Effective learning depends on the creation of new schema, or existing schema being revised, extended or reconstructed. Concept maps are concrete representations of these schemas and their interrelationships that are intended to represent the knowledge structures that human store in their minds (Jonassen, Beissner & Yacci, 1993).

1.1.4 Psychological Foundations of Concept Maps

The question sometimes arises as to the origin of our first concepts. These are acquired by children 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 (Macnamara, 1982). This early learning of concepts is primarily a discovery learning process, where the individual discerns patterns or 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 age 3, new concept and propositional 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 relationships 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 importance of concept map making activity for science learning with young children, but this is also true with learners of any age and in 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 concepts held by the learner prior to instruction on 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. We see, therefore, that conditions (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 in instructional strategies used and the evaluation strategies used. Instructional strategies that emphasize relating new knowledge to the learner’s existing knowledge foster meaningful learning. Evaluation strategies that encourage learners to relate ideas they possess with new ideas also encourage meaningful learning. Typical objective tests seldom require more than rote learning (Bloom, 1956; Holden, 1992). In fact, the worst forms of objective tests, or short-answers tests, 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. These ideas are shown in Figure 1.3.

Learning can vary from highly rote to highly meaningful. Creativity results from very high levels of meaningful learning. People often confuse rote learning and meaningful learning with teaching approaches that can vary on a continuum from direct presentation of information (which may be conceptually obscure or conceptually explicit) to autonomous discovery approaches where the learner perceives the regularities and constructs her/his
Figure 1.3 Schematic representation of rote and meaningful learning

own concepts. Both direct presentation and discovery teaching methods can lead to highly rote or highly meaningful learning by the learner, depending on the disposition of the learner and the organization of the instructional materials. These distinctions are shown in Figure 1.3. There is the mistaken notion that “inquiry” studies will assure meaningful learning. The reality is that unless students possess at least a rudimentary conceptual understanding of the phenomenon they are investigating, the activity may lead to little or no gain in their relevant knowledge and may be little more than busy work. In fact, the research basis for support of widely recommended inquiry learning is largely absent (Mayer, 2004; Kirschner et al., 2006; Sweller et al., 2007).

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 (Mintzes et al., 2000; Novak, 1990; Novak & Gowin, 1984). Concept maps are also effective in identifying both valid and invalid ideas held by students. They can be as effective as more time-consuming clinical interviews for identifying the relevant knowledge a learner possesses before or after instruction (Edwards & Fraser, 1983).
Another important advance in our 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. Figure 1.5 illustrates the memory systems of the human mind, and interactions with inputs from our affective and psychomotor inputs.

Figure 1.5 Key memory systems interaction in the brain during learning
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 a moment (Miller, 1956). 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 10-12 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 know 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 10-12 familiar but unrelated words to memorize in a few seconds, most will recall only 5-9 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 (Novak, 2002).

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 and processed (Anderson, 1992). We believe one of the reasons concept mapping is so powerful for the facilitation of meaningful learning is that it serves as a kind of template or scaffold to help to organize knowledge and to structure it, even though the structure must be built up piece by piece with small units of interacting concept and propositional 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 & Wandersee, 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 our brain works to organize knowledge in hierarchical frameworks and that learning approaches that facilitate this process significantly enhance the learning capability of all learners (Bransford et al., 1999; Tsien, 2007).

Obviously, our brains store more than concepts and propositions. While the latter are the principal elements that make up our knowledge structures and form our cognitive structure in the brain, in all forms of learning. Iconic learning involves the storage of images of scenes we encounter, people we meet, photos, and a host of other images. These are also referred to as iconic memories (Sperling, 1960; 1963). While the alphanumeric images Sterling (1967) used in his studies were quickly forgotten, other kinds of images are retained much longer. Our brains have a remarkable capacity for acquiring and retaining visual images of people or photos. For example, in one study (Shepard, 1967) presented 612 pictures of common scenes to subjects, and later asked which of two similar pictures shown was one of the 612 seen earlier? After the presentation the subjects were 97% correct in identifying picture they had seen. Three days later, they were still 92% correct, and three months later they were correct 58% of the time. This and many other studies have shown that humans have a remarkable ability to recall images, although they soon forget many of the
details in the images. Considering how often we look at pennies, it is interesting that the subjects asked to draw a penny in a study by Nickerson and Adams (1979) omitted more than half of the features or located them in the wrong place. It is believed that integrating various kinds of images into a conceptual framework using concept mapping could enhance iconic memory.

Human’s ability to recall sounds is also remarkable. The learning and recall of sounds is also referred to as *archaic* memory. Consider the musician who can play hundreds of songs without reading any music. Again it deals with memories that are not coded as concepts or propositions. Studies by Penfield and Perot (1963), among others, indicate that regions of our brain that are activated when we hear sounds are the same regions that are active when we recall sounds. While we can locate regions of the brain that are active in learning or recall of information using positron emission tomography (PET) scans, the specific mechanisms by which neurons store this information is not known.

There are obvious differences between individual’s abilities, and some of these have been explored by Gardner (1983). He has proposed a *Theory of Multiple Intelligences*. His work has received much attention in education and has served to draw attention to the broad range of differences in human abilities for various kinds of learning and performance. It is good that schools are recognizing that there are important human capabilities other than the recall of specific cognitive information so often the only form of learning represented in multiple-choice tests used commonly in schools and corporations. One reason we encourage the integration of the broad range of activities represented in our New Model for Education is to provide opportunities for these other abilities to be represented and expressed. Nevertheless, we see the organizing opportunities afforded by associating the various activities with an explicit knowledge structure as very beneficial. Time will tell if future research studies will support this claim of concept mapping activities.
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 se*. So-called “learning style” differences are, to a large extent, derivative from differences in the patterns 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 to move patterns 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 here could be part of this instruction. Other ideas for improving instruction to achieve understanding of the subject demand training in c-map constructions task. To illustrate how difficult it can be for individuals to modify their ideas, especially if they learn primarily by rote, we cite the example of interviews done by the Private Universe Project (PUP) at Harvard University (Schneps, 1989). The staff of PUP interviewed 23 Harvard graduates, alumni and faculty, asking each “Why do we have seasons?” Only eleven concepts, properly organized are needed to understand why we have seasons, and one arrangement of these concepts is shown in Figure 1.6. The PUP interviewers found that 21 of the 23 interviewed could not explain why we have seasons, a topic that is taught repeatedly in school. Included in this group was a graduate who had recently taken a course in the Physics of Planetary Motion, who also believed erroneously that seasons were caused by the earth moving closer to the sun in summer and further away in the winter. In fact, the earth is slightly closer to the sun when it is winter in Massachusetts, rather than in summer. The primary reason we have seasons in latitudes away from the equator is due to the tilt of the earth on its axis toward the sun in summer resulting in longer days and more direct radiation, thus greater heating. In
winter, the axis of the earth points away from the sun, thus resulting in shorter days and less intense radiation.

![Concept Map of seasons](image)

**Figure 1.6  The Concept Map of seasons**

What is interfering with these 21 Harvard people is confusion with the common experience that when we are closer to a fire or lamp, the heat is more intense than when we are further away. Thus, these people have failed to recognize that this same phenomenon is not operating to give seasons on Earth. They are transferring knowledge from one context to another, but incorrectly. This is commonly observed in many, many examples of “misconceptions” in every field of study. The only solution to the problem of overcoming misconceptions is to help learners learn meaningfully, and using concept maps to eliminate misconcepts can be very helpful.

### 1.1.5 Epistemological Foundations of Concept Maps

As indicated earlier, we defined concept as a *perceived regularity (or pattern) in events or objects, or records of events or objects, designated by label*. It is coming to be generally recognized now that the meaningful learning processes described above are the same processes which are used
by scientists and mathematicians, or experts in any discipline, to construct new knowledge. In fact, Novak has argued that new knowledge creation is nothing more than a relatively high level of meaningful learning accomplished by individuals who have a well organized knowledge structure in the particular area of knowledge, and also a strong emotional commitment to persist in finding new meanings (Novak, 1977, 1993, 1998). Epistemology is that branch of philosophy that deals with the nature of knowledge and new knowledge creation. There is an important relationship between the psychologies of learning, as we understand it today, and the growing consensus among philosophers and epistemologists that new knowledge creation is a constructive process involving both our knowledge and our emotions or the drive to create new meanings and new ways to represent these meanings. Learners struggling to create good concept maps are themselves engaged in a creative process, and this can be challenging, especially to learners who have spent most of their life in learning by rote. Rote learning contributes very little at best to our knowledge structures, and therefore cannot underlie creative thinking or novel problem solving.

As defined above, concepts and propositions are the building blocks for knowledge in any domain. We can use the analogy that concepts are like the atoms of matter and propositions are like the molecules of matter. There are only around 100 different kinds of atoms, and these make up an infinite number of different kinds of molecules. There are now about 460,000 words in the English language (most of which are concept labels), and these can be combined to form an infinite number of propositions. Although most combinations of words might be nonsense, there is still the possibility of creating an infinite number of valid and meaningful propositions. Poets and novelists will never run out of new ideas to express in new ways. We shall never run out of opportunities to create new knowledge. As people create and observe new or existing objects or events, the creative people will continue to create new consents and new knowledge. Creating new methods of observing or recording events usually opens up new opportunities for new knowledge creation. For example, the creation of the concept mapping
method for recording subject’s understandings has led new opportunities to study the process of learning and new knowledge creation.

1.1.6 Concept mapping versus topic maps and mind mapping

Concept maps are rather similar to topic maps in that both allow to connect concepts or topics via graphs, while both can be contrasted with the similar idea of mind mapping, which is often restricted to radial hierarchies and tree structures. Among the various schema and techniques for visualizing ideas, processes, organizations, concept mapping, as developed by Joseph Novak is unique in philosophical basis, which makes concepts, and propositions composed of concepts, the central elements in the structure of knowledge and construction of meaning. Another contrast between Concept mapping and Mind mapping is the speed and spontaneity when a Mind map is created. A Mind map reflects what you think about single topic, which can focus group brainstorming. A Concept map can be a map, a system view, of a real or abstract system or set of concepts. Concept maps are more free form, as multiple hubs and clusters can be created, unlike mind maps which fix on a single conceptual center.

1.1.7 Process of Concept Mapping

Concept mapping helps people to think more effectively as a group without losing their individuality. It helps groups to manage the complexity of their ideas without trivializing them or losing detail.

A concept mapping process involves six steps that can take place in a single day or can be spread out over weeks or months depending on the situation.

Step-1 Preparation Step

The first step is the Preparation Step. There are three things done here. The facilitator of the mapping process works with the initiator(s) (i.e., whoever requests the process initially) to identify who the participants will be. A mapping process can have hundreds or even thousands of stakeholders participating, although we usually have a relatively small group of between
Figure 1.7 The process of Concept Mapping

10 and 20 stakeholders involved. Second, the initiator works with the stakeholders to develop the focus for the project. For instance, the group might decide to focus on defining a program or treatment. Or, they might choose to map all of the outcomes they might expect to see as a result. Finally, the group decides on an appropriate schedule for the mapping.

Step-2 Generation Step

In the Generation Step the stakeholders develop a large set of statements that address the focus. For instance, they might generate statements that describe all of the specific activities that will constitute a specific social program. Or, they might generate statements describing specific outcomes that might occur as a result of participating in a program. A wide variety of methods can be used to accomplish this including
traditional brainstorming, brain writing, nominal group techniques, focus groups, qualitative text analysis, and so on. The group can generate up to 200 statements in a concept mapping project.

**Step-3 Structuring Step**

In the **Structuring Step** the participants do two things. First, each participant sorts the statements into piles of similar ones. Most times they do this by sorting a deck of cards that has one statement on each card. But they can also do this directly on a computer by dragging the statements into piles that they create. They can have as few or as many piles as they want. Each participant names each pile with a short descriptive label. Second, each participant rates each of the statements on some scale. Usually the statements are rated on a 1-to-5 scale for their relative importance, where a 1 means the statement is relatively unimportant compared to all the rest, a 3 means that it is moderately important, and a 5 means that it is extremely important.

**Step-4 Representation step**

The **Representation Step** is where the analysis is done -- this is the process of taking the sort and rating input and "representing" it in map form. There are two major statistical analyses that are used. The first is multidimensional scaling which takes the sort data across all participants and develops the basic map where each statement is a point on the map and statements that were piled together by more people are closer to each other on the map. The second analysis is cluster analysis which takes the output of the multidimensional scaling (the point map) and partitions the map into groups of statements or ideas, into clusters. If the statements describe activities of a program, the clusters show how these can be grouped into logical groups of activities. If the statements are specific outcomes, the clusters might be viewed as outcome constructs or concepts.

**Step-5 Interpretation step**

In the fifth step -- the **Interpretation Step** -- the facilitator works with the stakeholder group to help them develop their own labels and interpretations for the various maps.
Step-6 Utilization Step

Finally, the Utilization Step involves using the maps to help address the original focus. On the program side, the maps can be used as a visual framework for operationalizing the program. On the outcome side, they can be used as the basis for developing measures and displaying results.

1.2 CONCEPT MAPPING AS A FOLLOW-UP STRATEGY IN CHEMISTRY

"The objectives of learning in chemistry are for students to know how to use their chemical knowledge as consumers in order to promote health and sustainable development and in discussions and decision-making processes concerning nature, the environment and technology." In addition, the subject aims at providing knowledge of chemistry needed for the individuals from a natural science starting point to be able to participate in public debate, form their views on environmental issues, and contribute to a sustainable society.”

1.2.1 Concept mapping and Achievement in Chemistry

Traditionally, chemistry is a very difficult subject for students to master. Chemistry is often regarded as a difficult subject, an observation that sometimes repels learners from continuing with studies in chemistry. The achievement and retention in chemistry is affected by following factors.

(a) Curriculum Content

The advent of revised school syllabuses in the 1960s and 1970s in many countries saw a move towards the presentation of chemistry topic at school level in a logical order, the logic usually being that of the experienced academic chemist. Similarly, early chapters in almost all textbooks for first level of higher education courses start with topics like atomic theory, line spectra, Schrödinger equations, orbital, hybridisation, bonding, formulae, equations, balancing ionic equations, calculations, and stoichiometry. This is the 'grammar and syntax’ (Jenkins, 1992) of chemistry but is daunting for the student. Johnstone (2000) has made arguments against this 'logical' presentation cogently: The logical order may well not
be psychologically accessible to the learner. Much school chemistry, taught before 1960, laid great emphasis on descriptive chemistry, as a result memorization becomes an important skill to achieve examination success. Moreover it is argued that the learner find it difficult to cope with all three levels being taught at once. Indeed, today, there is a danger that chemistry depends too much on the representational body of knowledge, with inadequate emphasis on the descriptive.

![Chemistry Triangle](image)

**Figure 1.8 The Chemistry Triangle**

Chemical knowledge is learned at three levels: “sub-microscopic,” “macroscopic “and “symbolic”, and the link between these levels should be explicitly taught (Johnstone,1980).

Also, the interactions and distinctions between them are important characteristics of chemistry learning and necessary for achieving and comprehending chemical concepts. Therefore, if students possess difficulties at one of the levels, it may influence the other. Thus, learning strategy must be able to determine and overcome these difficulties.. The methods by which students learn are potentially in conflict with the nature of science, which, in turn, influences the methods by which teachers have traditionally taught (Johnstone, 1980). As a result, students face difficulty in applying their knowledge and they do not extend their knowledge into the real world. This aspect suggested that the chemistry syllabus to be learnt should not be defined by the logic of the subject but by the needs of the learner too. These two fundamental principles offer a constructive basis for dialogue in re-structuring the way Chemistry is offered at school and higher education: in
simple terms, define the material to be taught by the needs of the learner, and define the order of presentation by the psychology of learning. Such a statement is relatively easy to make but it may well prove to be very difficult to implement. Concept mapping helps in it.

(b) **Overload on Students' Working Memory Space**

The working memory space is of limited capacity (Baddeley, 1999). This limited shared space is a link between, what has to be held in conscious memory, and the processing activities required to handle it, transform it, manipulate it, and get it ready for storage in long-term memory. When students are learning from text they face a situations where there is too much to handle in the limited working space, they have difficulty selecting the important information from the other less important information. Faced with new and often conceptually complex material, the chemistry student needs to develop skills to organize the ideas so that the working space is not overloaded. Without the organizing structures available to the experienced teacher, the student frequently has to resort to rote learning, which does not guarantee understanding. To solve this type of problem, we need the ability to develop strategies to cope with information overload, which depends entirely on the conceptual framework already established in the long-term memory. Working space cannot be expanded but it can be used more efficiently. However, this depends upon some recognizable conceptual framework that enables student to draw on old, or systematize new, material. Miller (1956) suggested the idea of "chunking", the ability to use some strategy to bring together several items into one meaningful unit, thus reducing working space demands. Concept mapping helps in chunking the information and ease out the learner by minimizing the load on his memory.

(c) **Language and Communication**

Language has been shown to be another contributor in creating misunderstanding. Language problems include unfamiliar or misleading vocabulary, familiar vocabulary which changes its meaning as it moves into chemistry, use of high sounding language, and the use of double or triple
negatives (Cassels & Johnstone, 1985). An interesting example of the effect of language on working memory space overload is the work carried out to measure working memory space, using the second language of the pupils. They found that, where the learner was operating in a second language, the usable working memory space dropped by about one unit. It was suggested that this unit was being “used” to handle the language transfer (Johnstone & Selepeng, 2001). In USA, Gabel (1999) has noted that difficulties students have with chemistry may not necessarily be related to the subject matter itself but to the way of talking about it. In Australia, Gardner (1972) made a study of the vocabulary skills of pupils in secondary schools. He drew up word lists to show which non-technical words were inaccessible to pupils at various stages. He also examined the words and phrases which connect parts of a sentence and which give logical coherence to it. Development of logical arguments are impossible without these logical connectives. He found that many words used frequently by science teachers were just not accessible to their pupils rather unambiguous for them. In Scotland, similar investigations were conducted and extended into higher education. The study by Cassels and Johnstone (1980) has shown that the non-technical words associated with science were a cause of misunderstanding for pupils and students. Words, which were understandable in normal English usage, changed their meaning sometimes quite subtly, when transferred into, or out of, a science situation. For Example, the word “volatile” was assumed by students to mean “unstable”, “explosive” or “flammable”. Its scientific meaning of “easily vaporized” was unknown. The reason for the confusion was that “volatile”, applied to a person, does imply instability or excitability and this meaning was naturally carried over into the science context with consequent confusion. As concept mapping is devoid of too much vocabulary hence facilitates the learning there by removing confusing words.

Moreover learning involves the interaction of the information that the learner receives through his sensory system and the information that he or she already has available in his or her long-term memory. This enables the learner to recognize and organize the incoming information and make sense
of it. Unfamiliar or confusing words and constructions come into conflict with the organizational process. It is also emphasized that the cognitive processes may be considered to involve the interaction of the components of memory i.e Working memory and long-term memory.

Language influences the thinking processes necessary to tackle any task. This is supported by the following observations made by Cassels and Johnstone (1984). They noted that memory span is not determined by the number of words but by the grammatical structures e.g. embedded clauses that may themselves load the memory. They stress that the important factor in the sentence is its meaning while sentences with a negative require more of working memory capacity than do otherwise identical sentences lacking the negative. The whole area of language, including the use of representational symbolisms, needs careful thought. Previous work has established the reality and nature of the problem. Language helps or hinders interactions with long-term memory but it can also be a source of significant information overload. Perhaps this suggests that there has to be more opportunity for the learner to verbalize and discuss ideas as they are being presented. This would give opportunities for misunderstandings and confusions to become more apparent, allowing the learner to adjust thinking and clarify ideas. Concept mapping give opportunities to organize ideas and remove confusion.

(d) Concept Formation

Chemistry learning requires much intellectual thought and discernment because the content is replete with many abstract concepts. Concepts such as reactions, particular nature of substances, and hybridization are fundamental to learning chemistry. Unless these fundamentals are understood, topics including reaction rate, acids and bases, electrochemistry, chemical equilibrium, and solution chemistry become arduous. Therefore, inquiring into students’ conceptions of the fundamental concepts in chemistry serves as base for next further learning Real understanding requires not only the grasp of key concepts but also the
establishment of meaningful links to bring the concepts into a coherent whole. Ausubel's important work (1968) has laid the basis for understanding how meaningful learning can occur in terms of the importance of being able to link new knowledge on to the network of concepts, which already exist in the learner's mind. Concepts develop as new ideas are linked together and the learner does not always correctly make such links. This may well lead to misconceptions. Conceptions or pieces of intellectual thought either reinforce each other or act as barrier for further learning. To overcome obstacles in learning, students' conception researchers have been focusing on identifying and assessing students’ “misconceptions” (Helm, 1980), “alternative frameworks” (Driver, 1981), “children’s science” (Gilbert et al., 1982), or “preconceptions” (Novak, 1977). These labels are attached when students’ conceptions are different from the scientific ideas and explanations (Nakhleh, 1992; Taber, 2000; Nicoll, 2001; Ayas, Köse and Taş, 2002). There have been an enormous number of studies on misconceptions in chemistry and there are several reviews of this area. In addition, various studies indicate that student' difficulties in learning science concepts may be due to the teachers' lack of knowledge regarding students' prior understanding of concepts (Driver & Easley, 1978; McDermott, 1984). Bodner (1986) makes a salutary point when he notes that, 'We can teach - and teach well - without having the students learn". Alternative conceptions may not be just students’ fault. Chemical knowledge structures, for example, in “combustion,” “physical and chemical change,” and “dissolving and solutions” by their very nature lead to alternative conceptions argues Griffiths (1994). Students’ conceptions are constrained by both the perceiver (learner) and the perceived (chemical phenomena) (Ebenezer, 1991). Thus, learning is the process of restructuring, adapting, rejecting, modifying and even discarding knowledge.

1.2.2 Concept mapping and Retention in Chemistry

1. Students are rote learning (memorizing definitions and statements) instead of learning meaningfully (relating new knowledge to knowledge previously learned);
2. Students are unable to recognize the key concepts and concept relationships needed in order to understand the material; and
3. The key concepts or concept relationships may not be clearly presented by the instructor.

Several people have also noted that students’ inability to understand is due to the lack of connections between concept areas. Reactions of Chemistry enhance this impediment for three reasons. First, chemistry activities lack the conceptual structure that is associated with textbook-based instruction. Textbooks provide structure to associate facts within an appropriate conceptual framework. Second, certain topics have physical aspects, which may cause the students to overlook the important concepts to be learned in the activity. Third, chemistry is a complex, information-rich subject in which the students may become overwhelmed in their efforts to process the information effectively. In order for students to develop well-organized conceptual frameworks, they must choose to learn meaningfully rather than by rote. Ausubel distinguishes between rote learning as simple memorization of definitions and statements and meaningful learning, relating new knowledge to knowledge previously learned via concepts. The key idea of Ausubel’s learning theory is that humans think with concepts. The problem is that students get through school using little more than verbatim memorization of concept definitions or problem solving algorithms.

Permanent and meaningful learning depends a lot on learning strategies that determine the approach for achieving the learning objectives and are usually tied to the needs and interest of students to enhance learning. The desire to improve achievement through more effective instructional strategies and the increasing awareness of the importance of learner-centeredness in the teaching-learning process has directed a lot of attention to understanding how learners learn and how to help them learn concepts (Jegede, Alaiyemola, & Okebukola, 1990). As with concept mapping keys are identified and understood clearly by learner so they do not depend on
their memory to retain the concepts for a long time. Hence concept mapping contributes to retention.

Concept mapping as a follow-up strategy in learning can have several important functions. We differentiate four main functions:

(a) **Elaboration function.** Due to the affordance of expressing notions in nodes and relations in links, concept maps foster elaboration processes (Weinstein and Mayer 1986). This means that learners have to relate new information to their prior knowledge in order to determine what concepts are important and whether and how they interrelate.

(b) **Reduction function.** Weaver and Kintsch (1991) found that macro propositions which contain the top-level information of a text are recalled in more detail. Learners have to appraise the importance of concepts in order to decide whether they should integrate them in their concept map. Thus, learners concentrate on the most relevant macrostructure information of their learning topic.

(c) **Coherence function.** Concept mapping requires the externalization of knowledge and its structure. Thereby working memory is offloaded and the construction of coherence is facilitated (Kintsch 1998). Labeling the links connecting nodes emphasizes the kind. Similar colors can emphasize that certain concepts belong together. Thus, concept mapping fosters the building of a coherent structure of knowledge.

(d) **Metacognitive function.** Metacognitive processes are supported through concept mapping. Knowledge and comprehension gaps can become obvious when constructing and explicating relations between concept (e.g. Chi et. Al. 1989). At best, learners can overcome these gaps when they become aware of them.

Concept mapping falls into the large category of mediating tools. The concept of mediation refers to the fact that our relation with the outside world, including the other people is always mediated by signs and artifacts. According to Jonassen and Marra (1994) concept maps is a kind of Mind tools that enhance our understanding of how learners organize and use
knowledge. Mind tools, otherwise known as cognitive tools (Kommers, Jonassen, & Mayes, 1991) are intended to engage and facilitate cognitive processing. An important advantage of concept mapping is that it models the way human mind organizes knowledge. According to Solomon (2000) one of the main distinctions between information and knowledge is that while information is discrete, knowledge is arranged in networks with meaningful connections between nodes. While information can be transmitted as it is, knowledge needs to be constructed as a web of meaningful connections.

Concept mapping offers a close correspondence between psychological constructs and their external mode of representations. It uses a simple formal convention - nodes, links and labels on the links, integrates two kinds of coding i.e, verbal and visual, externalizes both cognitive and affective processes, stimulates self-appraisal and self-reflection and supports mental imagery (Stoyanov & Kommers, 1999).

Some distinctive features of concept mapping promote the assumption that it should be an effective technique for computer supported collaboration (Stoyanova, 2000).

• Concept mapping is a unique technique for externalising the cognitive structure of the students. Using concept mapping students communicate on the level of the whole picture of the problem space, representing their prior knowledge and vision. Explanations of and elaboration on the different perspectives based on concept mapping are much more full and comprehensive.

• Meanings of the concepts and ideas are clearly defined by the position of the concept in the whole picture and its interrelations with other concepts. This facilitates the process of group negotiation of meaning and promotes a deeper mutual understanding between collaborators. It is supposed that the process of group negotiation should be a shift for internal negotiation for students and meaningful integration of the new concepts in the cognitive structure of learners.

• Interacting by concept mapping, students have the possibilities to take a look at the whole problem space as it is visualised by other group
members. It should enhance the process of *critical reflection* as well as *creative thinking*.

The main assumption underlying this research is that shared cognition in collaborative learning is a substantial for cognitive construction and reconstruction and that concept mapping is an effective tool for mediating shared cognition.

### 1.3 COGNITIVE PROCESSES AND CONCEPT MAPS AS COGNITIVE VISUALIZATIONS

The internal cognitive processes that support the capabilities discussed above greatly improve our power to understand the external world and to make maximum use of our internal thinking capabilities, transforming our observations into understanding. These are remembering, understanding, applying, analyzing, evaluating and creating.

In summary, these six cognitive processes viz remembering, understanding, applying, analyzing, evaluating, and creating, work with the five cognitive capabilities viz Noticing, Scanning, Patterning, Sensing and Integrating to process data and information and create knowledge within the context of the situation. However, this knowledge must always be suspect because of our own self-limitations, internal inconsistencies, historical biases, and emotional distortions.

**Remembering**

The first of these processes, remembering, represents the methodology of focusing attention on a given area, and through imagination and logic creating an internal vision and scenario for success.

**Understanding**

The second supporting area is that of understanding. By this we mean the art of making maximum use of our own intuition developed carefully through experience, trial and error, and deliberate internal questioning and application. There are standard processes available for training oneself to develop understanding. Recognize that it is typically understood as being the ability to access our non-conscious mind and thereby make effective use of its very large store of observations, experiences and knowledge.
This is a tool to visually recognize relationships from discrete and diverse pieces of information and data. In addition to providing a systems interpretation as discussed earlier, mind mapping can also be used to trigger ideas and dig deeper into one's intuitive capability to bring out additional insights.

**Valuing or evaluating**

Valuing represents the capacity to observe situations and recognize the value underlying their various aspects and concomitantly be fully aware of your own values and beliefs. A major part of valuing is the ability to align your vision, mission and goals to focus attention on the immediate situation at hand. A second aspect represents the ability to identify the relevant but unknown aspects of a situation. Of course, the problem of unknowns always exists in warfare, and, while logically they are impossible to identify because by definition they are unknown, there are techniques available that help one expand the area of known-unknowns and hence reduce the probability of unknown unknowns occurring. Such areas were thoroughly explored in a recent brainstorming session held at the Naval War College. Experts within and outside the Defense Department were brought together to explore the future in terms of consequence management and unknown-unknowns.

The third aspect of valuing is that of meaning, that is, understanding the important aspects of the situation and being able to prioritize them and anticipate potential consequences. Meaning is contingent upon the goals and aspirations of the individual. It also relies on the history of both the individual's experience and the context of the situation.

**Analyzing or Judging**

The fourth supporting area is that of "judging." Judgments are conclusions and interpretations developed through the use of rules of thumb, facts, knowledge and experiences, and intuition. While not necessarily widely recognized, judgments are used far more than logic or rational thinking in decision making. This is because all but the simplest decisions occur in a context in which there is insufficient, noisy, or perhaps too much
information to make rational conclusions. Judgment makes maximum use of heuristics, meta knowing, and verification. Heuristics represent the rules of thumb developed over time and through experience in a given field. They are short cuts to thinking that are applicable to specific situations. Their value is speed of conclusions and their usefulness rests on consistency of the environment. Thus, they are both powerful and dangerous. Dangerous because the situation or environment, when changing, may quickly invalidate past-proven heuristics and historically create the phenomenon of always fighting the last war. Powerful because they represent efficient and rapid ways of making decisions, where the situation is known and the heuristics apply.

A related aspect of judgment is that of meta knowing. Meta knowing is knowing about knowing, that is, knowing how we know things and how we go about knowing things. With this knowledge, one can then go about learning and knowing in new situations as they evolve in time. Such power and flexibility greatly improve the final judgment and decisions made. It is closely tied to our natural internal processes of learning and behaving "Know thyself" as well as knowing how to make most effective use of the external data, information, and knowledge available. The third aspect of judgment is verification. This is the process by which we can improve the probability of making correct judgments by working with others and using their experience and "knowing" to validate and improve the level of judgmental effectiveness.

Concept map are tools that make “thinking” visible, reifying learners’ mental model about domain knowledge onto an explicit graphical device. Concept Mapping may be used for a variety of purposes. It is a technique used to structure, analyze and make sense of problems. Regardless of the Operational Research technique being applied, being able to understand the client's perception of the problem is vital to the success of an Operational research intervention. Concept mapping, by producing a representation of how the client thinks about a particular issue or situation, can thus act as a
One valuable technique for helping Operational Researchers. The technique's ability to help structure, organize and analyze data either a concept, view or thought enable both the client and the analyst together to begin to negotiate a suitable direction forward. As mentioned above, Concept Mapping in corporate sector used to allows users to structure accounts of problems. Dilemmas, feedback loops, and conflicts can be quickly distinguished, explored and worked upon. Moreover, it may increase the user's understanding of the issue through the necessity of questioning how the chains fit together and determining where isolated chunks of data fit in. Finally, it may act as a cathartic medium to go, through the process of explaining the ideas and how they fit together, and gives a better understanding of the issue. This makes possible the application of concept mapping in evaluation and creation. Reflection can be supported by confronting the learner with a different visualization of her own knowledge, while scaffolding can be implemented by contrasting the learners' visualization to that of an expert. Thus on the basis of concept map aims and objectives can be identified and explored, options examined to see which are the most beneficial and whether more detailed ones need to be considered, essential key elements and activities could be identified and designed for developing a training or instructional strategy.

One cognitive visualization or mapping technique is Concept Mapping. Concept Maps (CM) represent a person's understanding of a topic/problem/issue by mapping concepts and their relationships in a hierarchical way, where more general concepts are placed higher in the map and concepts at the same level of generalization are grouped together. There is extensive evidence that drawing a CM requires students to engage in higher cognitive functions (Novak & Gowin, 1984). CMs have typically been used in reading activities to aid students' comprehension of texts. For instance, ready made CMs may be presented as semantic summaries of texts that students need to comprehend (Hauser, Nuckles, & Renkl, 2006), or students may be asked to construct their own CMs to address specific questions (Chang, Sung, & Chen, 2002). Why might Operational Researchers use Cognitive Mapping?
1.4 CONSTRUCTION OF CONCEPT MAPS

A particularly good way to organize information about a problem or subject is to construct a "concept map." The process of constructing concept maps requires critical and analytic thinking (Moni & Moni, 2008). Novak describes concept mapping as

“A process that involves the identification of concepts in a body of study materials and the organization of those concepts into a hierarchical arrangement from the most general, most inclusive concept to the least general, most specific concept.”

Concept maps can be constructed in several ways. A simple method is to supply students with a list of related concepts and let them construct a map, placing the most inclusive, most general concept at the top and then showing successively less inclusive concepts at lower positions on a hierarchy. Learners must decide how best to represent the concepts hierarchically and the words to use to link concepts together. Another method is to let students identify key concept words from text of some kind and then arrange these concepts to form a hierarchical map.

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. Cross-links are relationships or links between concepts in different segments or domains of the concept map and 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 (Novak & Canas, 2008). In general, the greater the number of valid links between concepts, the more sophisticated the map is considered to be (Novak & Gowin, 1984). Construction of concept maps helps us pool together information we already know about a subject and understand new information as we learn. Concept maps consist of nodes and labeled lines called as links. Node is the name for important terms or concepts. Nodes are usually depicted with circles drawn around the term or concept, such as the nodes for "Living Things" and "Plants" drawn below.
Lines between nodes show which concepts are related. The label on the line tells how or in what way the concepts are related. For example, plants "are" living things. We can use concept maps when we begin working together on a problem, during the problem solving steps, and at the end of problem solving.

Steps of constructing concept Maps.

1. Writing the major terms or concepts about a selected topic. For example, if we are studying living things, some of the terms might include: animals, dogs, plants, cows, or grass.
2. Writing each concept or term on a separate piece of paper or 3 x 5 card.
3. Sorting out the cards into following categories;
   a) The terms which could not be understood
   b) The terms that are not related to any other term.
   c) Related terms: These cards are the ones we will use to construct the concept map.
4. Arranging the related cards close to each other.
5. Sticking the cards to a piece of paper as soon as you are satisfied with the arrangement. Leaving a little space for the lines we'll draw. Here is what your terms might look like if you used the ones we mentioned above:

   ![Figure 1.9- Nodes of Concept Map](image)
6. Drawing lines between the terms to show the links.

![Figure 1.10 –Links of Concept Map.](image)

7. Writing the nature of the relationship on the line drawn between the terms. Here is what the terms above might look like after we draw the lines.

![Figure 1.11 - Final Concept Map](image)

8. If one puts any cards aside in step 3, go back and see if some of them will fit into the concept map one has constructed. If they do, be sure to add the lines and relationships of the new items.

9. Summarize entire concept map into text form.

The concept map drawn here is very simple. Maps can become very complex and require a great deal of your time and attention, but they are useful in organizing learning, and demonstrating what we know about a particular topic.

1.5 USES OF CONCEPT MAPPING

Concept mapping is a powerful tool for facilitating meaningful learning and it serves as a kind of template or scaffold to help to organize knowledge and to structure it, even though the structure must be built up piece by piece with small units of interacting concept and propositional frameworks. By summarizing the subject using keywords and linking these
keywords to create a map of relationships, individuals are able to clarify for themselves what is involved in a certain subject and become more effective in using that information. The information collected in the map is easily accessed by looking at how the relationships between words or concepts have been outlined (Cicognani, 2000). An advantage of using concept mapping as a learning technique lies in the possibility to have a visual representation of information (Cicognani, 2000). Visual representation allows the development of a holistic understanding that words alone cannot convey, because the graphical form allows representations of parts and whole in a way that is not available in sequential structure of text (Asan, 2007). With the visual representation of keywords on a map, a learner is also able to refine language and vocabulary, identify the key issues of a text, organize these key issues into a meaningful chart, re-use the map in the future with a reasonable success (Cicognani, 2000). Concept maps are used in more than one way. Some of the ways are illustrated as under:

- Concept maps are used to stimulate the generation of ideas, and are believed to aid creativity. For example, concept mapping is sometimes used for brain-storming. Although they are often personalized and idiosyncratic, concept maps can be used to communicate complex ideas.

- Formalized concept maps are used in software design, where a common usage is Unified Modeling Language diagramming amongst similar conventions and development methodologies.

- Concept mapping can also be seen as a first step in ontology-building, and can also be used flexibly to represent formal argument.

Concept maps are widely used in education and business. Uses include:

- Note taking and summarizing gleaning key concepts, their relationships and hierarchy from documents and source materials

- New knowledge creation: e.g., transforming tacit knowledge into an organizational resource, mapping team knowledge
• Institutional knowledge preservation (retention), e.g., eliciting and mapping expert knowledge of employees prior to retirement
• Collaborative knowledge modeling and the transfer of expert knowledge
• Facilitating the creation of shared vision and shared understanding within a team or organization
• Instructional design: concept maps used as Ausubelian "advance organizers" which provide an initial conceptual frame for subsequent information and learning.
• Training: concept maps used as Ausubelian "advanced organizers" to represent the training context and its relationship to their jobs, to the organization's strategies objectives, to training goals.
• Increasing meaningful learning for example through writing activities where concept maps automatically generated from an essay are shown to the writer.
• Communicating complex ideas and arguments
• Examining the symmetry of complex ideas and arguments and associated terminology
• Detailing the entire structure of an idea, train of thought, or line of argument with the specific goal of exposing faults, errors, or gaps in one's own reasoning for the scrutiny of others.
• Enhancing metacognition (learning to learn, and thinking about knowledge)
• Improving language ability
• Knowledge Elicitation
• Assessing learner understanding of learning objectives, concepts, and the relationship among those concepts
• Lexicon development

Here are certain examples in which concept maps can be used.
1. Organizing information on a topic. Disorganized information is relatively useless. Useful knowledge must be organized so as to facilitate understanding and problem-solving ability. Students need to be taught how to construct hierarchical forms of knowledge organization. The concept map organizes knowledge into categories and sub-categories so that it can be easily remembered and retrieved.

2. Motivate the study of a topic. Constructing a map has considerable motivational value and challenge when introduced early in the study of a new topic. It can be looked upon as putting together in a puzzle. Maps made by students can be compared with other student maps and those of the teacher so the students can “see” exactly what is known about the new topic at the outset.

3. Revision of the topic. The concept map can be constructed at the end of topics as a class exercise or for homework. It is useful to compare student maps constructed as a motivational exercise with those constructed for the conclusion of the topic.

4. Generate discussion on topic. When using concept maps, students readily see that the structure of the subject they are studying can be very complex and that any particular concept can be related to many others.

5. Rank important ideas on a topic. While there is no best way to represent knowledge of a topic, there tends to be an agreement regarding the extent of exclusiveness (importance) and the inclusiveness (lesser importance) of concepts related to topic. Thus it is possible to determine from a number of maps the way concepts have been ranked.

6. Reinforce ideas about topic. The map can be used to demonstrate major idea in topic area and how these ideas can be related to other ideas.

1.6 NEED & SIGNIFICANCE OF THE STUDY

The reform of education through the use of new technology becomes an urgent task in view of the current reality that new learning environment taking place in the emerging knowledge-based society impinging on the roles of teachers. These are characterized by the paradigm shift in education
from old concept of ‘education’ to learning, from the shift in the teaching-learning process as well as the emergence of new spaces of learning from school to work place, communities and mass media, from childhood to adulthood and from real to digital and virtual learning environments. These changes has generated new types of learner, new process of learning and new approaches to evaluation of learning, which in turn have contributed to the changed roles of teacher as well as learner from conventional ones to a series of new roles. The teachers are no longer the sole source of information. They are only one of the multiple sources of knowledge and thus work better as facilitator of knowledge.

At present India is obligating schools to apply the newly developed science and technology curriculum. According to this new curriculum as per NCF 2005 every student must develop a thorough knowledge of basic science concepts, which they can apply in a wide range of situations. The students must also develop the broad-based skills that are so important for effective functioning in the world of work: they must learn to identify and analyze problems and to explore and test solutions in a wide variety of contexts. This firm conceptual base and these essential skills are at the heart of the newly developed science and technology curriculum and must be the focus of teaching and learning in the classroom. In the light of preceding introduction on the concept mapping, we can conclude that, in the world of science, concepts are very inter-related, many concepts are built on many others, and therefore concept mapping would be very useful in the science classroom as a learning tool. It is well known that concept mapping tools has been widely recommended and used in a variety of ways in science education in advance countries such as UK, USA, or Japan. But it is still a new method and not adopted by science teachers in India at college as well as school levels. But adopting concept mapping in our educational curriculum is possible.

Concept maps enable us to simplify and present theoretical ideas on graphical content. This tool will prevent memorizing the content.
Memorization is very common method on our education system which hinders sensible learning. Sensible learning creates a logical meaning by an individual between the new information and information that has been learned by previous education and establishes a complete meaning. Memory based learning creates misunderstanding or inability to connect the students’ previous knowledge with new one. Rote memorization promotes fear of learning because it is irrelevant to their own experiences. In addition, information learned by rote in the absence of connections with previously acquired frameworks is largely forgotten (Novak, 1998). So that, the aim of education must be to develop educational experiences that make easy meaningful learning and reduce the need for rote learning. Ausubel (1968) describes meaningful learning as the establishment of non-willing relations towards concepts and if learners choose to relate new information to ideas meaningful learning is achieved (Novak, 1998). Students’ performance and interests in science courses are decreasing because of complex textbooks. College ‘students’ knowledge of science is often characterized by lack of coherence and the majority of students end up in rote learning to pass the exams. Conceptual nature of chemistry seems to be particularly difficult for students and teaching-learning methods and techniques do not seem to make the learning process sufficiently easy for students (Gabel, 1999). C-map tools provides a variety of features that make it possible for teachers to use concept maps for a variety of the tasks that students perform (Cañas and Novak, 2005). Chemistry education starts in the sixth grade as integral part of science and technology courses which is a compulsory subject up to tenth standard, in furtherer studies it is learnt as an optional subject. NCF 2005 lays emphasis on enabling students to create a connection between in class-learned knowledge with the daily life events. Chemistry as a subject based on skeptic approach and research. At the roots of chemistry lays the ability to explain or make nature events explainable with a constructive approach. Critical and constructive can be enabled if the student takes an active role in class (Balm et al., 2008). According to Matson (2006), teaching science based on questioning, that is, the period of questioning the universe’s nature
and its creation, teaching programs that enable students to learn by seeing, living, creating and relating previous knowledge with the new learned knowledge, aims to breed individuals that can reach and research for information and eventually individuals that can produce new information. All these reasons forced our education system to move away from learning through memorizing and replace the system with a new Science and Technology. Teaching Programmes, which aims to grow individuals that question the problems they face and bring solution, question their being in the natures they live in, therefore concept mapping need to be focused in our educational scenario.

Concept mapping have been used in educational studies in every subject area. For educational purpose concept-mapping fulfill many roles: they allow students to reflect on and demonstrate their knowledge of a topic covered in class, act as tools to aid study and comprehension of a domain or story, support idea generation and organization in preparation for prose composition, and are used as instructional material for learning new concepts and their interrelationship (Anderson Inman & Zeitz. 1993). So as a learning strategy, concept mapping is likely to be effective if it is conducted on an ongoing basis over course of instruction (Bruillard & Baron. 2000). What is more, concept mapping has been used to promote positive self concepts, and positive attitudes towards science (Novak & Gowin, 1984) and increased responsibility for learning (Gurley, 1982).

The theory of concept mapping is consistent with the theories of knowledge representation (Anderson, 1995, 1991). Concept maps are important when one adopts a constructivist approach to learning. The theory behind it is that each individual develop mental schemas that serve to inform future thinking or action.

A variety of studies have demonstrated the effectiveness of concept mapping as a learning method. The effectiveness of concept mapping has been compared to several other learning techniques. Review of literature reveals that some research has been done on worked-out concept maps but
the influence of constructing concept maps by the student themselves, on their learning outcome has not been studied. However, its effectiveness as a Follow-up learning strategy has not been explored. Not many studies have been done to explore effectiveness of concept mapping in terms of learning outcome and specially retention in learning. Moreover, to develop a strategy of teaching through concept mapping, it is equally important to first explore the processes that contribute to effective mapping. Fensham and George (1973) investigated problems arising from the learning of organic chemistry while Kellett and Johnstone (1974) indicated that students had little conceptual understanding of functional groups and their role. They also found that a student’s ability was dependent on context, such that individual students can do well in some areas and badly in others. Bodner (1991) has listed several factors that may lead to misconceptions in the minds of learners. He notes the problems of rote learning where students possess knowledge without understanding. When the teacher first introduces an idea, the learner may already possess previous experience derived from the world around, including the media, which leads to confusion. In addition, there is also the problem where the scientific language remains constant while the meanings of the terms change until they become misleading. Many research tools appear in the literature to identify students’ misconceptions. Examples include the diagnostic tests developed by Treagust (1988) and Krishnan and Howe (1994). While the literature is replete with papers, which provide evidence of misconceptions, fewer papers suggest potential remedies. It is worth recognizing that misconceptions will occur - learner does not come to chemistry with empty minds. The process of learning chemistry will involve the modification or alteration of previously held ideas and this is a natural process. It is individual in nature and there is no way by which the teacher has the time or capacity to approach each learner on an individual basis. However, in practice, if concepts are developed with care, building on the language and thought forms already present, while allowing concepts to be
approached from several directions, the learner will be enabled to develop ideas more meaningfully. In addition, learners need the opportunity to ‘play with ideas’, to share ideas, to verbalize concepts so that, in a natural, step-wise fashion, concepts steadily move forward on a secure base. This will allow inadequate conceptions to be modified in an acceptable way. Nonetheless, misconceptions will always occur, even among those highly experienced in chemistry, the whole area of misconceptions including alternative frameworks and the ideas in constructivism probably needs some re-thinking. It appears to be a natural part of the developmental process and it appears to be individually idiosyncratic. However, strategies can be adopted to take advantage of this natural process in the development of more secure concept understandings. A useful future line of research might be to explore the effects of strategies, which teachers might use to take advantage of this natural process in order to give the learners an enriched understanding of important concepts. Identification of ideas as nodes and developing concept maps may all be very important in allowing misconceptions to be corrected effectively. So, in view of these facts investigator has decided to explore experimentally the effectiveness of concept-mapping as a follow-up strategy in learning chemistry in terms of achievement and retention in learning.

The following specific research questions were addressed.

1. Does concept mapping have a positive effect on learning outcome?
2. What is the relationship between characteristics of the concept maps and the learning outcome?
3. Are the learning outcomes associated with the quality of the cognitive processes during concept mapping?
4. What are different mapping styles that could be identified with respect to the learning outcome?
1.7 STATEMENT OF THE PROBLEM.

Selected research problem is stated as below

EFFECT OF CONCEPT MAPPING AS A FOLLOW-UP LEARNING STRATEGY ON ACHIEVEMENT AND RETENTION OF UNDER GRADUATE STUDENTS IN CHEMISTRY

1.8 OPERATIONAL DEFINITION OF KEY TERMS

1.8.1 Concept mapping as Follow-up strategy

Concept mapping as a Follow-up strategy means fostering learning by means of concept maps which are made by the investigator herself. This process involves the identification of concepts in study materials and their organization from the most to the least general.

1.8.2 Achievement

Achievement connotes final accomplishment of something noteworthy after much effort and a particular phase of action. Here in the study it refers to score obtained by a student on Achievement test developed by the investigator herself.

1.8.3 Retention in learning

In learning it is the ability to retain facts and figures in memory. Here in the proposed study it means scores obtained by a student on delayed Achievement test developed by the investigator herself.

1.9 OBJECTIVES OF STUDY

1.9.1 Main Objectives

1. To study the effectiveness of conventional reading in learning chemistry in terms of achievement and retention.

2. To study the effectiveness of concept-mapping as a Follow-up strategy in learning chemistry in terms of achievement and retention.

3. To compare the effectiveness of concept-mapping strategy over the conventional reading in terms of achievement and retention.
1.9.2 Subsidiary Objectives

4. To study the relationship of concept map characteristics with achievement and retention.

5. To study the relationship of cognitive processes with achievement and retention.

6. To study the relationship between cognitive processes and concept map characteristics.

7. To identify different type of mapping styles.

8. To study the effect of different mapping styles on achievement and retention.

9. To study the effect of different mapping styles on cognitive processes.

10. To study the effect of different mapping styles on concept map characteristics.

1.10 HYPOTHESES

On the basis of the review of the related literature, following research hypotheses were formulated.

1.10.1 Main Research Hypotheses.

1. Conventional reading in learning chemistry is effective in terms of achievement.

2. Conventional reading in learning chemistry is not effective in terms of retention.

3. Concept mapping as a Follow-up strategy to learning chemistry is effective in terms of achievement.

4. Concept mapping as a Follow-up strategy to learning chemistry is effective in terms of retention.

5. Concept mapping as a Follow-up strategy to learning chemistry is more effective than learning through conventional reading in terms of achievement.
6 Concept mapping as a Follow-up strategy to learning chemistry is more effective than learning through conventional reading in terms of retention.

1.10.2 Subsidiary Research Hypotheses

7 There is significant relationship of concept map characteristics with achievement.

8 There is significant relationship of concept map characteristics with retention.

9 There is significant relationship of cognitive processes with achievement.

10 There is significant relationship of cognitive processes with retention.

11 There is significant relationship between cognitive processes and concept map characteristics.

12 Different styles of mapping differ significantly with respect to achievement.

13 Different styles of mapping differ significantly with respect to retention.

14 Different styles of mapping differ significantly with respect to cognitive processes.

15 Different styles of mapping differ significantly with respect to C-Map construction.

1.11 DELIMITATIONS OF THE STUDY

The study was delimited to

1. A sample of 60 under-graduate engineering students studying in one engineering college situated at Faridabad.

2. Concept mapping as a learning strategy in chemistry only.