Chapter - 1

Conceptual Framework

1. Introduction

In twenty first century, achievements and success of any country depends on its ability to create and market complex knowledge as faster with deep understanding in a scientific way. Any country needs both academic institutions as well as industry want that acquire new complex knowledge in technology era. Knowledge can be applied more effectively for innovative ways and strategies in diverse field in solving practical problems and use on fieldwork. It's possible when people work effectively on reactions of matters around them with deep understanding of complex knowledge.

A branch of knowledge which studies of the Matter, its compounds, its substances, its particles, its Reactions and reactions phenomena of whole matter. Study of the reactions of the matters is complex knowledge of Chemistry. Chemistry, as a school subject is one of the most important science subjects in higher secondary school education. It equips students with a body of daily life's complex knowledge of reactions to make them functional and self-balance with socially in the fast-changing world. It helps students to realise the value of their environment and its chemical reactions. It is the students who need to appreciate and develop a sense of responsibility towards their own environment and society. So, as teacher find ourselves on highest tip of a complex knowledge scenario that demands superior pedagogical and andragogical practices. The emerging complex knowledge driven society is placing ever increasing demands on its teachers to satisfy its educational requisites and aspirations to students.

In this scenario, teaching-learning processes along with a suitable, relevant and appropriate plan make it indispensable. This shall lead to an awakening of curiosity, simulation of creativity, fostering of requisite skills and the development of interest, attitude and values within the educational system.

1.1 Theoretical Framework

1.1.1 Chemistry as a School Subject

Chemistry is one of the part of Science. Science is the root of Chemistry Subject. So, before one knows about characteristics and nature of the Chemistry subject in detail, need to know about Science. Science (from the Latin ‘scientia’, and meaning is "knowledge") usually describes the effort to understand how the universe works through the scientific method, with observable evidence as the basis of that understanding; a way of understanding the material world through thought and experimentation. The sciences tend to be positivistic in their approach to truth and knowledge, in contrast to the humanities which tend toward relativism.

Science is not just a subject but it is an arranged knowledge and a well-defined face like a complex molecule crystal. Hence, science does not have a single definition. However, many scientists, researchers, and philosophers made attempts to define science in their own ways. In the simplest form of natural science can be defined as “what scientists do”. There are some other definitions of science as follows:

- Conant (1951) views Science is an interconnected series of concepts and conceptual schemes that have developed as a result of experimentation and observation.
- Fitz Patrick (1960) defines Science as a cumulative and endless series of empirical observations which result in the formation of concepts and theories, with both concepts and theories being subject to modification in the light of further empirical observations. Science is both - body of knowledge and the process of acquiring knowledge.
- Lederman (1983) stated that Science is a dynamic, ongoing activity, rather than a static accumulation of information.
- Wilson, Edward (1999) defines Science is a systematic enterprise that builds and organizes knowledge in the form of testable explanations and predictions about the universe.

The definitions of science show the nature of science. Science is dual in nature; product and the process are the main aspects of science. Both the aspects are interconnected with and interdependent on each other. The product aspect of science acknowledges science as an accumulated and systematized body of knowledge whereas the process aspect of science

comprises of scientific method of inquiry and scientific attitudes. Therefore, the process aspect always remains in search of truth by adopting the scientific methods which are known as reliable, valid, objective, unbiased and verifiable. There is nothing wrong in saying that science is an overall product of human activity in the form of a systematic and organized body of knowledge. It is the product of all facts, connected with our information, concepts, generalizations, laws and theories framed on the basis of vast fund of collected knowledge.

Modern science is commonly divided into three major branches that consist of the natural sciences, social sciences and formal sciences. Each of these branches comprises various specialized yet overlapping scientific disciplines that often possess their own nomenclature and expertise. Both natural and social sciences are empirical sciences as their knowledge is based on empirical observations and is capable of being tested for its validity by other researchers working under the same conditions. There are also closely related disciplines that use science, such as engineering and medicine, which are sometimes described as applied sciences (Wikipedia, 2018).

Modern science is typically sub-divided into:

- The Natural sciences, which study the material universe;
- The Social sciences, which study people and societies;
- The Formal sciences, which study logic and mathematics.
- The Applied sciences, considered as disciplines in engineering and medicine.

A perfectly adequate definition as late as the 1930s, when natural science (the systematic knowledge of nature) seemed quite clearly divisible into the physical and biological sciences, with the former being comprised of physics, chemistry, geology and astronomy and the latter consisting of botany and zoology. This classification is still used, but the emergence of important fields to study such as oceanography, botany, meteorology, pharmacy and biochemistry (Russell, 1980).

Chemistry is a dynamic and all-encompassing subject. It is a distinct and dynamic science and science discipline that deals with the study of matter. Chemistry is the branch of Science that studies the structure of substance and its partials, the features, the inhabitants, and the phenomena of the Compounds. It is study of the matter's physical features, of the distribution of substances on the space, earth and its atmosphere, biosphere, and of human activity as it

affects and is affected by these, complex balance things between molecules in different matters, including the distribution of mass and energy.

Many famous Chemistry scientists have attempted to define the subject. The concept of Chemistry has also changed through the ages with other sciences researches, thus making its definition difficult.The definition of chemistry has changed over time, as new discoveries and theories add to the functionality of the science.

- Robert Boyle (1661) defined the term chemistry as a subject of the material principles of mixed bodies.

- In 1663, the chemist Christopher Glaser described ‘Chemistry’ as a scientific art, by which one learns to dissolve bodies, and draw from them the different substances on their composition, and how to unite them again, and exalt them to a higher perfection.

- Jean-Baptiste Dumas (1837) considered the word ‘Chemistry’ to refer to the science concerned with the laws and effects of molecular forces.This definition further evolved by Linus Pauling (1947) that means the science of substances: their structure, their properties, and the reactions that change them into other substances - a characterisation.

- Raymond Chang (1998) broadened the definition of "chemistry" to mean the study of matter and the changes it undergoes. Hoffman introduced the term transformation for chemical reactions especially in organic chemistry.

- Chemistry as subject is the study of molecules: the building blocks of matter. It is central to our existence, and leads our investigations into the human body, Earth, food, materials, energy, and anywhere and everywhere in between. The chemical industry, supported by chemistry research, underpins much of our economic progress, and provides wealth and prosperity for society (Oliver, J. and Paul, M., 2018).

The definitions of Chemistry display the nature of chemistry. Chemistry has many basic topics and principles at Higher Secondary level. Those are atoms and molecule, chemical bonding, state of matter, thermodynamics, equilibrium, periodic table, chromatography, etc. All are specific in nature; this equilibrium and thermodynamics topics are in calculative in nature; Periodic table has its particular nature, its base on element and it’s characteristic;

State of matter has a compound structure and reactivity with other element in manner. All are an integral part/area of basic Chemistry and it's dynamic in nature.

1.1.2 Importance of Chemistry as a school subject

NCF (2005) stated that Science should be introduced as separate discipline at the higher secondary stage. Exploring disciplines and approaching problems and issues from rich interdisciplinary perspectives are possible at higher secondary stage. The current two streams, academic and vocational, being pursued as per NPE-1986, may require a fresh look in the present scenario. The curriculum load should be rationalised to avoid the steep gradient between secondary and higher secondary syllabi. At this stage, the core topics of a discipline, taking into account recent advances in the field, should be identified carefully and treated with appropriate rigour and depth. The tendency to cover a large number of topics of the discipline superficially should be avoided." Chemistry is one of the subjects of Science discipline at higher secondary stage. Chemistry is a very wide and interesting subject, which touches on most other subjects such as the biochemistry and environmental Chemistry. In higher education, students learn about Chemistry mainly to pursue a career in this discipline**.**However, the aim of teaching Chemistry in higher secondary education is to give students necessary knowledge and skills to understand reactions of the matter as their home and utilize its resources sustainably during their lifetime.At present, Chemistry is one of the important subjects in the school curriculum. Chemistry is attached with such subjects as biology, physics, environment, mathematics, and derived other sciences (i.e. bio-chemistry, environmental chemistry, etc.). The subject matter of Chemistry includes study of compounds around environment. Chemistry has a very wide scope unparalleled by any other subject.National Policy on Education (2016) committee stated on Evaluation that to crack the various prestigious examinations like IIT, JEE, AIEEE, AIPMT, NEET etc. for better carrier and research in chemistry for better human life.

Chemistry is a science, it tries and develops good chemist who may be able to solve various medicinal, industrial, economic and material problems of the country and world. The importance of Chemistry can be understood more clearly by considering the effect of Chemistry teaching using chemistry use in daily routines on man as a human being, as an administrator, and as a Chemist. The practical, economic, social, cultural and intellectual importance is considered while teaching Chemistry at the higher secondary level.

Practical importance: Knowledge of Chemistry prepares the students to face various situational problems of daily routine. If a student is familiar with the natural chemicals of a country, its biosphere components, natural resources, mineral wealth, medicines its preparations, use of chemicals of day to day life it becomes easier for him to plan the future. Such a knowledge can be of much help to would be industrialists of a country and the students of Chemistry interested in setting up an industry after the completion of education can make a better selection for the methods of his industrial unit keeping in mind the daily life chemicals needed.

Economic Importance: The chemical industry has been a vital sector of the modern industrialized economy. The chemical and allied manufacturing sectors in the country employ over millions of individuals. This accounts for our nation's manufacturing and industrial workers. The chemical manufacturing sector has maintained a positive foreign trade balance for the past several decades. Knowledge of Chemistry can help students to a large extent in earning their livelihood. It is the knowledge that the students gain in Chemistry about the conditions prevailing around them that help them in utilizing their skills and time in a profitable manner. The knowledge of Chemistry gives the students the knowledge of various sources that are available and which could be profitably tapped to earn their livelihood.

Social Importance: Applications of chemical science have contributed significantly to the advancement of human civilization. With a growing understanding and ability to manipulate chemical molecules, the post-World War II chemist was considered a societal problem solver. They synthesized crop-enhancing agricultural chemicals to ensure a constant and viable food supply. They played a significant role in the eradication of deadly diseases by developing life-saving pharmaceuticals and chemical pesticides and Vaccines. Chemists also developed innovative plastics and synthetic fibres for use in a both industrial and consumer product (University of Michigan, 2018). Knowledge of Chemistry helps students in developing an appropriate social outlook and hence to develop a collaboration for the national of other countries. It also makes students -broadminded.

Cultural and intellectual importance of Chemistry*:* Knowledge of Chemistry helps students in acquiring knowledge about the cultural activity and intellectual life in scientific way of a particular country. Thus, helps them. Knowledge of Chemistry also helps students in developing their power of imagination and also encourages them to find out the cause and effect of various natural phenomena. According to Duvarci (2010) "Chemistry develops

students' way of thinking in a way that they use scientific method. Then, they can use these thinking abilities they gained in the chemistry class in any problem in their life. Also, students' critical thinking abilities can be improved by chemistry. For, this reason chemistry should be taught".

Importance in understanding other subjects: It exhibits a correlation with all other school subjects. Knowledge of Chemistry helps the students in understanding various other subjects like Agriculture, Mathematics, Biology, Physics and Statistics etc. Various historical events have been influenced by Chemical factors. Knowledge of Chemistry is also essential to acquire a thorough and proper knowledge of material science (pure science). Knowledge of Chemistry also helps to properly understand the subject matter of physics and Biology too. Chemical inquiry involves asking particular kinds of questions and using spatial data to answer those questions, rather than the rote memorization of isolated facts. Thus, we find that Chemistry occupies an important place in various fields of life.

Knowledge of Chemistry also inculcates sensitiveness to the chemical pollutions and environment. Chemistry is relevant for both the students who are likely to continue to the Chemical science research and those who would not proceed in the education system. Hence teaching of Chemistry occupies an important turning role in higher secondary education.

1.1.3 Objectives of Chemistry at Higher Secondary Level

The Objectives of Chemistry at Higher Secondary Level are derived from different sources as follows (NCF, 2005; Khirwadkar, 2007; Joshi, 2007 and Mani, 2015)**:**

- To attain desirable proficiency in the specialized areas of Chemistry at higher secondary level.
- To acquaint them with the latest concepts and advancement in these specialized in chemistry as branch of Science.
- To develop scientific attitude and scientific thinking.
- To develop scientific values such as honesty, accuracy, tolerance, respect for natural products and their properties.
- To develop laboratory skills in chemistry.
- To develop safety consciousness in practicing chemistry in school and life.
- To develop specific skills- calculation, observe, clean apparatus use of equipment etc.
- To provide a sound foundation preparing for higher education.

1.1.4 Teaching Chemistry in classroom

Chemistry teacher has taken task to deliver the prescribed curriculum - the objective stock of Chemistry knowledge through different methods of teaching. In the traditional Chemistry teaching method in the classroom teacher delivered lecture and the students passively watching and listening. The students are made to work on exercises individually, made assignments alone, and no scope for interaction within class students. The traditional method of teaching Chemistry is teacher-centered and focuses mainly on what the teacher does. Students' activities usually provided as a supplement to the planned delivery of content in prescribed curriculum. In contrast, methods rely heavily on the behavioural and cognitive learning methods. These methods focus mainly on what the students do.

Students from different populations need their diverse educational and technical advance methods demands on teachers in areas for which they were formally held accountable. If students' learning styles and teachers' teaching styles not match, then Problems occur. This has led to an increased emphasis on the development of student's ability to think rather than the teacher getting them to learn the content of subjects taught through mainly rote learning in this present scenario.

Sirhan (2007) said that the logical sequence of the content, language and communication, concept formation and lack of motivation creates problems in teaching. **Through the proper planning of the curriculum and the instructional strategy, the problems in the teaching and learning of Chemistry can be solved.**

Hence, today there is a need to ensure that the teacher is not only exposing the students with information but also structuring the content, organizing the data and sensing the problems. The teacher should also organize activities so that students can in turn process the information more effectively and make better and more rational decisions for higher quality learning. **Twenty-first century classrooms challenge traditional, teacher-centered methods to meet the increasingly diverse needs of students and the required for increase an academic achievement.**

1.1.5 Achievement in Chemistry

Achievement is the act of accomplishing or finishing. It can be defined as the act of acquiring knowledge, skills, ideas or understanding over and above those which already exist. It is thought of as a set of possible actions, an addition of ideas or skills, a reordering of ideas, or

an acquisition of concepts. The achievement requires learners to be involved in three distinctive set of process.

- *Internalization*: the processes which enable ideas or knowledge to enter the mind from an external source;
- *Internal processes*: those processes which enable the ideas or knowledge acquired to be compared or contrasted or integrated in some way with those which already exist;
- *Externalization*: the processes which enable ideas or knowledge or skills to leave the mind and to be recognized by other.

Achievement in Chemistry is something accomplished successfully, especially by means of exertion, skill, practice or perseverance, in relation to the prescribed Chemistry syllabus.

1.2 Constructivism

Constructivism is that one will construct his / her own perspective of the world based on their premises, through individual experiences and schema. Constructivism focuses on preparing the learner to learn through to problem solve in ambiguous situations. Constructivism entered mainstream educational thought and research in the 1970s through the work of Piaget and Vygotsky and other from same disciple (Windschitl, 2002). Constructivism forms one of the major theories developed, arising from the work of Jean Piaget's theory of cognitive development. Piaget's stage theory also became known as constructivism, because he believed children needed to construct an understanding of the world for themselves. Piaget's theory saw children as an active agency rather than being passive receptacles.

Constructivism is a theory of knowledge that argues that humans generate knowledge and meaning from an interaction between their experiences and their ideas. During infancy, it is an interaction between their experiences and their reflexes or behavior-patterns. Piaget called these systems of knowledge schemata. Piaget asserts that learning occurs by an active construction of meaning, rather than by passive receptacles. He explains that when a learner, encounters an experience or a situation that conflicts with his current way of thinking, a state of disequilibrium or imbalance is created. He must then alter his thinking to restore the equilibrium or balance. To do this, he makes sense of the new information by associating it with what he already knows, that is by attempting to assimilate it into his existing knowledge. When he is unable to do this, he accommodates the new information to his old way of thinking by restructuring his present knowledge to a higher level of thinking.

Constructivism is a learning theory based on the notion that people are “active” knowledge seekers powered by innate curiosity (Sunal and Hass, 2002). The idea that knowledge is not transmitted from teacher to student but actively constructed by each student as individual or group is central to constructivism.

Constructivist classroom

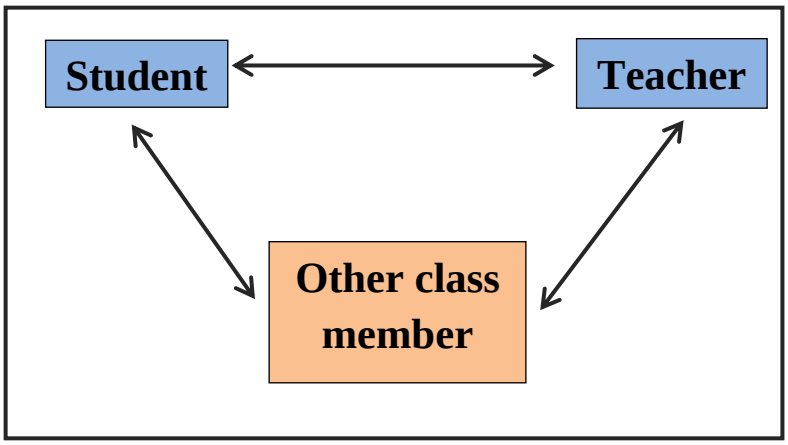

Figure 1.1: Constructivist knowledge sharing

The figure 1.1 depicts that in this setting the students work in groups or with other students, and the teacher takes on the role of ‘facilitator’ rather than ‘instructor’. The goal is to get the students to come up with their own solution to problems; and if the students have problems, they would turn to another student before asking the teacher. Constructivism implies that a child will be participating in ‘discovery’ learning.

Unlike the traditional and/or behaviorist theories of learning, constructivism fundamentally promotes the idea that the learner constructs his or her own knowledge. Whereas traditional and/or behaviorist pedagogies claim that learning is transmitted knowledge and teaching should be teacher centered, systematic and structured. Constructivist pedagogies claim that learning is constructed; knowledge and teaching should be student-centered and meaningful so that learners can construct their own knowledge (Rodger Bybee, 1990; Fosnot, 1996; Sunal and Hass, 2002; Windschitl, 2002). Constructivism contrasts with behaviorism which proposes that development arises from specific forms of learning, the child being seen as a passive recipient of environmental influences that shape its behavior. Hence Constructivism challenges the traditional teaching approaches and proposes re-structured and innovative teaching approaches for Achievement in chemistry.

1.2.1 Social Constructivism

Social constructivism emphasizes the importance of culture and context in understanding what occurs in society and constructing knowledge based on this understanding. This perspective is closely associated with many contemporary theories, most notably the developmental theories of Vygotskian social cognitive theory.

Social constructivism is a sociological theory of knowledge that applies the general philosophical constructivism into social settings, where in groups construct knowledge for one another, collaboratively creating a small culture of shared artefacts with shared meanings. Social constructivism can be defined as students building or 'constructing' their own knowledge through social experiences. It is emphasized that social culture plays a large role in the cognitive development of a person. Vygotsky's Social Constructivism suggests that knowledge is not solely constructed within the mind of the individual; rather, interactions within a social context involve learners in sharing, constructing, and reconstructing their ideas and beliefs. The social interactions provide the necessary language skills and understanding of cultural norms that facilitate learning through the use of tools available. Thus, social interactions with the teacher and other students become a significant part of the learning process. Social Constructivism can be enhanced through the social involvement of students in various situations. Social Constructivist classes reveal a shift in thinking in which the basic assumptions about what knowledge is, about how people learn, and about what is important.

Teachers who teach as if they value what their students think, create learners. Discussion and interactive discourse promote learning because they afford students the opportunity to use language as a demonstration of their independent thoughts. Discussion elicits sustained responses from students that encourage meaning making through negotiating with the ideas of others. This type of learning promotes retention and in-depth processing associated with the cognitive manipulation of information.

1.2.2 Characteristics of Social constructivism

The following are the characteristics of Social Constructivism:

- Construction of collaborative meaning is an important goal orientation of the classroom.
- Close monitoring of students' perspectives, thinking, and feeling by the teacher.

- The teacher and the students are both learning and teaching.
- Social interaction permeates the classroom.
- The curriculum and the physical contents of the classroom reflect students' interests and are infused with their cultures.

The implementation of social constructivist strategies needs to follow certain principles.

1.2.3 Vygotskian principles to be applied in a Social Constructivist classroom

The following Four Vygotskian principles are to be applied in a Social Constructivist class room:

- Classroom Learning and development is a social collaborative activity.
- The Zone of Proximal Development can be serving as a guide for lesson planning and curriculum.
- School learning should occur in a meaningful context and not be separated from learning and knowledge children develop in the "real world".
- Out of school experience should be related to the child's school experience.

Vygotskys' Social Constructivism introduces two concepts viz. the More Knowledgeable Other (MKO) and the Zone of Proximal Development (ZPD). Gaining an understanding of Vygotsky's Social Constructivism, needs an understanding of these two concepts in Vygotsky's work:

❖ **More Knowledgeable Others (MKO):**

The more knowledgeable other (MKO) is somewhat self-explanatory; it refers to someone who has a better understanding or a higher ability level than the learner, with respect to a particular task, process, or concept. Although the implication is that the MKO is a teacher or an older adult, this is not necessarily the case. Many times, a child's peers or an adult's children may be the individuals with more knowledge or experience. For example, who is more likely to know more about the newest teenage music groups, how to win at the most recent PlayStation game, or how to correctly perform the newest dance craze - a child or their parents?

In fact, the MKO need not be a person at all. Some companies, to support employees in their learning process, are now using electronic performance support systems. Electronic tutors have also been used in educational settings to facilitate and guide students through the

learning process. The key to MKOs is that they must have (or be programmed with) more knowledge about the topic being learned than the learner does.

- **Zone of Proximal Development (ZPD)**

The concept of the More Knowledgeable Other is integrally related to the second important principle of Vygotsky's work, the Zone of Proximal Development. This is an important concept that relates to the difference between what a child can achieve independently and what a child can achieve with guidance and encouragement from a skilled partner.

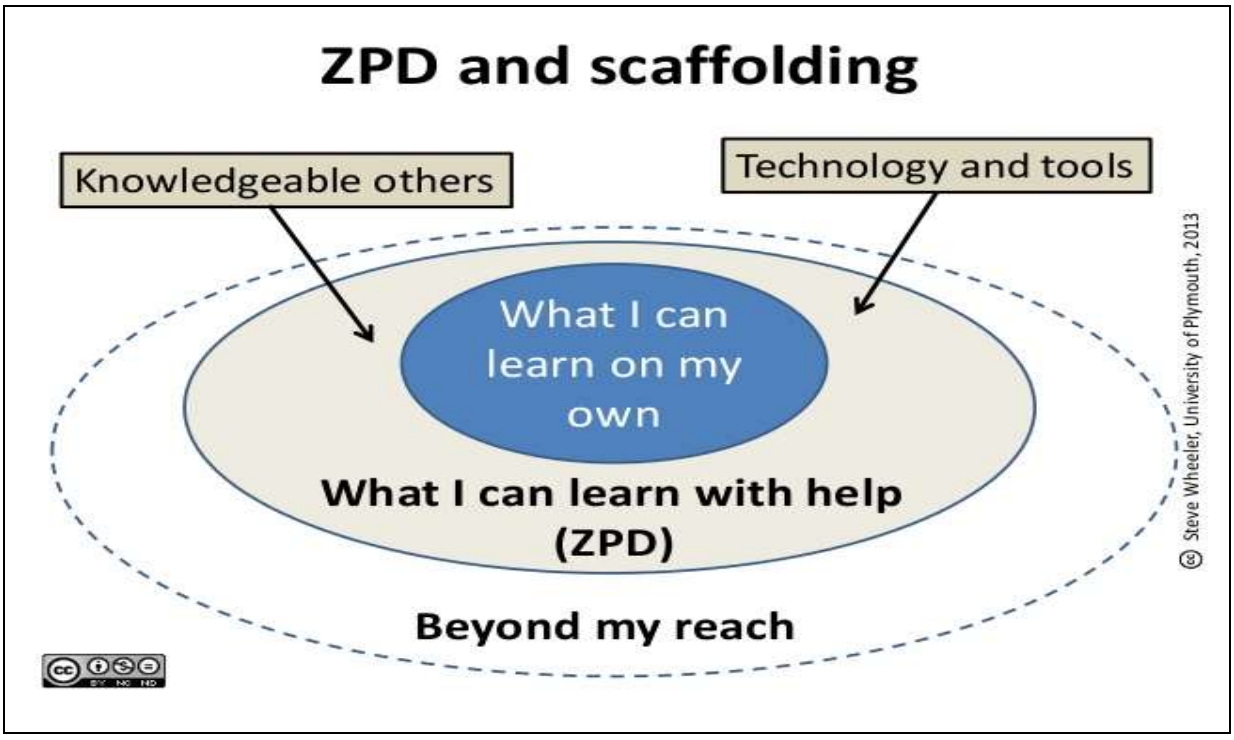

Figure 1.2 ZPD and Scaffolding

(**Source:**https://www.simplypsychology.org/ZPDScaffolding.jpg?ezimgfmt=rs:555x412/rscb19/ng:webp/ngcb19)

Vygotsky (1978) sees the Zone of Proximal Development as the area where the most sensitive instruction or guidance should be given - allowing the child to develop skills they will then use on their own - developing higher mental functions. Vygotsky also views interaction with peers as an effective way of developing skills and strategies. He suggests that teachers use cooperative learning exercises where less competent children develop with help from more skilful peers - within the zone of proximal development.

1.2.4 Constructivist Approach

It is an approach of learning found on the premise that, by reflecting on our experiences, we construct our own understanding of the world we live in. Each of us generates our own rules and mental models, which we use to make sense of our experiences. Learning, therefore, is simply the process of adjusting our mental models to accommodate new experiences. The constructivist approach in the teaching of science stipulates that teachers should apply certain strategies and methods which involve students in constructing the desired meaning of scientific concepts and which help the students to undergo the desired conceptual changes. According to Cooper (2007), "Students taught using a constructivist approach develop a deeper comprehension of materials as opposed to memorizing facts, imaginatively solve problems rather than follow procedure, and probe complex issues rather than recite culturally accepted beliefs. In constructivist approach, teachers serve as guide, monitors, coaches, tutors, coordinators, advisors and facilitators." The focus of teaching should be on knowledge construction rather than knowledge transmission.

Constructivist Approach in Chemistry Teaching

The science education has so many branches. Chemistry education is one of those branches of science. The common aim of all chemistry education researches is to help students to learn in most appropriate way. There have been many investigations in Chemistry teaching strategies and curriculum development in order to improve chemistry teaching. Rajendran (2012) has mentioned that recently, educators have emphasized constructivist approach in teaching science. The constructivist view is a very powerful perspective to many science education research studies. Rae (2008) said that there is a strong consensus among science educators that multiple approaches to learning are necessary to improve overall Science achievement. Effective Science instruction must not only increase learning, but also help students to develop necessary learning skills needed to succeed at higher level of Science and to reconstruct their conceptual knowledge and procedural strategies when necessary (Mahesha, 2014).

1.2.5 The Constructivist model

Rodger Bybee (1990) is the chief developer of the constructivist plan which involves five instructional phases; Engage, Explore, Explain, Elaborate, and Evaluate (5E Model). This model describes a teaching sequence that can be used for entire programmes, specific units and individual lessons.

Learning does not occur by way of passive absorption. Students are involved in more than listening and reading. They are developing skills, analyzing and evaluating evidence, experiencing and discussing and talking to their peers about their own understanding. Students will collaboratively to solve problems and plan investigations. Many students learn better when they work with others in collaborative environment rather than working alone in competitive environment. When active, collaborative learning is directed scientific inquiry, students succeed in making their own discoveries. Questions, observe, analyze, explain, and draw conclusions. View point that students are active thinkers who construct their own understanding from interactions with phenomena, the environment, and other individuals is based on the theory of constructivism. A constructivist view of learning recognizes that students need time to express current thinking; interact with objects, organisms, substances and equipment to develop a range of experiences on which to base their thinking; reflect on their thinking by writing and expressing themselves and comparing what they think with what others think and; make connections between their learning experiences and real world. The 5E instruction model is helpful for creating constructivist classroom. The 5E model sequences learning experiences so that students have opportunity to construct their understanding of a concept over a period of time.

The 5E's Model

Engage: Pique students' interest and get them personally involved in the lesson while pre-assessing prior understanding. Students are introduced to the instructional task during the engage stage. They make connections between past and present learning experiences and think about what they will learn during the upcoming activities. Activities are designed to engage students. Through activities and experiments, the lesson plans stimulate students' curiosity and encourage them to ask their own questions.

Exploration: Get students involved in the topic so that they can develop their own understanding. Exploration experiences provide students activities that help them to identify and improve upon misconceptions if any, processes and skills. Learners have hands-on fun in lab activities that help them to use prior knowledge to generate new ideas, explore questions and possibilities, and design and conduct a preliminary investigation. The teacher acts as a facilitator, providing materials and guiding the students' focus.

Explain: Provide students with an opportunity to communicate what they have learned and figure out what it means. During the Explain stage, students begin to communicate what they have learned by demonstrating their conceptual understanding, process skills or behaviors. Students share ideas with each other and with their teacher, who provides an explanation of the content that is meant to guide them toward a deeper understanding.

Elaboration: Allow students to use their new knowledge and continue to develop a deeper and broader understanding. During the Elaboration stage, students expand on the concepts they have learned, make connections to other related concepts and apply their understandings to the world around them through additional activities. Teachers extend students' conceptual understanding and skills.

Evaluation: Assess how much learning has taken place. The Evaluation phase helps students and teachers assess how much learning and understanding has taken place. It allows teachers to evaluate students' progress towards achieving the educational objectives. Evaluation can occur at any point during the instructional process.

1.2.6 Social Constructivist Strategies

The Social constructivist classroom is an environment where students build or construct their own knowledge. That does not mean they work alone or that they do not learn from what others have learned. To the contrary, many activities are hands-on and involve building on the work of others. Various strategies of social constructivism and provide social environment for children to construct their knowledge are:

1.2.6.1 Collaborative Learning

In a Vygotskian classroom, learning is promoted through collaboration - collaboration among students, and between students and teacher. From a social constructivist perspective as students share background knowledge and participate in the give and take of collaborative and cooperative activities, they actually negotiate meaning. They build knowledge, not as individuals, but as a group. People who surround the individual student, and the culture within which he lives, greatly affect the way he or she makes sense of the world.

Lejeune (1999) says that, it is based on the idea that learning is a natural social act. Learning occurs though active engagement among peers, either face-to-face. Collaborative learning is an educational approach that involves groups of learners working together to solve a problem, complete a task, or create a product. Collaborative learning activities can include

collaborative writing, group projects, joint problem solving, debates, study teams, and other activities. The main characteristics of collaborative learning are: a common task or activity; small group learning, co-operative behaviour; interdependence; and individual responsibility and accountability.

Learning is about keeping an active mind as one engages in processing any new information. The efficiency of a collaborative learning tool becomes more powerful depending on its capability to keep the learner involved in developing his critical thinking and motivated to process new information. A mind mapping application allows the instructor to create any type of informational sketch or outline, which can be used as a starting point by students. This method of sharing basic content encourages personalized learning. This way, students learn to think critically by asking questions, requiring feedback, adding comments and practicing their own creativity as they add on new content. The more the student becomes an active collaborator in the learning process the faster he will be able to own and interpret the delivered information.

Srinivas (2017) explained two Collaborative Learning Strategies:

- **Think-Pair-Share**: this strategy followed three steps: (1) The instructor poses a question, preferable one demanding analysis, evaluation, or synthesis, and gives students about a minute to think through an appropriate response. This "think-time" can be spent writing, also. (2) Students then turn to a partner and share their responses. (3) During the third step, student responses can be shared within a four-person learning team, within a larger group, or with an entire class during a follow-up discussion. The caliber of discussion is enhanced by this technique, and all students have an opportunity to learn by reflection and by verbalization.
- **Numbered Heads Together:** Members of learning teams usually composed of four individuals, count off: 1, 2, 3, or 4. the instructor poses a question, usually factual in nature, but requiring some higher order thinking skills. Students discuss the question, making certain that every group member knows the agreed upon answer. The instructor calls a specific number and the team members originally designated that number during the count off respond as group spokespersons. Because no one knows which number the teacher will call, all team members have a vested interest in understanding the appropriate response.

Again, students benefit from the verbalization, and the peer coaching helps both the high and the low achievers. Class time is usually better spent because less time is wasted on inappropriate responses and because all students become actively involved with the material

1.2.6.2 Cooperative Learning

Cooperative Learning framework used for classroom activities is based on Social Constructivism. In cooperative learning, the focus moves from teacher centered to student-centered education. Instead of sitting in a lecture or reading text, students are given a task or problem and are asked to identify a possible solution on their own and with the help of others. Rather than disseminating information directly, the teacher guides students to the source of the information they may require. In contrast to traditional teaching methods where students are perceived to be empty vessels awaiting the teachers' knowledge, Cooperative Learning theory recognizes the importance of the student's existing knowledge and puts that knowledge to work.

Gillies (2003) stated, "When children work cooperatively together, they learn to give and receive help, share their ideas and listen to other students' perspectives, seek new ways of clarifying differences, resolving problems, and constructing new understandings and knowledge. The result is that students attain higher academic outcomes and are more motivated to achieve than they would be if they worked alone". When students work collaboratively, they could achieve a better understanding of knowledge. Cooperative learning strategy makes students more productive in solving problems rather than to be competitive with others. Some cooperative learning activities are group problem solving, project method, group inquiry, simulations and debates. These activities in a Chemistry class encourage creativity, value and foster higher level thinking in students.

Students' learning goals may be structured to promote cooperative, competitive, or individualistic efforts. In every classroom, instructional activities are aimed at accomplishing goals and are conducted under a goal structure. A learning goal is a desired future state of demonstrating competence or mastery in the subject area being studied. The goal structure specifies the ways in which students will interact with each other and the teacher during the instructional session. Each goal structure has its place (Johnson and Johnson, 1989, 1999). In the ideal classroom, all students would learn how to work cooperatively with others, compete for fun and enjoyment, and work autonomously on their own. The teacher

decides which goal structure to implement within each lesson. The most important goal structure, and the one that should be used the majority of the time in learning situations, is cooperation.

Cooperation is working together to accomplish shared goals. Within cooperative situations, individuals seek outcomes that are beneficial to themselves and beneficial to all other group members. Cooperative learning is the instructional use of small groups so that students work together to maximize their own and each other's learning. It may be contrasted with competitive (students work against each other to achieve an academic goal such as a grade of "A" that only one or a few students can attain) and individualistic (students work by themselves to accomplish learning goals unrelated to those of the other students) learning. In cooperative and individualistic learning, you evaluate student efforts on a criteria-referenced basis while in competitive learning you grade students on a norm-referenced basis. While there are limitations on when and where you may use competitive and individualistic learning appropriately, you may structure any learning task in any subject area with any curriculum cooperatively.

Theorizing on social interdependence began in the early 1900s, when one of the founders of the Gestalt School of Psychology, Kurt Koffka, proposed that groups were dynamic wholes in which the interdependence among members could vary. One of his colleagues, Kurt Lewin refined Koffka's notions in the 1920s and 1930s while stating that (a) the essence of a group is the interdependence among members (created by common goals) which results in the group being a "dynamic whole" so that a change in the state of any member or subgroup changes the state of any other member or subgroup, and (b) an intrinsic state of tension within group members motivates movement toward the accomplishment of the desired common goals. For interdependence to exist, there must be more than one person or entity involved, and the persons or entities must have impact on each other in that a change in the state of one causes a change in the state of the others. From the work of Lewin's students and colleagues, such as Ovisankian, Lissner, Mahler, and Lewis, it may be concluded that it is the drive for goal accomplishment that motivates cooperative and competitive behaviour.

Cooperative Base Groups

Cooperative base groups are long-term, heterogeneous cooperative learning groups with stable membership (Johnson, Johnson, and Holubec, 2008). Members' primary responsibilities are to (a) ensure all members are making good academic progress (i.e.,

positive goal interdependence) (b) hold each other accountable for striving to learn (i.e., individual accountability), and (c) provide each other with support, encouragement, and assistance in completing assignments (i.e., promotive interaction). In order to ensure the base groups, function effectively, periodically teachers should teach needed social skills and have the groups' process how effectively they are functioning. Typically, cooperative base groups are heterogeneous in membership (especially in terms of achievement motivation and task orientation), meet regularly (for example, daily or biweekly), and last for the duration of the class (a semester or year) or preferably for several years. The agenda of the base group can include academic support tasks (such as ensuring all members have completed their homework and understand it or editing each other's essays), personal support tasks (such as getting to know each other and helping each other solve non-academic problems), routine tasks (such as taking attendance), and assessment tasks (such as checking each other's understanding of the answers to test questions when the test is first taken individually and then retaken in the base group).

The teacher's role in using cooperative base groups is to (a) form heterogeneous groups of four (or three), (b) schedule a time when they will regularly meet (such as beginning and end of each class session or the beginning and end of each week), (c) create specific agendas with concrete tasks that provide a routine for base groups to follow when they meet, (d) ensure the five basic elements of effective cooperative groups are implemented, and (e) have students periodically process the effectiveness of their base groups.

The longer a cooperative group exists, the more caring their relationships will tend to be, the greater the social support they will provide for each other, the more committed they will be to each other's success, and the more influence members will have over each other. Permanent cooperative base groups provide the arena in which caring and committed relationships can be created that provide the social support needed to improve attendance, personalize the educational experience, increase achievement, and improve the quality of school life.

Basic Elements of Cooperation

Not all groups are cooperative (Johnson and F. Johnson, 2009). Placing people in the same room, seating them together, telling them they are a group, does not mean they will cooperate effectively. To be cooperative, to reach the full potential of the group, five essential elements need to be carefully structured into the situation: a) positive interdependence, b) individual and group accountability, c) promotive interaction, d) appropriate use of social skills, and e)

group processing (Johnson and Johnson, 1989, 2005). Mastering the basic elements of cooperation allows teachers to:

- Take existing lessons, curricula, and courses and structure them cooperatively.
- Tailor cooperative learning lessons to unique instructional needs, circumstances, curricula, subject areas, and students.
- Diagnose the problems some students may have in working together and intervene to increase the effectiveness of the student learning groups.

The first and most important element is positive interdependence. Teachers must give a clear task and a group goal so students believe they "sink or swim together." Positive interdependence exists when group members perceive that they are linked with each other in a way that one cannot succeed unless everyone succeeds. If one fails, all fail. Group members realize, therefore, that each person's efforts benefit not only him- or herself, but all other group members as well. Positive interdependence creates a commitment to other people's success as well as one's own and is the heart of cooperative learning. If there is no positive interdependence, there is no cooperation.

The second essential element of cooperative learning is individual and group accountability. The group must be accountable for achieving its goals. Each member must be accountable for contributing his or her share of the work (which ensures that no one "hitch-hikes" on the work of others). The group has to be clear about its goals and be able to measure (a) its progress in achieving them and (b) the individual efforts of each of its members. Individual accountability exists when the performance of each individual student is assessed and the results are given back to the group and the individual in order to ascertain who needs more assistance, support, and encouragement in completing the assignment. The purpose of cooperative learning groups is to make each member a stronger individual in his or her right. Students learn together so that they can subsequently perform higher as individuals.

The third essential component of cooperative learning is promotive interaction, preferably face-to-face. Promotive interaction occurs when members share resources and help, support, encourage, and praise each other's efforts to learn. Cooperative learning groups are both an academic support system (every student has someone who is committed to helping him or her learn) and a personal support system (every student has someone who is committed to him or her as a person). There are important cognitive activities and interpersonal dynamics that can

only occur when students promote each other's learning. This includes orally explaining how to solve problems, discussing the nature of the concepts being learned, teaching one's knowledge to classmates, and connecting present with past learning. It is through promoting each other's learning face-to-face that members become personally committed to each other as well as to their mutual goals.

The fourth essential element of cooperative learning is teaching students the required interpersonal and small group skills. In cooperative learning groups students are required to learn academic subject matter (task work) and also to teach the interpersonal and small group skills required to function as part of a group (teamwork). Cooperative learning is inherently more complex than competitive or individualistic learning because students have to engage simultaneously in task work and teamwork. Group members must know how to provide effective leadership, decision-making, trust-building, communication, and conflict-management, and be motivated to use the prerequisite skills. Teachers have to teach teamwork skills just as purposefully and precisely as teachers do academic skills. Since cooperation and conflict are inherently related, the procedures and skills for managing conflicts constructively are especially important for the long-term success of learning groups. Procedures and strategies for teaching students' social skills may be found in Johnson (2009), Johnson and Johnson (2009).

The fifth essential component of cooperative learning is group processing. Group processing exists when group members discuss how well they are achieving their goals and maintaining effective working relationships. Groups need to describe what member actions are helpful and unhelpful and make decisions about what behaviours to continue or change. Continuous improvement of the process of learning results from the careful analysis of how members are working together.

These five elements are essential to all cooperative systems, no matter what their size. When international agreements are made and when international efforts to achieve mutual goals (such as environmental protection) occur, these five elements must be carefully implemented and maintained.

1.2.6.3 Concept mapping

Concept maps have their origin in the learning movement of constructivism. The concept mapping technique 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 all subjects as well as to represent the expert knowledge of individuals and teams in education, government and business. 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. Concept maps can also serve as “advanced organizers” for preview and review of material. Teachers can continuously refer to a concept map to show how to "grow" the connections, and to keep the instruction focused. Concept mapping is a technique for visualizing the relationships among different concepts. It is a technique that allows children to understand the relationships between ideas by creating a visual map of the connections. Concept mapping is a type of structured conceptualization which can be used by groups to develop a conceptual framework which can guide evaluation or planning (Mahesha, 2014, Trochim, 2003).

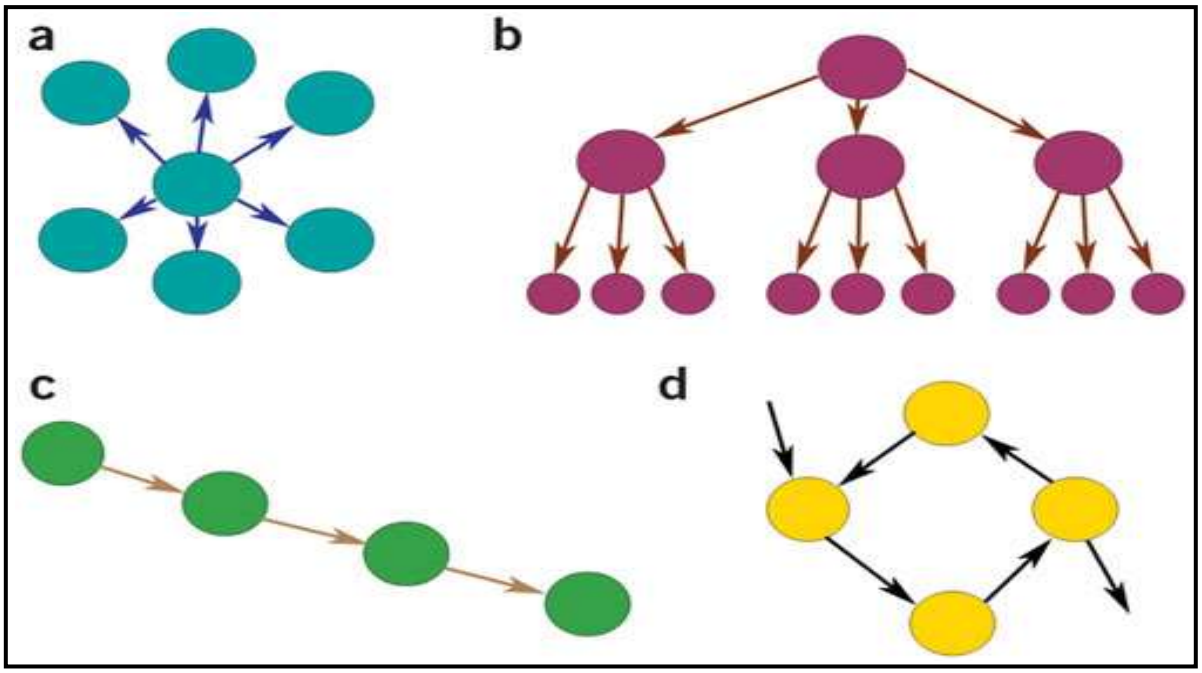

Figure 1.3: Types of Concept map: a) Spider, b) Hierarchical, c) Flowchart, d) Systems (Source:https://www.researchgate.net/profile/James_Kehler/publication/26761493/figure/fig1/AS:342381107924992@1458641425442/Four-main-types-of-concept-mappinga-Spider-mapping-b-Hierarchy-mapping-c.png)\

Four major categories of concept maps:

a) *Spider:* information systematically organized in a central theme or a concept in the map. Outwardly radiating sub-themes surround the center of the map.
b) *Hierarchical:* Presents information in a descending order of importance. The most important information is placed on the top. Distinguishing factors determine the placement of the information in the map.
c) *Flowchart:* information Organized in a linear format in the map.
d) *Systems:* Organizes information in a format which is similar to a flowchart with the addition of 'INPUTS' and 'OUTPUTS'.

Concept mapping as a Visual learning technique which helps students to:

- *Clarify thinking*: Students see how ideas are connected and realize how information can be grouped or organized. With visual learning, new concepts are more thoroughly and easily understood.
- *Reinforce understanding*: Students recreate, in their own words, what they've learned. This helps them absorb and internalize new information, giving them ownership of their ideas.
- *Integrate new knowledge*: Diagrams updated throughout a lesson prompt student to build upon prior knowledge and internalize new information. By reviewing diagrams created previously, students see how facts and ideas fit together.
- *Identify misconceptions:* a concept map helps to identify that what students know; and misdirected links or wrong connections reveal what they don't understand.

Student-Prepared concept maps can be used to gain insight into the way students view a scientific topic, examine the valid understandings and misconceptions students hold, and assess the structural complexity of the relationship's students depict. Teacher-Prepared concept maps can be used to organize their ideas in preparation for instruction, as a graphic organizer during class, and as a way to encourage students to reflect on their own knowledge and to work together and share their understandings in collaborative group settings.

The following different ways can be to use in teaching-learning:

- *Instructional Tool* – "Expert" maps could be presented to highlight key concepts and connections. These are detailed and flow from global maps executed for course design.
- *Learning Tool* – Students are asked to construct their own concept maps covering a section of the course material from class or the textbook. The instructor may need time to work with groups and individuals who are unfamiliar with the technique.

- *Collaborative Concept Mapping* - Frustration levels can be high when concept mapping is first introduced, especially in large classes of relative novices. To counter some of this anxiety and to encourage students to reflect on their own thinking 3 or 4 students could be asked to work together in groups on a concept map. This exercise is often a very rewarding and rich learning experience as peers argue, debate, and cajole each other. The result is a genuine effort to negotiate the meaning of scientific concepts, attempting (as scientists do) to reach consensus, or to stake out different points of view. The power of the process resides in the interpersonal sharing of ideas, which are made explicit to the instructor.
- *Fill-in Concept Mapping* –A concept map could be pre-constructed and the concept labels could be then removed while keeping the links. Then the class could be asked to replace the labels in a way that makes structural sense. This could be best done with small groups.
- S*elect and Fill-in Concept Mapping* – A concept map is created and then about one-third of concept labels are to be removed. The deleted concepts are placed in a numbered list on the map and students have to choose among them. An assumption is that as students' thinking approximates that of the instructor, the closer their connected knowledge is 'expert-like'.

Concept maps for Classroom use:

The following are the uses of concept maps in the Classroom:

- To Develop an understanding of a body of knowledge
- To Explore new information and relationships
- To Access prior knowledge
- To Gather new knowledge and information
- To Share knowledge and information generated
- To take notes during lecture.
- To group brainstorming as an excellent aid.
- To Providing graphics for presentations and term papers
- To Refine creative and critical thinking.

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. Structural flexibility makes concept mapping highly suitable for

multimedia environments since the linking employed in concept maps is an excellent match to the Internet's nonlinear paradigm. Thus, concept maps are useful tools for developing web interfaces and object indexing and retrieval (Gaines and Shaw, 1995). Studies suggest that organizing information via a concept map-based interface leads to more accurate search performance than the typically used web page-based browser (Canas et. al, 2003).

A concept map is not just a learning tool, but also an ideal evaluation tool for educators measuring the growth of and assessing student learning. As students create concept maps, they reiterate ideas using their own words and help identify incorrect ideas and concepts; educators are able to see what students do not understand, providing an accurate, objective way to evaluate areas in which students do not yet grasp concepts fully. Concept mapping software is also available that helps in researching, locating, connecting, relating, and grouping ideas and links together to generate on synthesis of ideas on common criteria.

1.2.6.4 Problem Solving

While problem solving accompanies the very beginning of human evolution, the nature of human problem-solving processes and methods has been studied by psychologists over the past hundred years. Social psychologists have recently distinguished between independent and interdependent problem solving. In psychology, problem solving refers to a state of desire for reaching a definite 'goal' from a present condition that either is not directly moving toward the goal, is far from it, or needs more complex logic for finding a missing description of conditions or steps toward the goal. In psychology, problem solving is the concluding part of a larger process that also includes problem finding and problem shaping. Considered the most complex of all intellectual functions, problem solving has been defined as a higher-order cognitive process that requires the modulation and control of more routine or fundamental skills. Problem solving has two major domains: mathematical problem solving and personal problem solving where, in the second, some difficulty or barrier is encountered. Further problem solving occurs when moving from a given state to a desired goal state is needed for either living organisms or an artificial intelligence system.

Problem-solving is a process - an on-going activity in which we take what we know to discover what we don't know. It involves overcoming obstacles by generating hypo-theses, testing those predictions, and arriving at satisfactory solutions.

Problem-solving involves three basic functions:

1. Seeking information
2. Generating new knowledge
3. Making decisions

Problem-solving is, and should be, a very real part of the curriculum. It presupposes that students can take on some of the responsibility for their own learning and can take personal action to solve problems, resolve conflicts, discuss alternatives, and focus on thinking as a vital element of the curriculum. It provides students with opportunities to use their newly acquired knowledge in meaningful, real-life activities and assists them in working at higher levels of thinking.

Problem solving model

Problem solving five-stage model that most students can easily memorize and put into action and which has direct applications to many areas of the curriculum as well as teaching-learning process:

1. **Understand the problem.** It's important that students understand the nature of a problem and its related goals. Encourage students to frame a problem in their own words.

2. **Describe any barriers.** Students need to be aware of any barriers or constraints that may be preventing them from achieving their goal. In short, what is creating the problem? Encouraging students to verbalize these impediments is always an important step.

3. **Identify various solutions.** After the nature and parameters of a problem are understood, students will need to select one or more appropriate strategies to help resolve the problem. Students need to understand that they have many strategies available to them and that no single strategy will work for all problems. Here are some problem-solving possibilities:

    - *Create visual images:* Many problem-solvers find it useful to create “mind pictures” of a problem and its potential solutions prior to working on the problem. Mental imaging allows the problem-solvers to map out many dimensions of a problem and “see” it clearly.

    - *Guesstimate:* Give students opportunities to engage in some trial-and-error approaches to problem-solving. It should be understood, however, that this is not a

singular approach to problem-solving but rather an attempt to gather some preliminary data.

- *Create a table:* A table is an orderly arrangement of data. When students have opportunities to design and create tables of information, they begin to understand that they can group and organize most data relative to a problem.
- *Use manipulative:* By moving objects around on a table or desk, students can develop patterns and organize elements of a problem into recognizable and visually satisfying components.
- *Work backward:* It's frequently helpful for students to take the data presented at the end of a problem and use a series of computations to arrive at the data presented at the beginning of the problem.
- *Look for a pattern:* Looking for patterns is an important problem-solving strategy because many problems are similar and fall into predictable patterns. A pattern, by definition, is a regular, systematic repetition and may be numerical, visual, or behavioural.

4. **Try out a solution.** When working through a strategy or combination of strategies, it will be important for students to …

- Keep accurate and up-to-date records of their thoughts, proceedings, and procedures. Recording the data collected, the predictions made, and the strategies used an important part of the problem-solving process.
- Try to work through a selected strategy or combination of strategies until it becomes evident that it's not working, it needs to be modified, or it is yielding inappropriate data. As students become more proficient problem-solvers, they should feel comfortable rejecting potential strategies at any time during their quest for solutions.
- Monitor with great care the steps undertaken as part of a solution. Although it might be a natural tendency for students to “rush” through a strategy to arrive at a quick answer, encourage them to carefully assess and monitor their progress.
- Feel comfortable putting a problem aside for a period of time and tackling it at a later time. For example, scientists rarely come up with a solution the first time they

approach a problem. Students should also feel comfortable letting a problem rest for a while and returning to it later.

5. **Evaluate the results.** It's vitally important that students have multiple opportunities to assess their own problem-solving skills and the solutions they generate from using those skills. Frequently, students are overtly dependent upon teachers to evaluate their performance in the classroom. The process of self-assessment is not easy, however. It involves risk-taking, self-assurance, and a certain level of independence. But it can be effectively promoted by asking student's questions such as "How do you feel about your progress so far?" "Are you satisfied with the results you obtained?" and "Why do you believe this is an appropriate response to the problem?"

1.3 Role of teacher in Social Constructivist classroom

The roles of the teacher in Social Constructivist classroom vary greatly as compared to traditional classroom. In traditional practice, the teacher's role as dispenser of knowledge is to transmit information and direct learners' actions. In contrast to the traditional practice, the Social Constructivist teacher takes the role of a coach and facilitator. The role of the teacher is to help learners, to process information and to facilitate learner thinking. One primary function of the teacher in a Social Constructivist classroom is that they take the role of a guide and a facilitator or in simpler terms a coach.

- To encourage and accepts learner autonomy
- use raw data and primary sources along with manipulative, interactive and physical material
- allows learners responses to drive lessons, shift instructional strategies and alter content
- inquiries about learners' understanding of concepts before sharing their own understanding of those concepts
- use cognitive terminology such as classify, analyse, predict and create when framing tasks
- encourages learners to engage in dialogue both with the teacher and with one another;
- seeks elaboration of learners' initial responses
- engage learners in experiences that might engender contradictions to their initial hypothesis and then encourages discussion

- provide time for learners to construct relationship and create metaphors; and
- Nurtures learners' curiosity.

From the above discussion it is clear that Social Constructivist approach is very relevant to teaching of Chemistry, where the students are given utmost freedom and ownership to what they learn and the role of the teacher is to provide such experiences that give them an opportunity to construct knowledge.

1.4 Rationale of the study

Twenty first century is the age of technology. Right from cradle to grave most of activities are controlled and fashioned by technology. Technology is not possible without Chemistry, because matters (its characteristics use) are backbone of any technological instrument. Chemistry is important in everyone's life whether one knows it or not but is directly affected by it. The purpose of Chemistry education is to develop scientific literacy which helps them to be interested in, and understand the world around them, to engage in the discourses about Chemistry, to be able to identify questions and draw evidence-based conclusions, and to make informed decisions about the environment and their own health and well-being. Chemical bonding and molecular structure, Equilibrium, Hydrocarbon and Environmental Chemistry are fundamental concepts in higher secondary school. This being the situation it becomes very important that all the school Students not only be aware about the basic concepts of Chemistry but possess thorough understanding of concepts, principles, facts and theories of Chemistry.

Understanding of chemical bonding and molecular structure lead other basic concepts in chemistry which need ground understanding in all concepts. Understanding and application of chemical equilibrium leads production and balancing chemical reactions. Chemical reactions shows inter molecular and intra molecular activity in substances, mathematical reasoning in nature and so it's hard to understand. Hydrocarbon is fundamental concept of Organic chemistry, which understanding leads other organic concepts deep understanding.

Research studies revealed that students hold misconceptions in chemistry. Some of the conceptual areas in which most studies have been conducted are chemical equilibrium (Sendur et al., 2010), acid-base (Kousathana et al., 2005), chemical bonding (Coll & Taylor, 2002; Ozmen, 2004), atomic orbital and hybridization (Nakiboglu, 2003), buffer solution (Orgil & Sutherland, 2008), solutions and their components (Çalık & Ayas, 2005; Pinarbasi & Canpolat, 2003), organic chemistry (Childs & Sheehan, 2009, Ratcliffe, 2002; Johnstone,

2006) and electrochemistry (Huddle & White, 2000). Jusniar, et al. (2020) found a misconceptions impact on other concepts in chemical equilibrium. For example, “Catalyst accelerates the rate of reaction and activation energy (E*) increases, the rate of reaction accelerates by adding Catalyst.” impacts the misconception that “Catalysts increase activation energy so that forward reaction is faster than reverse reaction.” Same misconceptions happen in chemical bonding, environmental and hydrocarbon and other area of chemistry, because of teaching method not able to provide understanding in depth.

The school days are the foundation for further study and therefore vigorous methods and approaches for cultivation and promotion of Chemistry should be adopted. It is observed that the students performed poorly in questions testing understanding or application of knowledge to new situation and majority of students were unable to answer questions that appear to be different from what they typically encountered in their books.

The same is supported in the study by Umashree (1999), where in it was found that of classroom observation of 240 lessons in secondary science in 185 cases (77%) the lesson was introduced by simply writing the topic on the blackboard and recounting the previous days’ lesson. Eighty percentage of the classes observed revealed the fact that the students participated only as a passive listener. The student participation if any was limited to seeking clarification on the teaching point. The teachers also felt that when it comes to examination, the students are expected to reproduce some sections of scientific information contained in the textbook, and hence they did not see the essentiality of conducting discussion sessions or participatory sessions.

NCF (2005) comments that it is harsh reality that children's voices, their experiences hardly find place in the classroom. Often the voice heard is that of the teacher and even when students speak that is only to respond to the question raised by teacher or repeating teachers' words. Students are rarely given opportunities to do things nor do they have opportunities to take the initiative. Even Malhotra (2006) holds similar views stating that ‘Teachers often provide lecture and students largely observe the teacher rather than actively participating in the classroom.’Ravula (2013) also found that most of the secondary teachers of social science working in both private and government schools are focusing more on completing the syllabus in time by presenting the content to the learners rather than giving importance to the students in learning the concepts.

National Policy on Education (2016) committee also stated on Evaluation that The Indian examination system is based on rote memory; questions are asked from text books and students who are able to reproduce what is written in the text books manage to get high scores. The memory and recall are an integral part of any education system, but is strongly of the view that the focus of education should be more on understanding and the examination system should be geared to test understanding rather than regurgitating text-book script. Also recommendation on selection of students through an aptitude based examination is in order, the highly competitive system of examinations designed for elimination of candidates, rather than selection of candidates as it ought to be, has confused and complicated the system. Students have been caught in a web of coaching classes, which promises much, and often puts enormous pressure on the students – not so much in giving them knowledge or understanding, but focusing on shortcuts to crack the various examinations – the more prestigious the examination like NEET, IIT-JEE, etc., the more the pressure on the students.

National Science Teachers Association (NSTA) (1998) adopted its position statement, the National Science Education Standards (NSES): a vision for the improvement of science teaching and learning. In that statement, the NSTA strongly supports NSES by asserting teachers regardless of grade level should promote inquiry-based instruction and provide classroom environments and experiences that facilitate professional development activities should involve students' learning in science, Teachers in the learning science and pedagogy through inquiry, and inquiry should be viewed as an instructional outcome (knowing and doing) for students to achieve in addition to its use as a pedagogical approach. Instruction is the focus from the transmission curriculum to a transactional curriculum. In a traditional method, a teacher transmits information to students who passively listen and acquire facts. Traditional method has more chance for misconception. In a Constructivist strategy, students are actively involved in their learning to reach new understandings and its form applicable. Constructivist teaching fosters critical thinking and creates active and motivated learners. A constructivist approach can be used to create learners who are autonomous, inquisitive thinkers and investigators.

There is a great need for research into the dimensions of the instructional and nurturing effects of various types of instructional practices in chemistry education today. Competence in teaching stems from the capacity to reach out to differing Students and to create a rich and multi-dimensional environment for them. This demands that we widen our experience with different models of instruction in various classroom settings. Chemistry education researchers

also should make an attempt to know exactly what changes in knowledge occur as a result of instruction. Chemistry education research, thus, should direct its attention to improve the existing procedures of chemistry instruction and to establish new and verified procedures for teaching chemistry. Also, the reviewed studies revealed that the constructivist pedagogy provides opportunities for students to construct relevance of content by relating new learning to students' personal experience and prior knowledge. So, the investigator has decided to apply constructivist strategy to the teaching of chemistry subject.

1.5 Statement of the problem

A Study on Effectiveness of Constructivist Strategy on Achievement in Chemistry among Higher Secondary School Students

1.6 Objectives of the study

Through this study, the objectives keep in mind are:

1. To develop strategies based on constructivist learning for teaching of Chemistry in Standard XI.
2. To study the effectiveness of the strategies based on constructivist learning in Chemistry for Standard XI students in terms of their academic achievement.
3. To study the reaction of students to the strategy based on constructivist learning in Chemistry.

1.7 Hypothesis of the study

In pursuance of the objectives of the study following null hypotheses were formulated:

Ho1 There is no significant difference in Pre Achievement test mean scores of Experimental and Control Groups.

Ho2 There is no significant difference in chapter wise Achievements tests mean scores of Experimental and Control Groups.

Ho3 There is no significant difference in post-test Achievement mean scores of experimental and control groups.

Ho4 There is no significant relation in terms of previous standard (X) chemistry knowledge and standard XI Chemistry concepts of experimental and control groups.

1.8 Operationalisation and Explanation of the terms

Operationalization of the terms

- ***Social Constructivist Strategies (SCS):*** In this study Strategies of teaching chemistry which allow the student to construct their own knowledge while working in groups/individual and those which adopted Social constructivist principles, 5E model and constructivist approaches (Cooperative Learning, Collaborative Learning, Concept Mapping and Problem Solving) and instructional material, activity, etc. These strategies were used to facilitate investigator in terms of the learning of the students along with the lesson plan.

- ***Achievement in chemistry:*** Achievement in Chemistry in the present study were the total scores obtained by the students on item representing knowledge, understanding, application and skills in the Chemistry Achievement test constructed by the researcher.

Explanation of the terms

- ***Treatment:*** Treatment refers to the strategies of teaching which were adapted to teach Chemistry to the eleven standard students. The treatment will include teaching of Chemistry through Social Constructivist Strategies.

- ***Traditional Method of Teaching (TMT):*** Traditional method of teaching is teacher centered in which teacher imparts knowledge and students simply receive it. In this environment, information is taught to the class in the form of chalk and talk and lecture, making use of learning aids. After teaching there may or may not be the scope for interaction. More emphasis is given to rote memory of the content matter rather than the thinking process.

1.9 Delimitation of the study

The study has the following delimitation:

1. The present study was delimited to standard XI of Gujarati Medium Schools of Anand city affiliated to Gujarat Secondary and Higher Education Board.

2. The present study was delimited to academic achievement only in Chemistry of standard XI in Gujarati Medium School.
3. The present study was delimited to four Units in Chemistry textbook of Standard XI of the year 2019-2020. (i. e. *Unit: 4 Chemical Bonding and Molecular Structure, Unit: 7 equilibriums, Unit:13 hydrocarbon and Unit:14 Environmental chemistry*)

1.10 Outline of the present work

This research study contains all the aspects of research they are divided in five chapters, which gives the overall short view of the whole study in chapters.

Chapter 1 gives the brief detail on theoretical background of the research. It contains points are Concept of Learning and Teaching, Theories of Learning, Teaching Chemistry in higher secondary level, constructivist Learning, Constructivist approach, 5E Model.

Chapter 2 contains reviews which are related to this study. It is divided in seven parts. Introduction, Review of Related Research studies conducted in India, Review of Related Research studies conducted at International Level, Eminent Features of the Study and Summery.

Chapter 3 focuses on methodology of research. In which points (i.e. research method, research design, selection of research design, variables of the study, population and sample of the study, development of tools, constructivist strategy lesson plan, data collection, interpretation and analysis of the data) are included.

Chapter 4 This chapter discuss on Introduction, Data Analysis and Interpretation of Achievement tests (i.e. tests 1 – 6), Analysis of Students' reactions of Experimental group data in brief.

Chapter 5 This chapter discuss on Introduction, Summery of the study, major findings, discussion, implications of the study and recommendations for future research.