CHAPTER - III

REVIEW OF RELATED LITERATURE

“To strive, to seek, to find and not to yield”

3.0 Overview

Review of literature ensures a sound basis for developing ideas as also the foundation for one's research this chapter reviews pertinent literature with reference to chemistry, the focal entity of concept maps as used in chemistry as also in general and those experimental studies which focus on concept maps as also the experimental design and other relevant areas.

3.01 Significance of Review Of Related Literature

Review of literature lays the foundation for formulating opinion, deriving ideas and highlighting the examples that go into the framework of one’s research.

The present study is on the effects of Conceptual Modeling as a Strategic tool for Enhancing Students Performance in Chemistry. Conceptual modeling is a very vast field with many tiers and levels. One important area of this vast field is concept mapping. The study has an experimental design and the areas for review of literature have been identified as follows: Chemistry, Conceptual Modeling with emphasis on Concept maps used in Chemistry, Concept maps in general, Concept maps used in experiments, Experimental design and Other relevant areas.

The researcher has been exposed to the teaching of Chemistry at the higher secondary level for the past two decades and has had occasion to read various books on Chemistry. Due to constraints of space and keeping in mind the aspects of relevance the following books pertaining to the subject have been reviewed.
3.1 Studies Abroad

Chemistry has various branches such as organic, inorganic, physical, analytical etc. Open Shaw (1955), has analysed the various important features of analytical Chemistry and has prepared a useful manual for qualitative organic analysis. Chemistry without laboratory exposure is incomprehensible. This useful laboratory manual contains a full analysis scheme which would be the basic foundation material for a student of Organic Chemistry.

Smith (1960), has written on Wave Mechanics in his book on Modern Physics and has devoted specific chapters to study the aspects of Mathematics in wave mechanics science. The various branches of scientific knowledge are so interrelated that the study of one branch will be invalid unless complemented by studying the other branches. Wave Mechanics is to be found in physics as well Chemistry and mathematics plays a vital role in understanding this topic. Therefore with specific chapters (7, 8 & 9) in the book, ‘An Introduction of Mathematics of Wave Mechanics’ is a very useful explanatory material for a student to comprehend the essence of Chemistry.

InGold (1963), has studied the structure and mechanism in Organic Chemistry. Chemistry is a science of matter which is based on the atom and its structure, which in turn combines through chemical reactions, giving rise to molecules. Even H2O, that elixir of life, is a molecule and this book traces the molecular structure as also the reaction mechanisms.

Stokes (1967), aims to provide a modern course of Organic Chemistry, specially designed for the student at the advanced level and for those seeking admission through an entrance examination. Very often a student of Organic Chemistry is disenchanted with the subject because of the constant repetition of symbols like C, H and O which give one an algebraic feeling. The author has made an attempt to give some meaning to the subject
by the careful use of electronic explanations for certain reactions and by
discussion of such important groups of organic chemicals as drugs, dyes,
synthetic fibers etc, at appropriate points in the text.

Following the latest recommendations of the Chemical Society with
regard to nomenclatures, the author has also given questions at the end of
each chapter. Starting with the development of the atomic theory along with
classification of atoms and the early history of organic Chemistry, the author
takes the reader step by step through the various concepts giving detailed
illustrations and explanations wherever required. The book also contains an
exhaustive index which makes fact finding easy as also a pleasure

Concept mapping as a strategic tool is an innovative area to explore. There have been a number of studies using the concept mapping techniques
to impart knowledge.

The concept of concept maps has been introduced as a teaching
strategy by Joseph D. Novak in 1970 and there after has been incorporated
by many in the realm of teaching.

Cardamone (1975), has studied concept mapping as a technique of
analyzing discipline and its use in the curriculum as also instruction in a
portion of college level mathematics skills course.

Guilford (1975) in keeping with the original objective of presenting
an intricate subject in such terms that a majority of students who need to
study applied statistics can easily comprehend, presented numerous
mathematical conceptions that constitute the body of statistics and these
have been expressed in crystal clear English. Students of various
specialization can easily select and concentrate on relevant contents in a
manner that would be time saving and easy. Information that generally
comes only from practical exposure is given in easy to digest capsules much
to the advantage of the reader. There is a vast amount of statistical treasure
given as exhaustive tables of values and the necessary formulae and methods to analyse data using standard statistical techniques have been painstakingly explained, making the process of data analysis and verification of research a joyful experience.

Fairweather and Tornatzky (1977), in “Experimental Methods for Social Policy Research” aim to provide actual experimental methods for scientists, public officials and citizens who are committed to the improvement of living conditions among all members of society. The authors address the methodological questions raised by the methods to evaluate newly created social model aimed at solving a particular problem and the methods needed to disseminate these models. Their techniques have an intertwining of logical thought, social action and traditional scientific and experimental methods.

Bodgen (1977), had prepared concept maps in association with a professor for each lecture in a genetics course which has a small minority of students who have reported to be of value in learning genetics. Bodgen in association with Cardemone in their studies have found that the primary benefit of concept maps accrues to the ones who construct the maps. It is significant that both Bodgen and Cardemone did not have words on the lines linking concepts.

Gurley (1982), has used two comparison groups and two experimental group to investigate the use of both Vee maps and Concepts maps by students in a high school biology class of a particular year.

The results show that Vee and Concept mapping students are better able to demonstrate for themselves the inter relationships between theory and methods, ideas and obstructions. The Vee-instructed students have a better idea how their laboratory activity supports and relates to chapter information. It has also been shown that the students have found the
learning strategies required understanding of the subject matter and hard work and they also recognize and value understanding over rote learning.

It was also found that students were more comfortable mapping in pairs or small groups compared to mapping alone.

**Hill and Holman (1983),** hold that man’s interest in Chemistry is a practical one for people are interested in how materials in the universe behave and react under different conditions and also the way in which these materials can be put to use for man’s own purpose. Apart from this practical approach, there is the logical scientific method of working which includes the various laws that have been discovered and where information as also development of ideas and theories are summarised to interpret and explain observations. The author has presented Chemistry as a unified and integrated subject using physical principles as a basis for both inorganic and organic sections. ‘Chemistry in Context’ as a single volume aims to show the subject in its wider context as a relevant and developing science, which makes an essential contribution towards society, industry and civilization. The text is replete with carefully chosen photographs and information which portray how chemical knowledge and chemical industry influence human life and society. The researcher has found immense use in this volume which has been designed for the present day syllabus incorporating the best of traditional courses as also the best of recent innovations.

**Minemier (1983),** has looked at the usefulness of concept mapping among college students with regard to basic skills of a mathematics course. The study reveals that though the students initially disliked concept mapping, they gradually accepted and saw some value in it. It has been shown that students can learn to make concept maps and that success in mapping comes through the understanding of material and practice.
**Bascones & Novak (1985)**, have researched on the development of problem solving skills in physics with regard to an alternative instructional system.

**Taylor (1985)**, has studied whether students could be helped to develop meaningful understanding of lab work in biology through concept maps and Vee diagrams. Seeking to make the lab experience a meaningful and rewarding one, the researcher taught two sections of students who were instructed briefly about concept mapping and Vee diagram techniques. The researcher of course had no control or influence over the lectures given to the student by the professor concerned. To the researcher’s satisfaction, it was found that those in the test group scored better than those in the control group.

**Feldsine (1987)**, working with college Chemistry students found a high level of resistance among most of the students when told to prepare concept maps for the topic study. But when they found as the time advanced that different topics became conceptually clear when they used concept maps, they became good to excellent in preparation of maps. The researcher also found in a qualitative analysis that important misconceptions regarding Chemistry were recognized and subsequently altered to stable and valid conceptions.

Chemistry to be taught through conceptual modeling with regard to concept map is still virgin soil with regard to teaching, especially in India.

**Marile (1987)**, in a study on elementary teachers, recommends trying out other Mathematical concepts, because he found that none of those selected could map the division map at the 75% criterion level.

**Niclos (1987)**, wanted to examine concept mapping as a strategy to bring about meaningful learning based on theoretical structures involving three groups (1) an experimental group which utilized the concept mapping
process (2) a traditional group where traditional teachings were used (3) a control group which were denied both experimental and traditional methods. It was found through a post test that both experimental and traditional groups fared significantly better than the control group. It was also found that the males did better than the females in the mapping process and the attitude of female towards science showed improvement with the mapping method.

Pankartius and Keith (1987), have conducted a study involving 103 ninth grade students pursuing the general science course. They compared concept mapping methods and text outlining methods over a period of eighteen weeks and found a 10% higher mean scores for the concept mapping groups.

Spaulding (1989), was a pioneer to study the effect of concept map techniques on Chemistry student achievement. Students with average ability numbering 107 from Biology and 44 from Chemistry from a public high School in East Central Florida were selected for the study. One week prior to the study the students were subjected to a pre-test and the treatment group was taught concept mapping technique for one week. All students received the regular course instruction for the next three weeks. While the test groups were asked to construct concept maps, the control groups were given the task of defining concepts. The post test administered after three weeks over the material covered showed no significant difference in achievement between the students of treatment and control groups.

Donn (1990), has researched on a direct teaching attempt in a laboratory course. A group of 750 students of the introductory biology course received instruction that was computed in a heuristic manner based on the view of constructiveness in knowledge. The group, categorised as having a deep approach to learning, were capable of more comprehensive
responses especially to the novel problems posed in the interview than the students who belonged to the group identified as surface approach learners.

Bayerbach and Smith (1990), have assessed changes in the context organization of 17 pre service teachers and their concept maps on the topic of effective teaching. These pre-service teachers during the senior year of their early childhood teacher education programme constructed and revised concept maps with their partner. They kept the record of each mapping experience in their reflective journal and also developed implications for teaching. The study illustrates the usefulness of concept maps describing students’ knowledge in a particular area and promoting reflection.

Allen (1990), has studied the effects of concept map as a meaningful learning achievement tool in Chemistry. With 53 participants divided into two groups, control and treatment groups, they were given instruction in TI method for the control group and concept mapping method for the treatment group. Though there were no significant differences between these groups with regard to meaningful learning and achievement in Chemistry even at the 0.05 level of confidence, the students recognized concept mapping to be important for enhancing meaningful learning.

Wandersee (1990), in an article has synthesised relevant facts, concepts and principles from cartography and has applied them to concept mapping. He recommends that researchers need to conduct studies that would investigate the graphic representation of scientific knowledge and thereby create, evaluate and improve, graphic tools that are meta cognitives such as concept mapping, which can be used in science teaching.

Stenvold and Wilson (1990), have studied the interaction of verbal ability and concept mapping in learning from a Chemistry Laboratory activity. The Quasi Experimental design had treatment groups who received concept mapping instruction and were given the task of constructing concept
maps before and after completing a series of laboratory activities. The control group on the other hand went through the same laboratory activity but did not construct concept maps. All students after completing the laboratory activities were administered a comprehensive test specially constructed by the authors to measure knowledge and comprehension of their laboratory related chemical concepts. The students were given 33 items comprehensive test after obtaining qualitative natural Science and Vocabulary subset scores from the 10 WA Test of Educational Development (ITED) from the student records of the previous semester. The cochr-an-cox t-test did not indicate any significant difference in the comprehensive test. However, significant regression equations were found between Maplinks and Links. The number of valid rings made on the map predicted the comprehension test performances.

Ross and Munby (1991), have reported the senior high school students’ understanding of concepts related to acids and bases. Grounded on the methodology of concept map construction from the curriculum, the concept map was used for designing multiple choice test and clinical interviews. This methodology was used for analysis of data and also for constructing concept maps for each participant. It was found that the participants held idiosyncratic concepts not consistently coincident on those of the prescribed curriculum. It was also found that every day concepts were retained better than Scientific concepts.

Novak and Dismus (1991), have studied 191 first and second grade children by giving them audio tutorial science lesson and also conducting periodic interviews to assess changes in the understanding of science concepts of students from grade I to grade XII. A simple sample (n=48) who did not receive audio tutorial lesson in grades I and II was also periodically interviewed from grade I to grade XII. The results showed that those students who had received audio tutorial science lessons exhibited more
valid concept understanding and fewer invalid concepts than their counterparts from the uninstructed group. The concept maps prepared from interview transcripts showed wide variation in knowledge for both groups and concept maps score using the scoring algorithms showed significant differences in favour of those students instructed through the audio tutorial science lesson. The data also reveal that early instruction in science had lasting impact and concept maps as a representative tool for cognitive development change had a value.

**Huang (1991),** in a study designed to determine the effectiveness of the concept mapping technique selected four non science classes in Taiwan to take part in the study. The first four weeks had all students exposed to regular course instructions. Fifteen minutes before the end of each class the students were given a list of concepts which they were not permitted to see during the class period. The experimental groups were asked to map the concepts while the control groups were told to define the concepts. The results of an ANOVA Via MRC analysis showed no significant difference in Chemistry achievement between the two groups. The study concludes that the concept mapping technique is an alternate learning method which may be appropriate for the lower achieving

**Morrison** and **Boyd** et al., (1992) have provided students of Chemistry with a standard text book on organic Chemistry which is a sub discipline of the central science which involves the scientific analysis of the structure and composition of all matter and gives a detailed account of properties, reactions and preparation of Chemical compounds through synthesis and other means stating that organic compounds are carbon based. These structurally diverse composition could also include hydrogen, nitrogen, oxygen, halogen, phosphorus, silicon as also sulphur. Organic compounds have a range of applications and form the basis for many products of everyday human use such as plastics, drugs, petrochemicals,
food, explosives and paints. In fact almost every earthly life process comes under the broad umbrella of organic compounds.

**Anderson (1992),** has studied the inter-relationships between constructivist models of learning and the current theory with reference to neurobiology, which in turn has implications for science education.

**Gregory (1992),** has stated the value of a conceptual model is directly proportional to how well it corresponds to the past present and future as also to the actual of potential state of affairs. Conceptual model are usually built with the prime concern of the truth or falsity of the concepts that are modeled. Citing the management problem in the structuring, it has been said that conceptual model of human activity systems are used in soft system methodology to arrive at the view point of stakeholders. In case of artificial intelligence, Conceptual Model or graphs are used for building expert systems and knowledge based systems in which the analysts are concerned with the representation of expert opinion and what is true and not their own idea of what is true.

**Esiobu and Soiba (1995),** have studied the efficacy of concept and Vee mapping heuristics under the following learning condition for improving students’ achievement in ecology and genetics.

- Co-operative (CP)
- Co-operative Competitive (CP-CM)
- Individualistic Whole (IW)

Tenth grade students numbering 808 participated in the study. The research showed that the experimental group taught with the help of the concept maps and Vee mapping under the three learning modes achieved significantly better than those in the control groups. The CP-CM students in
all the groups fared significantly better than their counterparts in the other two groups.

**Ford, et al., (1996)**, in their specialty of cardiology during the construction of an expert system have shown that concept maps are of value in facilitating meaningful learning. They have also shown that concept maps are a means of capturing and sharing experts’ knowledge.

**Fife and Berger (1996)**, have compared the knowledge of experts and novices through computer analysis of concept maps. Comparing similarities, common misconceptions or alternative conceptions and mis-relationships in the concept maps prepared by experts and novices. The design and procedure show the instructor providing a list of concepts and links and the students moving and joining concepts with links through the use of a computer programme. It has been found that it is possible to discriminate for a large number of students as well as pairs of students on concept maps. It is also possible to identity common misconceptions in alternative links and link directions.

**Markow and Ionning (1998)** addressed the problem of first year students learning little from the chemistry experiments that they perform. The main idea of the study is that construction of pre lab and post lab concept maps helps students understand the concepts involved in the experiment they performed using experiment design, the test group constructed pre lab and post lab concept maps while the control group wrote descriptive essays to explain the four experiments used for the study. Both groups were exposed to 25 items achievement test one week after each experiment. the students felt that constructing pre lab and post lab concept maps help them understand the conceptual chemistry of experiments

**Franconi and GaryNg (1999)**, a tool for intelligent conceptual modeling term the conceptual design phase of an information system as a
data warehouse supported by the i.com tool. The extended entity relationship (EER) adopted by i.com has a conceptual data model enriched with multidimensional aggregations and inter schema constraints i.com is fully integrated very powerful descriptive logic reasoning server which acts as a background inference engine. The authors state that the conceptual modelling language supported by i.com express

- The standard entity data model
- Aggregated entities
- Inter schema constraint

The tool allows for the creation, editing, managing and storing of several interconnected conceptual schema with a user friendly graphical interprets.

Steimann (2000), in their article, on the representation of role in object oriented and conceptual modeling endeavour to present the duality of objects and relationships which are so deeply embedded in our thinking that all modeling languages include as a fundamental distinction. Though the two are complementary there is also a third equally fundamental notion which is of roles. The authors discuss the role of conceptualisation and also present that basic definition of conceptual modeling and demonstrate how it accounts for many modelling issues including multiple and dynamic classification, object collaboration, polymorphism and substitutability.

It has been observed by Parton et al., (2000), that the life project did not look at literacy as merely a set of individual skills and competencies but more as emergent and situated in a particular social context. Therefore, literacy practices are not static nor are they bounded spatially or temporarily. As part of the project, groups undertook a mapping of the literacy demands which were associated with students and their learning capacities across a wide range of further education courses. They methodologically debate
planning and the operationalising mapping techniques have also been explored.

Coffey Carnot, et al., (2003), have shown how the use of concept maps can facilitate meaningful learning which is indicated from an educational perspective by a growing body of research.

The first International Congress on Concept Maps was held in Pampiona Spain. Canas et.al., (eds), have recorded the concept maps theory, methodology and technology of the proceedings of the first international conference on concept mapping held in Pampiona, Spain. There is also a special article in this volume by Brigs et al on concept maps applied to Mars exploration and public outreach. Canas, et al (2004), have contributed to the volume – I of the conference on C map tools published in Vol – I of the Conference held in Spain in which they have discussed concept maps as a significant tool for knowledge modeling and conducive to a sharing environment. The authors show how concept maps have been demonstrated to be an effective means of representing and communicating knowledge. By carefully choosing concepts and digging words that are shown on the map, the maps can be turned into useful classroom tools for observing nuances of meaning and helping students to organize their thinking. These maps are also useful in summarising the object of the study.

Yin Yue (2004), in an article on the feasibility of using the generalisability (G) theory to examine the dependability of concept mapping has shown how G theory has been applied to compare the technical qualities of the frequently used mapping techniques to construct a concept map with created linking phrases (C) and selected linking phrases (S). Some measurement facts that influence concept maps score have been explored and also estimated how to optimize different concept mapping techniques varying the conditions for the different facts. It has been found that
C & S are not technically equivalent and G Coefficients for S was larger than those for C.

Wang, Charles, Xiaoxawe et al., (2004), in an article hold concept maps to be effective and a robust teaching tool. But it needs to be conceded that the reach of appropriate use of concept map and strategy regarding the effectiveness in facilitating and achieving specific learning objectives is rather limited. In a study that involved 156 College students, extra credit points were awarded for participation and the students were at random allocated to one of the four treatment groups such as Group I (Control group), Group – II (concept identifying mapping strategy group) Group – III (proposition identifying mapping group) Group – IV (student generating mapping group). It was found that in all criteria tests there were significant differences between the control group and the concept identifying mapping group. There were no statistical significances found among the other three concept mapping strategies group.

Liberato (2004), has discussed the concept of mapping to capture and archive expert knowledge. This has been shown by working in various corporates where research was conducted using concept maps for development efforts and also to create and transfer knowledge and information in corporate environments.

Freeman, Lee, et al., (2004), have analysed form and benefits of concept mapping in four areas viz, enable share understanding, the inclusion of effort, the balance of power and client involvement. Concept mapping theory and research show concept maps to be appropriate tools to assist communication. Concept maps are easy to use and are held to be beneficial by users. An experiment was carried out to test these assumptions and to analyse the power and benefits of concept mapping using a typical business scenario involving sixteen groups of two individuals each. The results
which were analysed through empirical testing of hypothesis and protocol analysis show an overall support of the theory and ease of use.

**Novak (2005),** in his 12 year longitudinal study of the effects of an early intervention programme describes the methods and outcomes. The study was begun as a challenge to the prevailing consensus such as that the primary school students were either “pre operational or concrete operational” with regard to their cognitive development and that they were not capable of learning abstract concepts. Based on the fact that Novak’s early research as per the Asubellian theory suggested otherwise, this study describes the new tool, tracing its development over 12 years of the children’s conceptual understanding in science as compared to a matched control group. The concept map was developed during this study as a means to trace conceptual development in children. It was found that students who underwent this form of instruction far out performed their non instructed counterparts. It was also found that the difference between the two groups increased as the student progressed through the years. **CM-Ed** is a multi-lingual and multimedia software specially designed for drawing concept maps.

**Mackinnam, and Keppell (2005),** hold concept mapping to be a unique means for negotiating the professional studies. Addressing particular approaches in the use of concept mapping, they showed how concept mapping tools go beyond class room planning into the realm of “idea exchange”, where concept mapping acts as the “mediator”. The notion of negotiated concept mapping has been analysed in the context of teacher education and also medical school software development. There was further discussion on the potential for negotiating ideas using concept mapping based on empirical materials such as qualitative observations by the authors, surveys on students and student interview data.
Crane, and Mooney (2005), have provided a stepwise instruction with regard to understanding, planning and engaging the coordinates of community resources which in turn support the transition of youth with disabilities into adult life. This document is organized in the following four distinct steps 1. Pre Mapping 2. Mapping 3. Taking action  4.Maintaining, Sustaining and Evaluating mapping efforts.

Kinchin Lan et al., (2005), have engaged in trials over a two year period on the concept mapping activities of an undergraduate Micro biology class. This study offers insight into the best ways of employing concept mapping as a tool in the higher education settings. The aim of the study was an investigation of mapping activities which in turn would improve students integration with the material presented and also be used as a method of course evaluation. It was found that the emphasis placed on the aspect of concepts in the initial stages had a profound influence on the conceptual development and its trajectories exhibited by students, though initial conceptual structure seemed resistant to change. Once established, it was possible to move forward in this regard to the subsequent choice of superordinate concepts. In the second year the students were encouraged to restructure their understanding with the help of a concept map. The concept labels that were prescribed excluded the terminology that had posted a constraint on the student’s conceptual development in the first year. It has been found that the following was necessary to optimize the concept mapping activities; (1) The map should have a student centered teaching philosophy. (2) The efforts should be collaborated. (3) The students should be given enough time for the reflection of development. (4) Specific terms that restrict conceptual development should be avoided. There should also be a linkage between mapping activity and course grades which in turn provides motivation for active engagement in the task.
Uzuntiryaki and Geban (2005), in their study have investigated the understanding of solution concepts and their attitude science as a school subject on 8th grade students through concept mapping, compared to the traditional instruction method (TI). The solution concept test was developed after examining related literature as also interviews with teachers regarding observations on the difficulties of students. The test was administered to 64 students of the eighth grade, selected from two classes from a general science course which was taught by the same teachers. The teacher provided conceptual change text along with concept mapping to the experimental group. This instruction explicitly dealt with misconceptions in the minds of students, i.e., the material was designed in such a way that misconception could be replaced by scientific concepts and new concepts integrated into existing concepts. The control group was taught through the TI method which comprises instructions through lecture and discussion. It was found that the conceptual change that was accompanied by concept mapping instruction brought about a significantly better acquisition of scientific concepts related to solution concepts and also produced a significantly more positive attitude towards science as opposed to the TI method. It was also found that logical thinking ability and prior learning had strong predictors for concept map learning related to solution concept learning.

Conlon (2006), in an article on the topic “Analyse the Formative Assessment of Classroom Concept Maps”, concludes that this technique is a powerful learning technique and that it can be enhanced by computer technology. Though software tools were available for the preparation of concept map there was not enough feedback on their content. The author has reported on development of a semi automated software analyzer for formatively assessing concept maps. Reporting on classroom trials it has been pointed out that high school students have experienced enhancement by the use of the analyzer.
Halton and Clarke (2006), have written an article where the conception of Scaffolding has been expanded with the following four key elements.

1. Scaffolding agency expert, reciprocal and self scaffold.
2. Scaffolding domain conceptual and heuristic scaffolding.
3. The identification of self scaffolding with meta cognition and
4. Identification of six zones of Scaffolding activities, each zone was distinguished by the matter under construction with the relative positioning of participants in the act of Scaffold.

The authors have illustrated these key elements with empirical evidence from a variety of research studies with regard to the role of the Teacher in the matter of instruction. It has been contended that the major objective of structure in the progressive relocation of the Scaffolding agencies is the direction of learners and the long term goal is to equip the students to take control over their own learning.

The Hindu (Monday July 3, 2006), in ‘Mind Mapping, an excellent tool for Students’, has reported that Mind mapping / concept mapping helps to read, assimilate, analyse and remember facts and information. Madhumati N in her article on mind mapping / concept mapping as evolved by Tony Buzan, says it serves as an excellent tool of learning. Concept mapping involves identifying the key factors of concept or a central idea and thinking up new and related ideas which are associated with the central theme. A typical mind map is a pictorial personalized expression of wants and understanding of topics. Facts are organized grouped and linked in a particular pattern and this aids usual memory. When one recalls the picture, one will able to write an essay comfortably. Chapter wise organization of
mind maps would help students prepare for exams better than browsing over hundreds of pages.

Coffey, et al., (2007), discuss concept maps as a meta-cognitive tool that helps people to think about thinking. The meta-cognitive tool based on concept maps permits the user to develop the unique type of course description. Course arrangements created by this method do not have the usual linear sequences of topics generally found in TI methods at the college level. This tool is a part of an environment that is designed to foster meaningful learning and reuse of course design and instructional context. This software tool is described as appropriate to a creation of a course depicted from concept maps.

The research project literacy for learning in further education of Mannion et al., (2007), in the UK, involves collaboration between two universities and FE (Further Education) Colleges. The investigation was on the everyday literacy practices of student with the view to mobilizing these to enhance the learning abilities.

In a quasi experimental study, Ling Yun et al., (2007), have examined the effectiveness of concept mapping in a primary science course in Singapore. This study used concept mapping as a revision tool for enhancing pupils’ examinations performances with the objective of determining whether there are significant differences in achievement levels between those exposed to concept mapping and TI during revision. These groups consisted of both primary, gifted and main stream classes. Findings of the study would help the implementation of concept mapping as an instruction.

Derbentsev et al., (2007), have dealt with three experiments that were conducted to examine the effects of map structure, concept qualification and focus questions on dynamic thinking during the
construction task of concept map (Cmap). The first experiment compared cyclic and hierarchical structures. The second examined impact of quantification of the header concept in the map, while the third experiment explored the effect of the focus questions on the map. In all the three experiments the Cmap content was ensured and the number of dynamic propositions and the number of quantity concepts. It was found that dynamic thinking increased significantly because of the cyclic structure, the quantification of the header concept and the focus question “how”, oral and revision tool at the primary school science classes.

Shamaefsky (2007), expresses that not all demonstrations involve the use of exciting visual display of any one (or) a series of scientific principles. Concept maps can be used to demonstrate and review inter relationship between scientific concept or principles. Concept maps are tools that aid people to conceptualize and store in memory a conglomeration of facts making up complex topics and are paradigms – concept maps promote creativity and flexibility because they help place facts in the constructs of the learning modalities of students. Presenting the pattern of organisation of concept maps, from the view point of the faculty it has been shown that the strength of concept maps is its presentation as a simple diagram used to represent words, ideas, tasks or other items link to an arrangement around a central key or idea. In other words, concept maps are used to generate, visualize, structure, clarify, and also to aid study with regard to organisation, problem solving and decision making.

Research has found that prior knowledge in any learning situation improves learning outcomes Gurlitt (2008), has investigated the extent to which the activation of prior knowledge involves learning outcomes for the less experienced learners at the high school level and experienced learners at the university level in a hypertext environment. The extent to which relationships between the concepts in the map are made explicit has been
defined as map coherence. Classifying the mapping task of creating and labeling lines as low coherent and the mapping task of labeling provided lines as high coherent, the learners were randomly assigned to any one of the following three groups

- High coherent activation group
- Low coherent knowledge activation group and
- Base line condition without prior knowledge activation group.

The results showed overall effect for the following:

- Prior knowledge activation
- Learning experience.
- An interaction between learning experience and the coherence of prior knowledge activation talk on learning outcomes.

High school students were seen to benefit the most from labeling provided lines while the University student benefited the most from creating and labeling the lines. Therefore it can be said that the interaction effect and effects of specific mapping tasks on process measure would support the view that different prior knowledge activation tasks are suited for different groups of learners.

**Hay et al., (2008),** in their attempt to study the learning visual have analysed the role of concept mapping in higher education. The article explores the concept mapping method as a tool for enhancing teaching quality in higher education. The article shows how concept mapping can be used to transform abstract knowledge and understanding into concrete visual representation that are liable to comparison and measurement. Four important uses of their method have been outlined.

- The identification of prior knowledge / prior knowledge structure among students.
• The presentation of new material in ways that facilitate meaningful learning.

• The sharing of expert knowledge and understanding among teachers and learners.

• The documentation of knowledge change to show integration of student prior knowledge and teaching.

It is not that teachers should completely abandon the tried and tested methods of teaching, but that they can definitely have significant enhancement through the method of concept mapping.

A case study by Andrews et al., (2008), demonstrates the use of concept mapping strategy as an effective tool for assessing environmental understanding. Collecting data from 325 middle school pupils aged between 11 to 14 years the study compares those enrolled in a model, university based informal, residential, marine education programme named the “marine quest” and a match group of non participating students. The study has used a non randomized Solomen four groups experimental design, where the differences in the structural complexity and content validity of knowledge about marine animal life are explored. It has been found that there are significant differences in the frequencies of concepts, relationships levels of hierarchy, branching and cross linking against the frequencies that types of critical concepts depict, especially among the participants who belong to the environmental education intervention groups. The study concludes that concept maps are a valuable alternative or adjunct to traditional pencil and paper test and provide both qualitative and quantitative measures for conceptual understanding.

Chiou Chie – Chang (2008), has studied the effects of concept mapping and student’s learning achievement and interest. The study
examines the use of concept mapping to help students improve their learning achievement and interest. The students numbering 124 enrolled in an advanced accounting course in the school of management of Taiwan University were selected from two classes. This experimental study provided data on two important aspects.

1. The adoption of the concept mapping strategy significantly improved the students learning achievement compared to the use of a traditional expository teaching method.

2. Most of the students were fully satisfied with the use of concept mapping in their advanced accounting courses. It was also found that the concept mapping helps students' to understand, integrate and clarify, accounting concepts apart from enhancing their accounting learning, interest and capabilities. This study also shows that concept mapping could be put to relevant use in other curriculum areas as well.

Kern and Crippen (2008), in their article on “Mapping for Conceptual Change” have shown that students’ understanding of science develops through everyday experiences. Students generally come to school with their own specific notions of how the world works. It becomes the teacher’s responsibility to make students overcome their pre conceived, naive notions and egg them on towards a more scientific understanding. Conceptual change is a fundamental requirement of student learning. Students understanding can be aided with strategies specifically designed to aid rationalise students’ perception. The authors through this article explain the strategy of how the process of recursive concept mapping helps in what they call “Mapping for Conceptual Change”.

Hillbert et. al., (2008), have analysed the cognitive process during concept mapping, as well as, the basic pictures of the concept maps produced by the learners along with the learning outcomes of 38 university
students. In order to test whether differences in learning outcomes occur because of differences in general ability the verbal and spatial ability have also been assessed. Using the cluster analysis, two types of ineffective learners were identified as “Non labeling mappers” and Non planning Mappers”.

On the other hand the effective learners showed a lot of effort in planning the mapping process and in constructing a coherent concept map. Those students (advanced beginners) with prior concept mapping experiences have shown that their strategies are more evident than the strategies of those (successful beginners) who have not used these learning strategies before. Based on these findings suggestions for a direct training approach that consisted of worked out examples in the strategy training and indirect training a course with supported learners with strategy was developed.

Amundsen et.al., (2008), in their research on the use of an unstructured form of concept mapping to aid academics in the analysis of course content have used concept mapping as a first step in the course design process. Though there was initial skepticism among some academics with regard to concept mapping, in the end it was reported by a majority of them that they valued the process and have expressed to what extent they have gained from concept mapping. The findings show the concept mapping process to be an alternate means to rethink course content. Concept maps, it has been found, also highlight relationships among concepts and encourages one, to view the course as an integrated whole. Concept maps frequently provide the occasion to make explicit the kind of thinking needed for the course.

Hay and Kinchin (2008), in their article on “Using Concept Mapping to Measure Learning Quality” describe a method of teaching which is based on the concept mapping techniques originated from Novak. They
explain how concept mapping can be used to measure prior knowledge as also how simple mapping exercises can increase student teacher integration and enhance understanding in ways that are meaningful. The concept mapping technique facilitate quick and easy measures of the knowledge change in students and teachers, thereby enabling them to identify those parts of the curriculum that the students understood from those that the students have not. It has been shown that the method is effective even for very large student groups in the fifty minute time slots that are usually allocated for teaching at the higher education level.

“Concept Mapping as a Research tool to Evaluate Conceptual Change Related to Instructional Methods” is an article by Miller et.al., (2009), in which it has been shown that concept maps are in common use in a variety of educational settings as an instructional tool as also a learning aid. The authors have also recognised concept mapping as a potential research tool and offer a protocol for their employment in research. Illustrating from a study that used concept maps to investigate the conceptual change of pre-service and in-service teachers during their participation in special and general education courses which used multimedia, case based instruction, the authors have shown the viability of concept maps as a research tool. They have also provided specific receivers for creating a concept map scoring system in support of their view that concept maps can be used as a research tool to evaluate learning and growth in knowledge.

Rich Hart et.al., (2009), have developed a concept map instrument that can be used by teachers along with an analytical framework for interpreting students’ responses. Conducting a preliminary study the concept map has been used to evaluate changes in the conception of thinking in students. This had been done by the teachers actively seeking to make thinking more visible. The concept maps of 239 students from grades 3 to 11 were analysed and it was found that the students’ conception of thinking
improves with age but can also be developed to a great extent through a classroom culture which includes rich opportunities for thinking. The concept map as an instrument, has proved to be a robust tool for uncovering the thinking of students about thinking.

**Conlon (2009),** explains the collaborative research approach as a self developed review system of pedagogy called TCM/4. Previous experimental studies have shown that text comprehension and summarisation skills of the young can be improved by techniques based on Text Concept Mapping (TCM), but a practical pedagogy has not been elucidated from these studies which can provide adoptable techniques in the context of a typical secondary school classroom. By developing the collaborative research approach and the new pedagogy TCM/4, TCM along with the new technology will help support pedagogy as an effective base. Through a case study of strategy it has been indicated that pupils enjoy lessons and share the teacher’s views which in turn is helpful in comprehending texts.

**Bulunuz and Jarrett (2009),** have analysed pre-service teachers’ understanding of six concepts of earth and space science which form a part of the elementary school syllabus. The six concepts identified were Reason for seasons, Phases of the moon, Why the wind blows, The rock cycle, Soil formation and Earthquakes. The effect of readings hands – on learning situations and concept mapping for improving conceptual understanding have been specifically examined in the study. An open ended survey was conducted on 52 undergraduates from two sections of a science methods course. Explanations about the selected concepts were given three times as pre-test and twice as post test along with various instructional interventions. Scored with a three point rubric, the answers indicated the target population in the beginning had many misconceptions or alternative conceptions. A two way ANOVA test with repeated measure analysis (pre test / post test) demonstrated that reading and learning situations are both successful in
building understanding and statistical significance was found in the hands on learning situation. It was also found that the concept mapping had additive effect in building understanding as evident from the results of the second post test. The findings paved the way for identifying useful strategy which science instructors at the University level could use in clarifying science concepts.

**Rueda et.al., (2009),** conducted a study with social education students at the University of Bas country with the aim of evaluating the concept map editor (CM-Ed). Graphically presenting concepts of the learning domain and relationships between them enable students to integrate new knowledge into their current cognitive structure. Making use of the flexibility found in computer aided drawing graphs several concept mapping tools were developed and their use studied over a period of a few years.

**Garcia (2009),** has given a narrative style bibliography on concept mapping. Reviewing six articles published between 1992-2005, the author provides an annotated bibliography of (1) Cognitive Mapping: A Qualitative Research Method for Social Work (C.Bitoni); (2) Collaborative Concept Mapping Provoking and Supporting Meaningful Discourse (C.Bontel; JnLinen, E Roelofs. and G.Erikens); (3) Extracting, Representing and Analyzing Mental Models (K.Carely and M.Palmquist); (4) Concept Maps as an Assessment Tool in Psychology Course. (J.M.Jacobs – Larson and D.A. Hershey); (5) The Knowledge Area as an Extension to the Concept Map; Reflection in Action (R.McAleese); (6) Validity of the Structural Properties of Text Based Concepts Maps; An empirical assessment (S.Nadkami and V.K. Narayanan).

In their investigation on the impact of using a strategy of two visuals while reacting, as also concept mapping and underlining on the performance of intermediate students who learn English as a foreign language, **Hay et al., (2009),** have chosen 60 Iranian students who were learning English as a
foreign language at the intermediate level. These 60 students were selected from a larger population by means of a proficiency test. Dividing the selected students into 3 groups one was exposed to the knowledge mapping technique and the second group to the underlining technique and the third group was the control group.

The first two experimental groups were taught how to use knowledge mapping and underlining strategies, respectively, during reading. Finally, all the three groups were given the same reading comprehension test. The result showed that the underlining group scored the highest followed by the knowledge mapping group and the control group performed the lowest.

“Use Standards to Draw Curriculum Maps” is an article by Franklin et.al., (2009), where a specific curriculum is started at every grade level and the library media specialists are entrusted with the job of knowing subject areas. These specialists then develop the collections to meet the content relevant to curriculum standards. It should be ensured that in order to meet school needs the collection mapping with specific curriculum should relate to local state and national standards. This technique will ensure the building of a collection that really meets the needs of the learning community. Visual representations are used to evaluate the collections in this technique of collection mapping.

The study by Amadieu et al., (2009), has explored the effects of HPK (high prior knowledge) versus LPK (Low prior knowledge) with regard to concept map structures such as hierarchical and network. The study is on disorientation, cognitive load and learning from non linear documents and the infection process of a retrograde virus (HIV). There were 24 adult participants whose overall subjective ratings of disorientation and cognitive load, as well as, detailed analysis of eye movement and navigation data were used. It was learnt that LPK learners gained equal factual knowledge from hierarchical and network concept maps. They also gained
more conceptual knowledge from the hierarchical concept maps and invested less mental effort with regard to the post test after learning with the hierarchical concept maps. On the other hand, more factual knowledge was gained by the HPK learners from the hierarchical maps than from the network concept maps. These learners also gained equal conceptual knowledge from both concept map structures. While LPK learners experienced higher disorientation learning with network concept maps, there was no differential effect found among HPK learners with regard to the concept map structures.

Lim Kyu yon et al. (2009), have studied the effect of the concept mapping strategies at three generative levels such as Expert generative concept maps, Partially learner generative concept maps and Fully generative concept maps in connection with knowledge acquisition. Self regulated learning (SRL) and its interaction with the different levels of the generative was tested through 124 randomly selected undergraduates. Assigned to the three different groups the participants were differentiated by high and low level SRL skills. It was found that the Fully generative map group performed better than even the ones in the Expert generative mapping group. Those participants with high SRL skills outperformed those with low SRL skills at all the treatment levels.

Kevin (2009), has investigated, 74 Science students from the sixth grade as to how well they represented text structures from a 900 word text book chapter on soil conservation with the help of a concept map template with four super ordinate terms and 24 unsorted concepts. The findings show the students were more successful in clarifying the pre selected terms under the given super ordinate categories than in identifying relevant concept sets, as also articulating three different relationship types among the terms. However, no significant differences were noticed in the mapping performance of students at different reading levels. It is interesting to note
that two thirds of the students enjoyed concept mapping showing preference to read and map rather than just read without mapping.

**Gerstner et al., (2009),** have investigated the application of concept mapping in both teaching and learning of a science topic among secondary school students in Germany. The purpose of this research was to find out:

1. Whether different teaching approaches would affect the concept map structure or the student’s learning success.

2. Whether the structure of concept map is influenced by gender.

3. Whether the concept mapping structure is a reliable indicator of students’ learning success.

The experiment was carried out with 149 high achievers of the fifth grade drawn from four secondary schools in Germany. The average age of participants was 10 years, and gender distribution was balanced. There were two teaching approaches used (1) teachers’ centered instruction and (2) Students’ centered learning.

A concept mapping phase followed each set of instructions. Student groups were divided between these two approaches. Using the Kinchin Adam method of concept map structures, the three different map structures were defined as spokes chains and nets. A multiple choice knowledge test with the pre, post and retention test design was constructed. Parametric tests such as MANOVA, one way ANOVA and T test were used to identify the differences in gender, teaching approach, number of nets per concept maps and their interactions. The type of teaching approach was found to have an effect on concept map structure but was not a longer term learning success. The students belonging to the teacher centered approach produced more net structures than those in the hands on instruction group. More net structures were found for female groups. The study suggests that Kinchin clarification
scheme for gauging concept map quality may be a good indicator of the learning success of a student, especially when applied in combination with knowledge test.

**Gerstner and Bargner (2010),** have conducted a study based on learning at work stations and the relation to instruction. The cognitive and motivational effects within different educational instruction keys were monitored. The teacher centered versus hands on instruction, without a knowledge consolidation / concept mapping phase and hands on instructions with a knowledge consolidation phase / concept mapping were studied. Using the same content for these different kinds of instruction, a total of 397 high achievers at the 5th grade level were selected. A pre test, post test and retention test design was used to detect short term and long term learning success along with the documenting of decrease rate of newly acquired knowledge. There was additional monitoring of intrinsic motivation. It was found that the teacher centered approach provided higher short term learning success, while hands on instruction resulted in relatively lower decrease rate. It was found that after six weeks all students attained similar levels of newly acquired knowledge. Nonetheless, it was found that concept mapping as a knowledge consolidation phase positively affected the short term increase in knowledge.

**Moore (2010)*** refers to chemistry as a whole branch of science which is about matter. Chemistry according to him is the study of the composition and properties of matter and the changes it undergoes. Matter and energy are the two basic components of the universe. The author subscribes to the futuristic view that some day what is science fixation today may become reality and it may be possible to transform the human body into energy and back as a human form in a transporter.

**Tseng et al., (2010),** have studied mining concept maps from new stories for measuring civic scientific literacy in media. A given list of 3657
index terms from science text books were matched against a rural based logarithm of the term association network which was culled from Chinese news articles / stories, key terms, known or new words or phrases from existing lexicons. The resulting term network including 95 scientific terms was visualized in a concept map to scaffold the instrument developers. The resulting instrument of 50 items which reflected the scientific knowledge revealed in the daily news stories met the goal of measuring civic scientific literacy in media. The concept map / mind map from the test also serve as a convenient tool for item classification, to develop a collaborative and expert review and discussion.

**Byrne and Grace (2010),** have used a photograph associated technique in the concept mapping tool as a novel method of eliciting childrens’ ideas. Eleven year old children were studied with regard to their knowledge about specific concepts related to microbial activity, which in turn were presented and discussed in relation to the effectiveness of the concept mapping photograph association technique (CMPAT) as a tool to draw out their ideas. It has been concluded that this tool could be used for ideas about various science concepts of children in other age groups also, especially when language is a barrier to participation.

**Schaal et. al., (2010),** have conducted an assessment based on concept mapping with pre/post test design while monitoring an interdisciplinary hyper media assisted learning unit, on hyper nation and thermodynamics based on cooperative learning with 53 pairs of ninth graders who cooperated for six lessons in an interdisciplinary learning activity. Since an interdisciplinary learning activity in such a complex knowledge domain, needs to combine many different aspects, the focus was on long term knowledge. The learners constructed computer supported concept maps which were analysed by a specific software. The results showed the acquisition of a higher order domain, specific knowledge
structure, which in turn indicates a successful interdisciplinary learning in a hypermedia learning environment.

Ketpichainarong et al., (2010), have assessed students’ achievements and attitude using the tools of the conceptual understanding test, concept mapping, students’ document, CLES Questionnaire, students' self reflection and interviews. The effectiveness of an inquiry based cellulose laboratory unit in promoting biotechnology enquiry in undergraduate students was explored. It was seen that students gained significantly with regard to content knowledge on enzyme substrate interaction and its application. Students’ report on their project showed that the development of the critical thinking scientific process gives one abilities to apply knowledge on enzyme cellulose to industrial application. The questionnaire responses and students’ self reflection on interviews showed that they reacted positively to this teaching strategy. It is significant that the teacher in the study has had mastery of both content and pedagogical technique.

Tzeng-Jeng yi (2010), has investigated the impact of concept maps from two strategic orientations such as comprehensive and thematic representation on the performance of cognitive operations of readers such as perception, verbatim memory, just reasoning and synthesis, while reading history articles that hold different perspectives of a historical incident which has had a profound impact on Taiwan. The result showed how the design and focus on concept maps could influence the formation of mental representation and to what extent these may facilitate or constrain the readers memory formation and reasoning about reading material.

Khwaldeh et al., (2010), investigated the contribution of conceptual change text along with concept mapping instruction. The study focused on 11th grade students’, understanding of respiration concept and retention of understanding. An appropriate text was developed by examining related
literature and interviewing teachers regarding their observations of students’ difficulties. A pre test, post test and delayed post test were administered to 70 eleventh grade students from two classes of the same high school in an urban area. The experimental group of 34 students received conceptual change text accompanied by concept mapping instruction while the control group of 36 students received TI (Traditional Instruction) by the same teacher. The other variables pertaining to the study included previous understanding and logical thinking ability. It was found that logical thinking, treatment, previous understanding of cellular respiration concepts made statistically significant contribution to the variation in their understanding of concepts relating to cellular respiration. The study also shows that conceptual change text accompanied by concept mapping instruction was significantly better than traditional instruction with regard to retention.

Duan and Cruz (2011), opine that a concept might map to multiple semantics by itself and so an explicit formalisation is usually required for identifying and locating intended semantics in order to avoid misunderstanding and confusion in conceptual models.

Lower (2011), has given Chemistry I Virtual Text Book for solutions based on their Chemistry and physical properties. This resource for General Chemistry information is mainly aimed at the first year university level and advanced high – school courses and offers a more comprehensive, organized and measured approach than that found in most standard text books. The book is also useful as review material for not only students at the advanced level in Chemistry but also Biology, Geology and Engineering.

Carpi (2011), states the properties of Chemical bonding and shows how the present 118 pure elements listed in the Periodic Table could expand to innumerable compounds through chemical bonding. Using the simple example of sodium and chlorine which in their basic state are highly poisonous, in combination as sodium chloride these become the most widely
used components of human life. These two dangerous substances—sodium which so violently reacts with water that it burst, into flames and chlorine the greenish gas which is so poisonous that it was used as a weapon in World War I, when chemically bonded become the compound that is so safe that we humans consume it every day.

Ronis (2012), has compiled a variety of information on the thermo dynamical through a lecture series meant for students of the McGill university in a series of 26 lectures schedule for 2012. The outline of the university. Programme is succinctly drawn up with topics and text chapters clearly demarcated. it is a comprehensive guide replete with information on exam pattern as also model question paper.

Ross and Morrison (Internet 1), have listed four major design approaches which instructional technology researchers would be most likely to use for their experimental studies. These “core” designs include.

- **True experiments:** The ideal design for maximizing internal validity. The feature that distinguishes true experiment from the less powerful designs is the Random assignment of subjects to treatment, thereby eliminating any systematic error that might be associated with using intact groups. The two or more groups, are then subjected to identical environmental conditions while being exposed to different treatments. In educational technology research, treatments frequently consist of different instructional methods. The study by Clariana and Lee (2001) has been cited as an example of a true experiment. Given the true experimental design which they had employed, the authors were able to infer that the learning advantages obtained were due to the properties of overt responding rather than extraneous factors related to the lesson, environment or instructional delivery.
• **Repeated Measures**: In this variation of the experimental design treatments are administered to all subjects. Twenty subjects were made to read a paragraph containing 5 words in each form. They were then asked to list as many italicized words and as many underlined words as they could remember. The repeated measures design according to the authors is the reason studied by [Gerlic and Jousorec](1999).

• **Quasi Experimental Design**: Quite often in Educational studies, it has been found to be neither practical nor feasible to assign a subject randomly to treatment. This is so in school based research for the classes are formed at the beginning of the year. A common application in educational technology would be to expose two similar classes to alternative instructional strategies and compare them on designated dependent measures such as learning, attitude and class room behaviour. An important component of this design is pretesting to establish group equivalence.

• **Time series Design**: This is the variation of the Quasi experimental approach and it involves repeated measurement of a group with the experimental treatment induced between two of the measures.

• **Deceptive Appearances: The Ex post Facto Design**: This basic design involves giving a class of 100 students of educational psychology, the option of using a word processor or paper and pencil to take notes for lectures on cognitive theory. Selecting 55 for the word processor and 45 for the paper and pencil, 40 from each group are randomly assigned for the study. The result showed a greater quantum of notes by the group using word processor and also higher scores on the quizzes. Despite the appearance of a treatment comparison and random assignment, this kind of research is not an
experiment but an Ex post facto study because no variables were manipulated. Moreover, the existing groups were self selected and were used for comparison. The random selection only helped reduce the number of participants to manageable numbers and did not assign them to specific treatments. The Ex post Facto might sometimes look like an experiment but is closer in design to correlational study.

- **Wikipedia** specifies that experimental research designs are used for the controlled testing of a casual process. This design is commonly used in science as also other areas in social sciences such as sociology, psychology etc. The classical experimental design has a pretest and a post test where the total population of participants are divided into two groups of sample called the test group experimental and the control group. The result of the experiment is to gauge from the divergence of the two samples. The other grouping is the Solomon four group design where the sample is randomly divided into four groups. The two groups called experimental groups and the other two where there is no experimental manipulation of variables. Two groups are administered the pretest and the post test, and the other two groups are given only a post test. The third kind of experimental design is the factorial design which is similar to the classical design except that there are additional samples used.

  **Hurvitz et.al., (Internet II),** have focused on the alternative conception in quantum Chemistry held by honors students at high school. They have studied how an intervention while using, interactive simulations in quantum Chemistry can alter student understanding. Chemistry students in four high schools were observed prior to, during and after their use of the Quantum Science Across Disciplines (QSAD) materials which were developed at Boston University. Student concept maps and interviews were used to find the base line misconceptions of student regarding understanding
of quantum science in Chemistry. Students in the experimental classes were required to investigate quantum phenomena using the simulations and then make a presentation. Similar assessment methods were used for both the experimental and the control classes.

Chemistry is a subject that needs to be perused in detail, not only by students belonging to the science group or teachers teaching through conventional methods or concept mapping methods, but more so for qualified chemists who need to update their knowledge periodically.

Yensen (Ed), (InterNet III), in the Strategies for Learning from Concept Maps to Learning Objects and Books to Works, holds that the concept mapping is a structured process focused on a topic and construct of interest involving input from one or more participants, that produces an interpretable pictorial view (concept maps) of their idea and concepts and how these are inter related.

Concept maps allow for clustering or contextual organizing according to themes or attributes. It is possible to discern overlaps or commonalities between concept maps from different disciplines which allows for cross disciplinary enrichment. Concept maps allow the generation of multiple ways of constructing meaning which promotes transfer and learning for practitioners and students alike. From a learning stand point a concept map can suggest instructional strategies, including choice of media, since the propositional logic connecting concepts will determine the level of abstraction and hence the degree of assimilative difficulty for the learners.

The construction of concept maps are further facilitated by the use of specially designed software. Some of the software used to construct concept maps are
1. Mind manager enterprise edition
2. Inspiration
3. C map
4. The brain

Concept Mapping is used to help design and construct new courses and new modules within courses. Students always enjoy concept mapping and often state that they have developed a new appreciation for the subject matter. Concept Mapping can be used by small groups to facilitate problem solving, project learning, evaluation and management curriculum development, process low charting and as a template for the systematic mining and management of resources. The author holds that the concept maps module for Chemistry could be in principle, a one page map to guide a student through a class of problems.

There are a number of studies which have used the experimental design to test the efficacy of the concept mapping techniques.

3.2 Studies in India

Vijayakumar (1981), chose select portions in chemistry to study the diagnostic remedial approach. The main objective was to analyse the frequency of error committed by students in their understanding of organic chemistry as also the different types of difficulties which existed in the selection of components. The study showed extensive error even in basic aspects such as chemical terminology, formulae, structure and information that were associated with chemical symbolism.

Kothari (1985), keeping in mind the little attention that is paid to the important dimension of research methodology especially in social sciences has endeavoured to make familiar the art of using different research methods and techniques in “Research Methodology Methods and Techniques”. The
book consists of 14 chapters outlining in coherent details, the guidelines to research starting with the meaning of research. The book carries the readers through defining the research problem, the design, the sampling techniques, measurement and scaling, data collection and sampling, testing of hypothesis, along with detailed information on the various statistical techniques such as chi square ($X^2$) ANOVA, Multivariate analysis etc. The role of computer and the part it plays in the analysis of data and report writing are also discussed in an easy to comprehend manner.

Chemical industries have developed in a major part due to the applications of the concepts of analytical Chemistry. Knowledge and practice of analytical Chemistry is a must for the personnel of research laboratories as also chemical industries. Aspiring Chemistry graduates need to have a sound knowledge and the authors Gopalan et al (1986), have presented the basic principles of analytical Chemistry in a simple, easy to comprehend fashion.

The key concepts of Analytical Chemistry have been assiduously explained with special reference to the practical courses commonly conducted in undergraduate laboratories. Dealing with modern instrumental methods of analysis the book avoids the befuddling mathematical aspects which appear to be an anathema to most Chemistry students. There is also a chapter on analytical Chemistry in consumer protection for promoting consumer awareness with regard to the role played by Chemistry. A question bank helps readers and students to check their comprehension and capabilities. In order to facilitate further ventures into other topics, the authors have provided a very useful bibliography

Andal (1990), in her research has investigated whether concept mapping can be a useful innovative teaching technique for learning physical science. Taking a sample of boys and girls from the state and central board schools. she has designed an experimental study with the test and control
group to find out the ability, interest and attitude which contribute towards performance. The researcher has arrived at the conclusion that concept mapping has the linear influence on scholastic performance in physical science among the ninth standard students and also that concept mapping has a positive relation to post test scholastic performance among both genders.

**Jayathilagan (1991)**, has evaluated concept mapping as a strategy for teaching Zoology to plus one students in Higher Secondary Schools. The study attempts to examine the effectiveness of concept mapping as a teaching strategy with regard to students’ achievement. The participants, 45 male students and 45 female students from the eleventh standard of a Government Higher Secondary School situated in a rural area were studied over a year. It has been reported that concept mapping strategies as a teaching technique is more effective than the conventional method of realization of all instructional objectives selected for the study such as knowledge, understanding application and skills. The study reports that there was progressive improvement in the academic achievement of Zoology students in subsequent examination after the introduction of concept mapping techniques. The researcher concludes that the concept mapping strategies have proved useful for rural students to have meaningful learning.

**Banarjee (1993)**, had administered a diagnostic test to find out whether students and teachers committed errors in understanding chemical equilibrium. The diagnostic test revealed that both teachers and students were prone to errors in area such as Le chatlier's principle, rate equilibrium, applications of equilibrium to acids, base and ionic solutions.

**Rajammal (1994)**, has studied the effectiveness of concept mapping on achievement in educational psychology. Selecting 133 students of the B.Ed., Degree Course, an experimental study was conducted with 75 students in the experimental group and 58 students in the control group. The
technique of exposing experimental group students to a teaching session with concept mapping and the control group to traditional teaching method was used. Both groups were given the post test. The findings showed that those exposed to teaching through the concept mapping technique scored significantly better than those given the traditional lecture method. The study concludes that concept mapping can be tried out as an effective teaching strategy at various levels of education.

Kumudha (1999), has stated that acquisition of knowledge is learning in an organised manner and information so gleaned can be organised into units such as concepts, rules, ideas, principles, images and network. She further states that science education generally imparts knowledge in such a way that students are enabled to learn what they had learnt to a more complex situation. According to her science instruction involves learning of content and also learning of process. The conceptualising process is a strategy for learning how to perform a specific scientific task. Information used in such strategies are sets of related concepts and they also represent the sequences in which concepts are processed. Such a strategy is held to be a dynamic model of human thinking because it provides explicit representation of the relationship among concepts as also the sequential cognition and processing of these concepts.

Khartmal (2009), emphasises that understanding science is of vital importance in science education research. Concept map is a tool which can be used to bring out the knowledge of students and teaching and learning experience in any given domain. Concept maps are node link diagram which depict knowledge in a two dimensional, hierarchical fashion. The author reviews concept maps in science education using the illustration of a case study on the effectiveness of such maps for bringing out students’ knowledge structure pertaining to the domain of cell biology. There is a significant increase in the depiction of concepts and proposition using concept maps as
against the description method. According to the author a concept map depicts four main cognitive processes such as

- subsumption
- progressive differentiation
- Integrative reconsillation and
- super ordinate learning

Incidentally the author also acknowledges that these cognitive processes have been proposed by Ausubel and that these helped to build a knowledge frame work during class room learning. Concept maps have been advocated as a useful tool for diagnostic, pedagogical assessment, data collection and knowledge organisation.

**Pandiya Vadivu (2010)**, Says that one uses concept to observe and interpret events and objects. A Concept Map according to her is device for representing the conceptual structure of subject/discipline in a two dimensional form, Concept mapping is a technique in which knowledge graphs are networks of concepts, the network of knowledge consists of a construction of concepts of that knowledge area into a coherent hierarchical system, these concepts are linked together to form propositions that are distinctive in each individual case. Through concept maps it could be possible to find new meanings and relationships even with regard to familiar material.

**Gopal (2010)**, conducted an experiment on 94 ninth grade students to assess the efficacy of teaching through the use of concept maps as a strategic tool, the pre test and post test scores were subjected to t-test analysis and the results showed that the students who received knowledge through the strategic tool of the concept maps perform better in understanding the concepts of English grammar as compared to the ones taught through the commonly prevalent options.
Nirmala and Shakunthal (2011), have studied concept mapping in development of critical thinking among nurses and were able to show that there is a significant improvement in the critical thinking skills of nursing students. In the post test evaluation of the experimental group as opposed to the thinking capabilities of those nursing students in the control group. The study further states that the critical scores were poor due to the high standard of the assessment tool. Therefore, it has been recommended that a critical thinking assessment tool may be developed to suit the nursing community and that further research is required to promote concept mapping as a teaching and learning strategy.

The Hindu (17.11.2011), carries an article on how a group of researchers have shown for the first time that swallow tail butterflies have an array of sensors on their forelegs that allow them to get a flavour of the leaves they land on. The team led by the scientists at J.T.Biohistory Research Hall based in Osaka have said that the larvae of plant eating insects need specific types of plants to feed on. Scientists found that swallow tail butterflies lay eggs only when they detect the presence of specific chemicals in the leaf as they drum their forelegs on the surface. This study throws new light on how different species use chemical detection to boost their chances of survival.

Narayana Moorthy, Trustee of Infosys Science Foundation (The Hindu : 17.11.2011) has stated that any discussion on the state of science in India must begin with discussing how our children learn science in school. He has further stated that most of our school children are forced to learn by rote. He further recommends that school and college students need to be helped to become adept in analytical thinking and problem solving.
3.3 Benefits of Review of Related Literature

This extensive review of literature has helped the researcher formulate information on the various aspects. Review the books on Chemistry which have been listed form only a part of the exhaustive number of books which the researcher has perused in order to be completely informed about the various and even minutest details that should be borne in mind both for teaching Chemistry as also teaching through the use of concept maps which forms the part of conceptual modeling. The various studies reviewed on concept mapping both general and Chemistry in particular have helped the researcher to design concept maps on the five selected topics and which have been used as a strategic tool to impart knowledge of Chemistry with the view to enhancing students' performance in Chemistry by studying about research design especially the experimental design the researcher has been able to devise an experiment which would stand the test of reliability and validity. The statistical tool and the significance reviewed have immensely help the researcher employs such tools to analyse data, test hypothesis, list findings and draw conclusions.

The fourth chapter presents the methodology and the five Concept Maps specially designed to enhance performance in Chemistry.