Chapter 1

Introduction

1.1 Introduction

The Report on Policies for Science Education "Science is a cumulative and endless series of empirical observations which result in the formation of concepts and theories. Both concepts and theories are subjected to modification in the light of further empirical observations. Science is both a body of knowledge and the process of acquiring and refining knowledge" The word 'science' comes from the Latin word 'scientia' which means knowledge or to know. Science is a systematized body of knowledge gained by human observation, experience and experimentation. Science is dynamic. It is knowledge as well as the process of its continuous development and refinement. Science is both a product as well as a process. It is an endless process of observation, exploration and acquisition. Science is now an everyday-science for everybody; its knowledge is no longer confined to the classes. It has to reach the masses. It is a broad subject covering a vast majority of topics related to life. There are different fields of science like, Biology, Chemistry, Physics, Earth science and many others. All the branches have their specializations and all the branches are interrelated. Chemistry is one of the branches of science. Chemistry deals with the composition, structure and properties of matter. Knowledge of chemistry has grown so vast that it is too divided into sub branches. Some of the branches are Organic chemistry, Analytical chemistry, Industrial chemistry, Polymer chemistry, Biochemistry, etc.

Chemistry is the science of matter, its properties, structure, composition and its changes during interactions and chemical reactions. In particular, chemistry studies interactions between atoms, and chemical bonds.

The different branches of Chemistry are depicted below.

Chemistry

- Analytical chemistry
- Biochemistry
- Computational chemistry
- Polymer chemistry
- Physical chemistry
- Quantum chemistry

- Electrochemistry
- Inorganic chemistry
- Materials science
- Organic chemistry
- Spectroscopy
- Stereochemistry
- Thermochemistry

The following section presents an overview to the research work, its focus and nature.

1.2 Statement of the Problem

A Study of the Problems Faced by Higher Secondary Students in Learning Chemistry

1.3 Explanation and Operationalisation of the Terms

The terms that are of prime importance to the study are opertaionalised. The researcher has explained the terms Higher Secondary Students and Chemistry. The term Problems has also been operationalised with reference to the present research work.

Higher Secondary Students: The students of Std XI and XII. In the present study, the students of Higher Secondary Science stream were selected.

Chemistry: Chemistry is a branch of Science. Chemistry is the integrated study of the preparation properties, structure and reaction of the chemical elements and their compounds and the systems which they form.

Problems: This refers to academic problems related to learning of chemistry i.e. the problems faced by students in comprehending the concepts in Chemistry both related to theory and practicals subject of grades XI and XII.

The research was carried out with the following objectives in mind.

1.4 Objectives of the Study

The objectives of the study are mentioned below.

1. To study the problems of the higher secondary science students in learning chemistry. (theory)
2. To identify the problems faced by the higher secondary science students in performing chemistry practical.
3. To find the measures adopted by the higher secondary science students to overcome the problems.

The researcher made attempts to find the answers to the following questions.

1.5 Research Questions

- What are the academic problems faced by the higher secondary students in learning chemistry?
- Which are the misconceptions in chemistry formed by the higher secondary students?
- How do the students overcome the academic problems?

1.6 Delimitation of the Study

The study is delimited to the academic problems of the higher secondary students of Charutar English Medium School, Anand.

1.7 Rationale of the Study

Chemistry is one of the major subjects taught at the Higher Secondary Schools. The students have to study a range of important concepts in Organic Chemistry, Inorganic Chemistry, Physical Chemistry and other branches too.

Many students have problems related to comprehending the complex concepts of Chemistry **(Ocholo, O., 1986 and Surti R.M.,1988).** The students find a range of topics like hydrocarbons, chemical reactions, redox reactions, nomenclature, elements and compounds, valiancy, bonding, etc. It is important to understand the problems that the students face during the teaching learning process at Std XI and

XII. It is due to the lack of conceptual understanding and the inability to comprehend the complex terms that a number of misconceptions and common errors are made by the students.

In addition, sometimes the teachers are not well equipped with the methodologies of teaching the subject. They are unable to use interactive and participatory methods to teach. This also makes Chemistry appear unappealing and difficult to students. This is a barrier in learning Chemistry.

These academic problems and an unfavorable attitude towards Chemistry further hinders the process of learning Chemistry and also leads to a negative attitude towards the subject. It is therefore important to address the problems faced by the students and also understand the same.

The researcher has made an attempt to study the academic problems of the Higher Secondary School Students of Charutar English Medium School.

The scheme of Chapterisation is depicted below.

1.8 Scheme of Chapterisation

Chapter 1

The present chapter focuses on the overview of the study, objectives and research questions of the study and significance of the study.

Chapter 2

Discusses the concepts related to the research and conceptual framework.

Chapter 3

Includes the review of related literature and its implications to the present study.

Chapter 4

Aims at listing the procedure of the study and its research methodology.

Chapter 5

Presents the data analysis and interpretation.

Chapter 6

This chapter findings the discussion, conclusion and suggestions of the study.

The following chapter presents the conceptual framework and includes the terms and concepts related to the study.

Chapter 2

Conceptual Framework

The present chapter presents a detailed description of all the terms and concepts that are of prime importance to the study.

2.1 Introduction to Science

Jawaharlal Nehru in one of his speeches said “Science does not simply sit down and pray for things to happen, but seeks to find why things happen. It experiments and tries again and again and sometimes fails and sometimes succeeds and so adds bit by bit to human knowledge. This modern world of ours is very different from the ancient world or the middle ages. This great difference is largely due to Science. My preference are all for science. The world is a narrower place now and there is little to discover in it. So it seems. But that is not so, for science has opened up tremendous new vistas which wait to be explored and of adventure there is no lack, especially in India today”.

The words by Pandit Nehru in the passage above depict the importance of science and its dynamic nature. The word ‘science’ comes from the Latin word ‘scientia’ which means knowledge or to know. Science is a systematized body of knowledge gained by human observation, experience and experimentation. According to modern thinking, the curiosity of man to know himself and his surroundings has led to an accumulation of a vast body of knowledge called ‘science’. Today science is an amalgamation of observation, identification and theoretical explanation of the phenomena that occur in nature. It helps us to understand the world around us and to appreciate and its complexities. Thus, science is all around us. Science is a process by which we try to understand the natural and physical world around us. Science implies a systematic study of the environment as well as many living and non-living entities that exits in it.

Science is the study of ideas and techniques at work in the progressive enfoldment of natural knowledge. According to William James, “New acts burst old rules and then newly divined conception bind old and new together into reconciling law” ‘Science like life flourishes on its own decay by discovering new facts, which

challenge productively its own once established rules. In this context, science is a great human enterprise, not only endless and faceless but also stable and fluid.

The nature of science can be understood from its definitions.

2.2 Definitions of Science

Science is an endless frontier. Some of the definitions of Science are mentioned below.

"Science is the most objective thing known to man. Science attempts to make chaotic diversity our sense experience which corresponds to logically uniform system of thought."

- Albert Einstein

"Science is a cumulative and endless series of empirical observation, which result in the formation of concepts and theories, with both concepts and theories being subject to modification in light of further empirical observation"

-Fitzpatrick

However, it is equally important to look beyond mere precise definition and see what science includes. The following aspects are of fundamental importance in the study of the subject.

→ Direct and indirect observation

→ Scientific inquiry- asking question

→Drawing inference from observation

→ Recording observation

→Developing ways and means to find answers

→ Classification and checking evidence

Based on the definitions of science we can say that, Science is a both a body of knowledge and the process of acquiring it. Thus, science is one of the activities that

human beings have created to address needs, interests and desires. It is a disciplined way of understanding existing knowledge as well as creating new knowledge.

Science is a very important part of life and can be found in almost everything. It is a way of passing knowledge from one generation to another. So, we can build our collective knowledge to solve more and more complex problems and thereby relate to our existence, happiness and productivity.

Science is a very broad subject covering majority of topics dealing with life as well as things us. If explains the process as well as significance of the phenomena around us. There are different branches of science. It is important for an individual to know them in order to understand their presence in day to day life. The following section represents the branches of Science.

2.3 Branches of Science

There are different branches of science. Each branch of science has detailed sub branches. These branches are interdependent and interrelated. The basic branches of science are Physics, Biology, Chemistry and Earth Sciences.

Brief descriptions of the branches are presented below.

Biology is the science which deals with the study of living organisms.

Chemistry is a branch of science which deals with the study of matter. The sub branches of chemistry are mentioned below.

• Analytical chemistry • Biochemistry • Electrochemistry • Inorganic chemistry • Materials science • Organic chemistry	• Polymer chemistry • Physical chemistry • Quantum chemistry • Spectroscopy • Stereochemistry • Thermo chemistry

Physics is a branch of science that studies matter and energy and its motion and interactions. The subfields of physics are depicted below.

Earth science is also known as geo science deals with study of the planet Earth. Its sub fields are indicated below.

The above discussion reveals that the Science is the most diverse subject. All the above mentioned branches of science are taught at their fundamental levels in schools in some way or the other. Chemistry is one of the branches of science and plays a central role in science.

2.4 Chemistry and its Branches

"Chemistry is the science of molecules and their transformation. It is the science not so much of the one element but of the infinite variety of molecules that may be built from them."

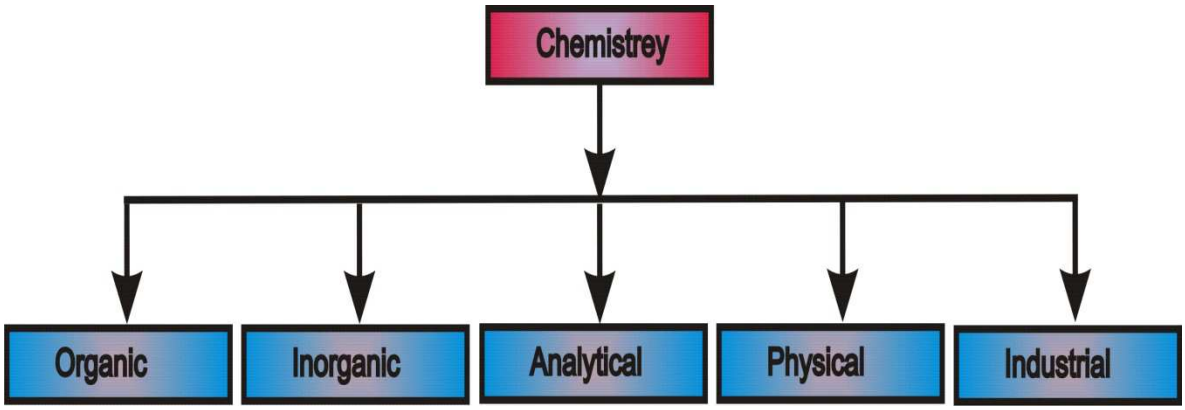
- Roald Hoffmann

Chemistry deals with the composition, structure and properties of matter. These aspects can be best described and understood in terms of basic constituents of matter: atom and molecules. Hence chemistry sometimes is called the science of atoms and molecules. Chemistry is a basic science whose central concerns are

- the structure of atoms (elements)
- the composition and properties of compounds
- the reactions between substances with their accompanying energy exchange.

Chemistry is a versatile subject. As the knowledge of chemistry has grown its division into different branches has become necessary. The main branches of chemistry are depicted in the figure 2 below.

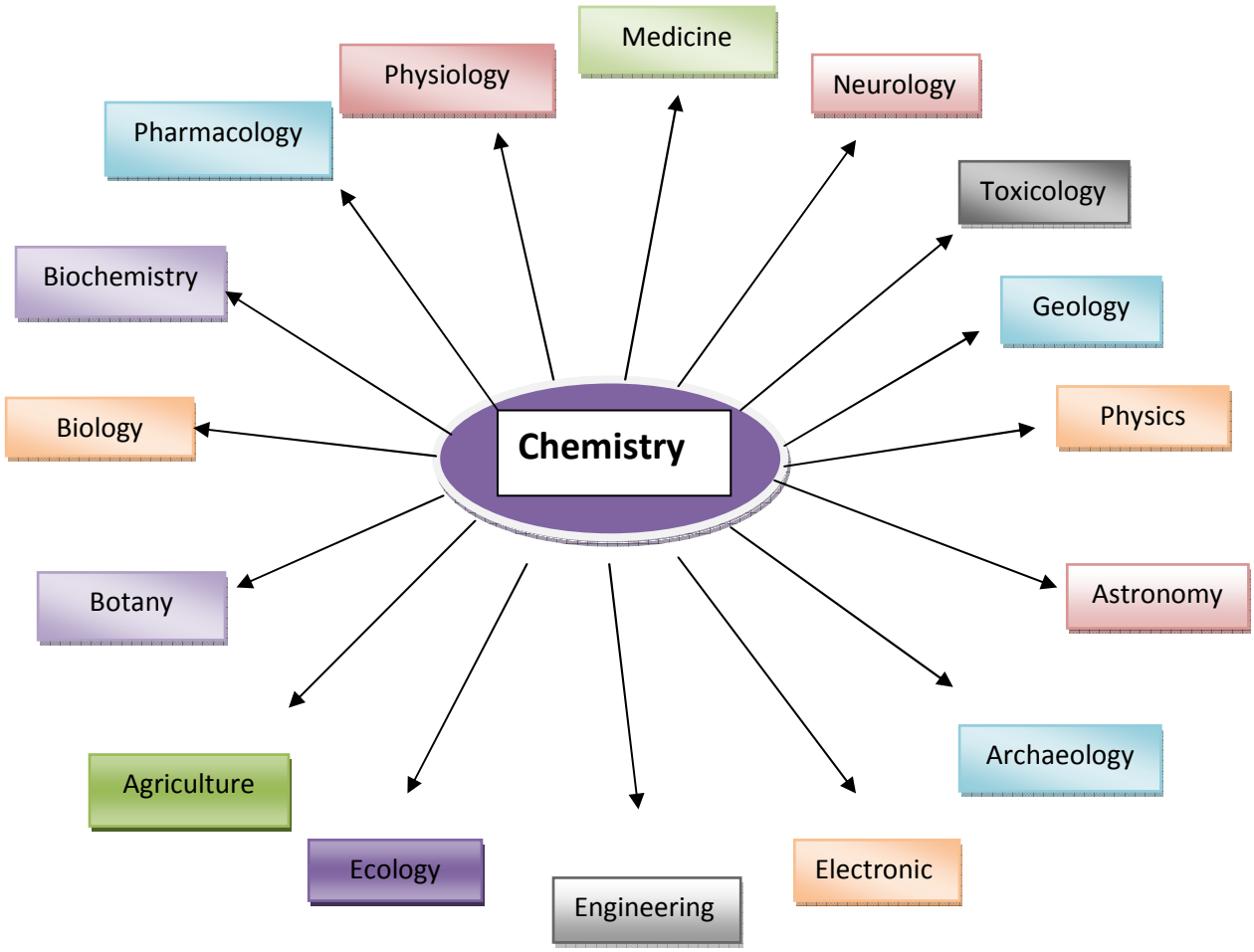
Figure 1: Branches of Chemistry



Chemistry cannot be isolated from the other branches of science as it deals with many kinds of matter which are studied in detail in other branches of sciences.

It plays central role in science and often interviewed with other branches of science. The same is depicted in the figure 2 below.

Figure 2: Chemistry as a central science



So, Chemistry is important in diverse areas. It is importance to many branches of science. Chemistry is all around us. It is the air we breathe, the food we eat, it is the science of our body. **Chemistry is thus one of the important subjects that the students learn throughout their schooling process. Chemistry is one of the subjects that the students need to learn at the higher second level. Moreover, the students learn important concepts related to day to day life. The focus of the present research is to find the difficulties that the learners have in learning chemistry.**

The following chapter focuses on the Review of Related Literature and its implications to the present study.

Chapter 3

Review of Related Literature

3.1 Introduction

The following sections present the reviews related to books and researches in science and chemistry in specific.

3.2 Review of Related Literature

A literature review is a body of text that aims to review the critical points of current knowledge including substantive findings as well as theoretical and methodological contributions to a particular topic. Its ultimate goal is to bring the reader up to date with current literature on a topic and forms the basis for another goal, such as future research that may be needed in the area. According to Gay "Review of related literature involve the systematic identification, location and analysis of document containing information related to the research problem". The review of related literature obtained through books and researches are presented below.

Bhattacharya (1979) conducted a critical study of science education in Assam & Meghalaya schools and found that all the teachers qualified to teach science taught other subjects as well. The economic condition of science teachers was poor private nations were most common. The schools had hardly any freedom for purchasing book, most of the schools did not subscribe to science journals. None of the school had a trained librarian.

Mehna (1986)studied the factors affecting academic achievement in science, the research finding imply that the pupils performance in science can be improved (1) If teachers succeed in generating a feeling of liking science among pupils.(2) If teachers develop aptitude for science among children by providing scientific information.(3) If teachers motivate children to learn science subjects. This needs adequate training for teachers in making science teaching interesting & in training them in the technique of arousing pupils' motivation for leasing science.

Ocholo, O. (1986) conducted a study of the perception regarding chemistry Teaching –learning process of Std IX Students of English medium school of Baroda. The objective were to Study the perceptions of students regarding teaching methods, chemistry curriculum and evaluation technique adopted in school to find the purpose with which the students opt for studying chemistry. A probability sampling-cluster sampling was used. Questionnaire and interview were used. It seemed that students were satisfied with regard to the teaching methods used by their teachers. However, the students did mention a range of difficulties in learning Chemistry.

Surti, R.M. (1988) made a study of the problems of higher secondary school teachers of Bharuch District. Objectives were to study the general opinion of teachers the higher secondary school of Bharuch District. To study the teacher problem of physical facilities for teaching various subjects such as science geography etc, in higher secondary schools of Bharuch district. Major findings were no objection was observed in implementation of the new patterns of education. Higher secondary school had to face many problems related to the text book, the teachers training and physical facilities for teaching.

Saxena S.P. (1988) studied sequential attainment of concept in chemistry through periodic table at secondary state. Objectives were to study the effects of concept based instructions using a control and experimental group design. It was found that the experimental group taught by discussion method and supplemented by reading material regarding the related concepts gave better result in term of their performance.

Greenwood, N.N. (1997) has written an innovative and successful text book Chemistry of the Elements (2nd Ed.) that presents a balanced coherent and comprehensive account of the chemistry of the elements for both undergraduate and postgraduate students. This crucial central area of chemistry is full of ingenious experiments, intriguing compounds and exciting new discoveries. All the contents of the periodic table are presented through experiments. Thus the periodic table and the properties of the elements can be taught by experiments and demonstrations

Khirwadkar,A. (1998) conducted a study on Development of Computer Software for Learning chemistry at Std IX. A Computer software simulation programme was

prepared and the materials were tried out. The finding revealed that the materials could be used effectively as some subject topics require much of an imagination for students. The objective were to develop CAL package in chemistry for std IX science stream students to study the effect of software package on students' achievement in relation to students'(1) Intelligence level (2)motivation level and (3) attitude towards the package. The software package was found effective in terms of academic achievement of students. It was also found that majority of students and chemistry teacher had positive attitude about the various aspect of software package.

Vishwakarma,R. (2001) studied the Problems of Chemistry Teachers in Higher secondary school of Vadodara. The objectives of the study were (1)To study the problems of higher secondary chemistry teachers.(2)To study the infrastructure problems and facilities available for teaching chemistry at higher secondary level. Sample consisted of 21 teachers working in higher secondary school of Vadodara (English and Gujarati medium). Purposive sampling technique was used. Questionnaire and interview schedule were used. Findings of the study revealed that chemistry teachers faced lot of problems like organizational problem, laboratory facilities, infrastructure, budget, and personal problem. Major findings of the study were (1)Most of the schools in the sample do not have adequate infrastructure facilities for the Laboratory (2)Academic problem: All the schools in the sample does not have adequate staff in lab.(3)36% of the teacher observe that curriculum of the higher secondary classes does not satisfied the needs of the pupils.(4)33.3% teacher thought that assignments given to students were not satisfactory.

John,O.O. (1996) studied the perception regarding Chemistry Teaching-Learning process of the Std XI Students of English medium school of Baroda. The objectives of the were to study the perception of the students regarding teaching method adopted in chemistry teaching, curriculum an valuation technique adopted in school. To examine reason presented by the students for attending tuition classes. Major finding of the studies were that teaching method being adopted was inadequate and inappropriate. However, large numbers of students were motivated in learning chemistry. Students were satisfied to some extent with the chemistry curriculum. Students studied chemistry with certain career perspectives in mind such as to be an Engineers, Doctor and chemist.

Begum (1990) conducted a study on problems of teaching new science syllabus for standard VII in Andhra Pradesh and their impact on pupils. The objectives of the study were (1) to examine the difficulty level and suitability level of all lessons and exercise included in the new science syllabus as perceived by science teachers. (2) To examine the problems involved in the implementation of the students activities suggested in the new science textbook and problem there in. (3) to examine the problem faced by teachers about the content and teaching method in the in-service training programme. (4) To study the nature of execution of the exercises faced by teachers within the context of content, teaching method, audio-visual aids, suggest the measures which would improve the quality of science teaching. The major findings of the study were (1) more than 60% of the teachers found the content in recent syllabus, now as well as over loaded. (2) Dictation of notes by teachers was dominating method of getting exercises done by the students. (3) Lack of facilities for science teaching conceived to bother teachers a lot. (4) It was observed that achievement in science favored significantly those students, whose teacher had attended an in-service programme. (5) it is proposed that school condition need to be improved through, say supply of science kits and hand-books for teaching-learning process by practicing processes of science such as classifying, inquiring and experimenting.

Ekpoj (1991) studied chemistry laboratory, safety skill and practice students education in selected secondary school in AKWA, Ibom state. Objectives of the study were to assess the chemistry laboratory safety skill by students and to assess the chemistry laboratory safety practices adopted by students. It was found that more than 70% students failed to protect their eye, face, hands, and their body too. They did not wear apron and gloves while engaged in chemical experimentation. They had poor knowledge about identified emergency facilities and equipment's, study revealed evidence of poor experimental technique.

Sood,J.K. (2005) has mentioned about objectives of teaching science and place of science in school curriculum. He says the direction and objective of science teaching have undergone many changes after the World War II. Science for all has become slogan all over the world. NPE (1986) and National Curriculum framework for school education 2005 have included science in school curriculum as a core subject. Science is an integral part of learning both at primary and secondary level. Knowledge of

science and technology as a part of general education will provide basic knowledge and skill.

3.3 Implications of the above reviews to the present study

From the above review of books and researches it is evident that science is an important subject and is an important part of the curriculum at all levels. Moreover, the review of related literature from books suggested a range of teaching learning methodologies used to teach science. The review indicates that students face a number of problems in learning Chemistry. These problems are related to textbooks, practical work, lack of clarity of previous concepts, etc. The review of related helped the researcher decided the objectives, tools and data analysis techniques for the study. The next chapter focuses on the Research Planning and Procedure. The details of the research methodology are indicated in the subsequent sections.

Chapter 4

Research Planning and Procedure

4.1 Introduction

This chapter contains research design, research type, population, sampling technique, tools description, data collection process and an over view of the data analysis techniques. It gives a clear idea of the study conducted by the researcher and the process of the research endeavor.

4.2 Research Design and Nature of the Study

The present research was a Survey. Attempts were made by the researcher to prepare a questionnaire for students keeping in mind the concepts taught in Chemistry at the Higher Secondary Schools i.e. Std XI and XII. The focus was to find the difficulties faced by the Std XI and XII students in learning Chemistry. The study is both qualitative and quantitative in nature.

The details are further mentioned below.

4.3 Population

The population of the present study constituted all the students of Std. XI and XII science stream of English medium school of Anand city following the Gujarat Secondary and Higher Secondary Board Syllabus.

4.4 Sample and Sampling Procedure

The sample of the study comprised of 119 students studying in the Higher Secondary Section (Std XI and XII) of Charutar English Medium School, Anand. In addition, two teachers of Chemistry were also a part of the sample.

The sample was drawn using convenient sampling technique.

The data was collected using the following tools.

4.5 Tools

The researcher constructed a questionnaire for the students of Std XI and XII. The questionnaire contained a series of questions related to the problems faced by students in learning Chemistry and also related to the topics in the Chemistry Textbook of Std XI and XII. The questionnaire was shown to experts and modifications were made to incorporate the suggestions given by the experts

The researcher constructed an unstructured interview schedule for teachers of Chemistry, Charutar English Medium School, Anand.

4.6 Data Collection, Analysis and Interpretation Procedure

The detailed description about the process of data collection is mentioned clearly stage wise.

Stage 1: Researcher constructed a questionnaire for Higher Secondary School Students of Std XI and XII. The questionnaire was shown to experts and modifications were made to incorporate the suggestions given by the experts.

Stage 2: Researcher administered the questionnaire and collected the data from Std XI and XII students.

Stage 3: Researcher interacted informally with the two Chemistry Teachers of Charutar English Medium Schools and made attempts to find the problems of the students in learning Chemistry. The researcher made attempts to find and record the observations of teachers vis-à-vis problems of students in learning chemistry both theory and practical.

Stage 4: Data Analysis and Interpretation

Data Analysis sand Interpretation was done using content analysis.

Stage 5: Documentation of the research work

The subsequent chapter focuses on data analysis and interpretation.

Chapter 5

Data Analysis and Interpretation of Data

The present chapter devotes itself to data analysis and interpretation of the data collected. The data analysis and interpretation is below.

5.1 Data Analysis and Interpretation of the data collected from the Std XI students by using a questionnaire

A questionnaire was used to find the problems of students in learning Chemistry. The question wise analysis is presented below.

Table No: 5.1 Data Analysis and Interpretation of the data collected from the Std XI students by using a questionnaire

Questions	**Responses of students (Problems in topics/ concepts of Chemistry)**
1. Which topics in chemistry do you find difficult? List the topics and also mention the reasons for the same.	90% of the students found organic chemistry difficult. This was mainly because they could not differentiate between the nomenclature and structures of the compounds. The students also had difficulties in writing the names of the organic structures, writing IUPAC nomenclatures and identifying different organic compounds. 45% students had difficulty in comprehending the core concepts of Thermodynamics. 50% students mentioned that they could not understand the grouping of elements and also were confused with the s,p,d,f block elements. The chapter that was found most difficult by students was classification of elements wherein the central focus was the Periodic Table of

	Elements. 60% students indicated that they could not balance reactions and did not understand the concepts mentioned in the chapter Redox Reactions. The students did not state any concrete reasons for the above difficulties.
2. What are the common problems that you face while studying Chemistry (Theory)?	35% students said that they could not remember the chemical equations and balance them. 50% students mentioned that they did not face any problems. They could read and comprehend the concepts on the basis of the lectures / classes that they attended in schools and classes. 15% stated that the language used in the text book was too technical and they had problems in comprehending the concepts.
3. What problems do you face while performing chemistry experiments in the laboratory?	80% of the students said that they did not have any problems in the laboratory. 20% of the students depicted the following difficulties. - Difficulty in availability of the apparatus. - Difficulty in the availability of the chemicals. - Attitude of the laboratory incharge with respect to the breakage and usage of apparatus in the laboratory. - Difficulty in arranging the apparatus for practicals.

4. How do you solve your conceptual / theoretical / content based difficulties related to chemistry?	90% of the students said that they read the text books to understand the concepts and even crammed some of the concepts. In some cases, they consulted the coaching class teacher or the class teacher.
5. How do you overcome the problems faced by you while performing experiments in the chemistry laboratory?	80% students said that they did not have any problems related to the practical work related to content. 20% of the students expressed they had few difficulties with respect to the experiments but as and when they repeated the experiments and interacted with the teachers and friend they could manage to successfully perform the experiment.
6. What are the activities that you and your classmates normally do during the chemistry theory sessions? (What activities do you do in the class?)	All the students mentioned that they were engaged in the following activities. • Discussion of the difficult concepts • Peer teaching in informal manner • Practice problems given in the text book • Attend sessions at schools and coaching classes • Make notes as well as read them
7. Do you like Chemistry? Why?	70 % of the students said that they liked Chemistry. The reasons for the same were mentioned by just 10% students. The students said that they like chemistry because they enjoyed learning it and working in the chemistry laboratories. 10% students did not respond to the question. 20% students expressed disliking towards the subject. They mentioned that they studied the same because it

	was a compulsory subject.
8. Any other comments/ observations that you would like to make with respect to the problems faced by you in learning Chemistry.	No response was obtained.

From the above table it is evident that students were involved in a number of activities related to both theory and practical of Chemistry. But these activities only focused on the development of the lower order thinking skills of students. The data collected does not reveal any challenges or exploration tasks or projects in Chemistry. Students learnt Chemistry through discussions, sharing of notes, attending sessions and performed practical work related to the syllabus. Some students said that they studied the subject because it was compulsory while a majority said that they enjoyed learning chemistry.

Students did not express any major problems in the laboratory. 80% of the students said that they did not have any problems in the laboratory. 20% of the students expressed they had few difficulties with respect to the experiments but as and when they repeated the experiments and interacted with the teachers and friend they could manage to successfully perform the experiment.

The problems that a few students faced in the laboratory were related to the physical aspects of the laboratory like setting the apparatus, issue the apparatus, chemicals and equipments, etc. Some students also complained about the behavior of the teacher and laboratory assistant during the practical by stating that the teacher did punish them.

The students had some difficulties with respect to the topics in the std XI syllabus. They were mainly related to Organic and Inorganic Chemistry. 90% of the

students found organic chemistry difficult. This was mainly because they could not differentiate between the nomenclature and structures of the compounds.

The students also had difficulties in writing the names of the organic structures, writing IUPAC nomenclatures and identifying different organic compounds.45% students had difficulty in comprehending the core concepts of Thermodynamics. 50% students mentioned that they could not understand the grouping of elements and also were confused with the s,p,d,f block elements. The chapter that was found most difficult by students was classification of elements wherein the central focus was the Periodic Table of Elements.

60% students indicated that they could not balance reactions and did not understand the concepts mentioned in the chapter Redox Reactions. 35% students said that they could not remember the chemical equations and balance them. 50% students mentioned that they did not face any problems. They could read and comprehend the concepts on the basis of the lectures / classes that they attended in schools and classes. 15% stated that the language used in the text book was too technical and they had problems in comprehending the concepts.

A large majority of the students 90% said that they could overcome the above difficulties by reading the text books to understand the concepts and some even crammed the concepts and consulted the coaching class teacher or the school class teacher.

The data analysis and interpretation of the data gathered through the std XII students are depicted below.

5.2 Data Analysis and Interpretation of the data collected from the Std XII students by using a questionnaire

Table No: 5.2 Data Analysis and Interpretation of the data collected from the Std XII students by using a questionnaire

The response obtained from Students are analyzed depicted below

Questions	**Responses of students (Problems in topics/ concepts of Chemistry)**
1. Which topics in chemistry do you find difficult? List the topics and also mention the reasons for the same.	20% of the students found expressed that they found the Chapter on Solid State difficult. 25% students had difficulty in comprehending the core concepts of the chapter on electrochemistry and redox reactions. 40% students mentioned that they could not understand the grouping of elements and also were confused with the s,p,d,f block elements. 60% students indicated that they could not balance reactions and did not understand the concepts related to Organic Chemistry. 60% students also found the chapters Aldehydes and Ketones very difficult to understand and study. 20% students stated that they could not comprehend equilibrium and principles related to it. Some students (approximately 20%) expressed difficulties in the chapters and concepts relate to polymers, alcohols, hydrogen, chemical kinetics,

	phenol and ethanol, geometrical isomers. A large majority of the students expressed the above difficulties. Only 15% students said that they did not have any difficulties at all. They could read, discuss and clear their doubts.
2. What are the common problems that you face while studying Chemistry (Theory)?	The students stated the following problems. 40% students said that they could not remember the reactions completely. Students also mentioned the difficult areas namely oxidation reduction reactions, IUPAC nomenclature , Aldehydes and Ketones, periodic table and hydrocarbons. 30% students mentioned that they could not understand the numerical related to physical chemistry and had difficulties in solving the problems. 30% students mentioned that they did not find Chemistry interesting and therefore studied it for examination purpose only. 10% students said that the course was too lengthy and semester duration was too short. Students also complained about the lack of coordination between the teaching of theory and practical and lack of linkages between the two.
3. What problems do you face while performing chemistry experiments	90% students said that they do not have any problems in the laboratory and are able to perform most of the practical work /experiment with the help of the

in the laboratory?	teacher and pair work in the laboratory. Some minor difficulties that were indicated were managing the issue and maintenance of the apparatus and instruments, identifying some chemicals (in cases when they were not labeled) and lack of accurate and precise results. One of the students also mentioned that s/he was unable to concentrate in the laboratory because the laboratory classes were mostly noisy. Some students said that they could not use the apparatus like the burette, pipette , etc properly and so could not obtain proper results.
4. How do you solve your conceptual / theoretical / content based difficulties related to chemistry?	80% of the students said that they read the text books to understand the concepts, crammed some of the concepts. In some cases (approximately 25%) the students said that they consulted their notes or the previous year's notes. The students also discussed their doubts with their teachers. Some of the students mentioned that they could understand the text books and concepts related to the various topics in Chemistry because they simultaneous attended coaching classes for competitive exams. During these classes some of their doubts were clarified. 10% of the students expressed that they just cram the content and manage to clear the examinations.
5. How do you overcome the problems faced by you while performing experiments in the chemistry laboratory?	80% students said that they did not have any problems related to the practical work related to content. If they have problems they get it clarified from their laboratory in-charge or teacher. 10% of the students expressed they had few difficulties with respect to the handling the apparatus

	during the experiments. These students said that they try to repeat the experiments till they get accurate or acceptable results.
6. What are the activities that you and your classmates normally do during the chemistry theory sessions? (What activities do you do in the class?)	All the students mentioned that they were engaged in the following activities. • Discussion of the difficult concepts • Peer teaching in informal manner • Practice problems given in the text book • Attend sessions at schools and coaching classes • Make notes as well as read them • Read previous year notes • Refer to the likely questions and question papers • Write the reactions and definitions repeatedly inorder to remember the same.
7. Do you like Chemistry? Why?	75 % of the students said that they liked Chemistry. The reasons for the same were mentioned by just 10% students. The students said that they like chemistry because they enjoyed learning it and working in the chemistry laboratories. 20% students said that they like organic chemistry. 25% students expressed disliking towards the subject. They mentioned that they studied the same because it was a compulsory subject.
8. Any other comments/ observations that you would like to make with respect to the problems faced by you in learning Chemistry.	20% students said that the course was lengthy 70% students did not respond to the question. Some of the students said that they found it difficult to manage the theory, practical work and other activities /classes.

From the above table it is evident that the students did face a number of difficulties in learning Chemistry. These were mainly related to Organic, Inorganic and Physical Chemistry. The students indicated a range of topics that were complex. 20% of the students found expressed that they found the Chapter on Solid State difficult.

25% students had difficulty in comprehending the core concepts of the chapter on electrochemistry and redox reactions. 40% students mentioned that they could not understand the grouping of elements and also were confused with the s,p,d,f block elements. 60% students indicated that they could not balance reactions and did not understand the concepts related to Organic Chemistry. 60% students also found the chapters Aldehydes and Ketones very difficult to understand and study. 20% students stated that they could not comprehend equilibrium and principles related to it. Some students (approximately 20%) expressed difficulties in the chapters and concepts relate to polymers, alcohols, hydrogen, chemical kinetics, phenol and ethanol, geometrical isomers. 30% students mentioned that they could not understand the numerical related to physical chemistry and had difficulties in solving the problems. Thus a large majority of the students expressed the above difficulties. Only 15% students said that they did not have any difficulties at all. They could read, discuss and clear their doubts. **This does indicate that the students have a number of questions with respect to the core concepts in Chemistry at Std XII.**

In addition, 30% students mentioned that they did not find Chemistry interesting and therefore studied it for examination purpose only.

90% students said that they do not have any problems in the laboratory and are able to perform most of the practical work /experiment with the help of the teacher and collaboratively with their peers in the laboratory.

Some minor difficulties that were indicated were managing the issue and maintenance of the apparatus and instruments, identifying some chemicals (in cases when they were not labeled) and lack of accurate and precise results. One of the students also mentioned that s/he was unable to concentrate in the laboratory because the laboratory classes were mostly noisy. Some students said that they could not use the apparatus like the burette, pipette , etc properly. Students complained of air gaps, contact of chemicals and allergy, etc. 10% students strongly expressed that they had a

few difficulties with respect to the handling the apparatus during the experiments. These students said that they try to repeat the experiments till they get accurate or acceptable results.

This indicates that the students need training and guidance in handling the apparatus in the laboratory. Students face problems in using the simple apparatus like a burette and a pipette.

However, 80% students said that they did not have any problems related to the practical work pertaining to the comprehension of the content. If they had problems they got it clarified from their laboratory in-charge or teacher.

All the students mentioned that they leant Chemistry by reading, attending sessions, discussing difficult concepts with peers and at times with teachers. Some of the students practiced problems and numerical consistently to master the numerical and also referred to previous year note and question papers to score better in the exams.

75 % of the students said that they liked Chemistry. The reasons for the same were mentioned by just 10% students. The students said that they like chemistry because they enjoyed learning it and working in the chemistry laboratories. 20% students said that they like organic chemistry.

25% students expressed disliking towards the subject. They mentioned that they studied the same because it was a compulsory subject. In addition, 20% students said that the course was lengthy. Some of the students also found it difficult to manage the theory classes, practical work and other activities /classes

The data analysis and interpretation of the data gathered through the Chemistry teachers are depicted below.

5.3 Data Analysis and Interpretation of the data collected from the teachers by using an unstructured interview schedule

Data was gathered through informal interaction and an unstructured interview schedule from the Chemistry teachers. The following questions were asked to the teachers to get an overview of the problems of students.

Table No: 5.3 Data Analysis and Interpretation of the data collected from the teachers by using an unstructured interview schedule

Questions	**Responses of teachers (Problems in topics/ concepts of Chemistry)**
Which are the concepts /topics in Chemistry that students find difficult?	The topics that the students find difficult were redox reactions, thermodynamics, chemical kinetics, hydrocarbons, and elements of s, p, d, f blocks and periodic tables.
Which are the common errors that the students make?	The teachers did not mention any common errors but said that students made errors in following concepts. The students get confused with the concepts of elements and compounds, balancing equations and hydrocarbons.
How do the students overcome the problems that they have in the topics related to Chemistry?	The students discuss with the teachers as well as friends. Some students get their doubts clarified in the tuition classes. Students cram the formulae and descriptions. Students refer to the previous year notes and likely questions as well as question papers.
Do you conduct any remedial teaching session?	No remedial teaching sessions are conducted but the doubts of students are clarified as and when they approach the teachers. Sometimes the question papers are discussed in the class.
What are the problems that	Students do not follow instructions.

students face in the laboratory?	Students manipulate the results. Students sometimes do not complete their work and copy the practical from other journals. Students face problems in handing apparatus.

Thus from the above table it is evident that the students face problems in both theory and practical work. The most difficult topics were redox reactions, thermodynamics, chemical kinetics, hydrocarbons, and elements of s, p, d, f blocks and periodic tables. The teachers did not mention any common errors but said that students made errors in following concepts. The students got confused with the concepts of elements and compounds, balancing equations and hydrocarbons.

Moreover, no remedial sessions were conducted but informally students were helped to overcome their problems vis-à-vis the difficulties I chemistry. Students faced a number of problems in the laboratory. The problems were related to handling apparatus and completing practical work.

The teachers expressed that they found it difficult to handle and monitor students' performance in the laboratory. This was mainly because they worked in pairs and tend to talk more often.

5.4 Conclusion

Through the data analysis and interpretation in the present chapter a number of findings and conclusion can be drawn. The data analysis reveals that students have problems in learning chemistry. The following chapter presents the findings and conclusion of the study.

Chapter 6

Suggestions, Implication and Conclusion

6.1 Introduction

This Chapter includes conclusion, suggestion and implication of the study. The chapter presents the outcomes of the study and also scope for future researches.

6.2 Discussion

Chemistry is one of the basic branches of Science and it needs to be taught as well as learnt through a number of interactive methods. The core concepts of Chemistry form the basis of higher studies in the subject. The interaction with teachers and students revealed that the students had problems in learning a number of topics related to organic, inorganic and physical chemistry. Moreover, the students solved their problems through discussion, reading and referring to various materials. These are ways to find temporary solutions to the conceptual difficulties and also make the students as well as teachers more exam oriented.

One of the major problems that the students as well as teachers indicated was of practical work in Chemistry. Some students of std XI expressed that they had difficulties with the availability of the apparatus and chemicals. Another problem that was indicated was with respect to the behavior and attitude of the laboratory incharge (during some situations like problem of breakage and need for guidance to use of apparatus in the laboratory). Thus students had difficulty in arranging the apparatus for practical and using them.

The students of std XII also expressed that had difficulties in managing the issue and maintenance of the apparatus and instruments, identifying chemicals (in cases when they were not labeled) and also could not obtain accurate and precise results. Some students said that they could not use the apparatus like the burette, pipette, etc properly. Students complained of air gaps, contact of chemicals and allergy, etc. In addition, students strongly expressed that they had a few difficulties

with respect to the handling the apparatus during the experiments and they had to repeat the experiments in order to get accurate or acceptable results.

The teachers also mentioned that students did not follow instructions, manipulated the results, did not complete their work and copied the practical from other journals. In addition, problems related to handling apparatus and using them was also indicated by the teachers.

This indicates that the students need training and guidance in handling the apparatus in the laboratory. Moreover, the teachers too need to think of alternative ways of providing proper guidance to the student's in order to ensure smooth and effective functioning of the laboratory.

The students of Std XI and XII had difficulties in theory. The Std XI students expressed the following difficulties. 60% students indicated that they could not balance reactions and did not understand the concepts mentioned in the chapter Redox Reactions. 35% students said that they could not remember the chemical equations and balance them. 50% students mentioned that they did not face any problems. They could read and comprehend the concepts on the basis of the lectures / classes that they attended in schools and classes. 15% stated that the language used in the text book was too technical and they had problems in comprehending the concepts. In Std XII, 25% students had difficulty in comprehending the core concepts of the chapter on electrochemistry and redox reactions. 40% students mentioned that they could not understand the grouping of elements and also were confused with the s,p,d,f block elements. 60% students indicated that they could not balance reactions and did not understand the concepts related to Organic Chemistry. 60% students also found the chapters Aldehydes and Ketones very difficult to understand and study. 20% students stated that they could not comprehend equilibrium and principles related to it. Some students (approximately 20%) expressed difficulties in the chapters and concepts relate to polymers, alcohols, hydrogen, chemical kinetics, phenol and ethanol, geometrical isomers. 30% students mentioned that they could not understand the numerical related to physical chemistry and had difficulties in solving the problems. Thus a large majority of the students expressed the above difficulties. Only 15% students said that they did not have any difficulties at all.

The teachers on the other hand did not conduct any remedial teaching sessions. However, they did help the students through informal ways.

From the above discussion it is evident that the students faced difficulties in learning Chemistry. Moreover, they need input in laboratory usage and also need practice in doing the experiments. The relationship between theory and practical is also missing. Some students do not follow the link between the two. This has made cramming more popular among the students and study is more exam specific rather than content mastery oriented.

The findings of the study are depicted below.

6.3 Findings

The findings of the study are depicted below objective wise.

Objectives	Findings
Objective 1 To study the problems of the higher secondary science students in learning chemistry (theory).	**Std XI students** 90% of the students found organic chemistry difficult. This was mainly because they could not differentiate between the nomenclature and structures of the compounds. The students also had difficulties in writing the names of the organic structures, writing IUPAC nomenclatures and identifying different organic compounds. 45% students had difficulty in comprehending the core concepts of Thermodynamics. 50% students could not understand the grouping of elements and also were confused with the s,p,d,f block elements. The chapter that was found most difficult by students was classification of elements wherein the central focus was the Periodic Table of Elements.60% students indicated that they could not balance reactions and did not understand the concepts mentioned in the chapter Redox Reactions. **Std XII students** 20% of the students found expressed that they found the

	Chapter on Solid State difficult. 25% students had difficulty in comprehending the core concepts of the chapter on electrochemistry and redox reactions. 40% students mentioned that they could not understand the grouping of elements and also were confused with the s,p,d,f block elements. 60% students indicated that they could not balance reactions and did not understand the concepts related to Organic Chemistry. 60% students also found the chapters Aldehydes and Ketones very difficult to understand and study. 20% students stated that they could not comprehend equilibrium and principles related to it. Some students expressed difficulties in the chapters and concepts relate to polymers, alcohols, hydrogen, chemical kinetics, phenol and ethanol, geometrical isomers.
Objective 2 To identify the problems faced by the higher secondary science students in performing chemistry practical.	Std XI students expressed that they had difficulties with the availability of the apparatus and chemicals, handling apparatus and performing practical experiments. The students of std XII expressed that they had difficulties in the issue and maintenance of the apparatus and instruments, identifying chemicals (in cases when they were not labeled), handling apparatus and could not obtain accurate and precise results.
Objective 3 To find the measures adopted by the higher secondary science students to overcome the problems	Both the Std XI and XII students would discuss the problems with their peers and teachers. Students also clarified their doubts in coaching classes. They referred to previous year notes and papers. Cramming was a common technique used to remember the content.

Thus the overall findings of the research are depicted below.

1. Students faced difficulties in numerous topics namely electrochemistry and redox reactions, s,p,d,f block elements, concepts related to organic chemistry, Aldehydes and Ketones , chemical reactions, hydrocarbons and chemical kinetics.
2. Students faced problems in handling apparatus, organizing the experimental setup, issuing and maintaining the apparatus.
3. Students find it challenging to obtain accurate results. This was mainly because they could not use the instruments and apparatus skillfully.
4. Managing students in the laboratory and monitoring students' learning was a challenge for the teachers.
5. Some students performed practical work- experiments without understanding the concepts and the purpose cum relevance of the experiment. Students even copied the experiments and results without actually performing the practical.
6. Students were not trained to use the laboratory instruments and apparatus nor were they aware of the do and don'ts in the laboratory.
7. Students' attitude towards learning Chemistry was exam oriented and not mastery or skill oriented.
8. Learning did not seem to be a challenging task for the students.
9. Students crammed most of the definitions, descriptions, experiments, formulae and even reactions.
10. Almost all students had problems in balancing equations and writing IUPAC nomenclature (names).

The major findings of the study are indicated above. The study lead to valuable suggestions and also has generated ideas as well as prospects for future researches. The same are indicated below.

6.4 Suggestions and Scope for Future Research

The following are the suggestions that can be made based on the finding of the study.

- Teachers of Chemistry have to be selective in identifying the objectives of the experiment and link theory with practical in the laboratory.
- Teachers need to explain the basic concepts related to the experiment and then instruct the students to do practical. This will enable the learners to link theory with experiments. Moreover, use of interactive teaching techniques in the laboratory will enable students to pay attention and comprehend the difficult concepts related to Chemistry.
- Some exploration tasks can be given to student's inorder to generate their curiosity and sustain their interest in learning Chemistry.
- Students need to be involved in interactive learning process and materials can be developed for the teaching the difficult and complex topics in an effective manner.
- Combining laboratory instructions with technology aided instructions can further make the lab sessions more learner-oriented and individualized.
- Ongoing and continuous evaluation needs to be seriously implemented at grade XI and XII in schools.

The scope for future studies is depicted below.

- Experimental studies that focus on material production and testing its effectiveness can be undertaken.
- A similar study can be carried out with a larger sample.
- Materials production and tryout of Laboratory Programmes can be undertaken to develop laboratory management skills among students.

  In addition the following studies can also be carried out.
- Development of Computer Software to Teach Chemistry at Std.XI.
- A study of the Problems of Learners in Higher Secondary Schools in Gujarat State.
- Diagnosis and Remediation of the Learning Difficulties of Std.IX students in Periodic Table of Elements

- Comparative Study of Traditional Methods and Technology Based Methods in Teaching o Periodic Table.

The implications of the study are presented below.

6.5 Implications of the study and Conclusion

Chemistry is one of the most important subjects taught in schools. It enables the students to understand the world around them. The study has highlighted a number of problems in learning Chemistry.

Students of the Higher Secondary Section face problems in organic chemistry and topics related to the periodic table. This indicates that a number of materials need to be developed and provided to students, so that, it leads to effective learning. The study also brings out the fact that Chemistry needs to be learnt in an interactive manner.

In addition, practices needs to be linked to the theory to ensure wholestic learning approach to chemistry. The study has indicated that students need more précised clear instruction in the laboratory.

It can be concluded that the present study was a fruitful endeavor and helped the researcher understand the problems of the students at the higher secondary level. The study will help the researchers and teachers be sensitive to the problems of the students and work out ways to encourage students to learn Chemistry and use it constructively in day to day life.

Bibliography

Bhattacharya M. (1989) Bhattacharya M. (1989) A critical review of work done on the use of computer as an instructional tool for teaching chemistry. M.Phil., Edu., Delhi : University of Delhi.

Mehna (1986) Studies in Science Education in school by Rajashree Mohanty.

Ocholo,Opiyo,J (1986) A study on Perception regarding Chemistry teaching – learning process of Std.IX students of English Medium Schools of Baroda.

Surti, R.M (1988) A study of the problem of higher secondary school teacher of Bharuch District.

Sexena, S.P. (1988) Sequential attainment of concept in chemistry through periodic table at the secondary stage. Independent study, Bhopal : Regional collage of education.

Greenwood, N.N (1997) Chemistry of the Elements (2^{nd} Ed) School of Chemistry University of Leeds. UK

Khirwadkar, A. (1998) Compute Assisted Instruction (CAI). UGC-JRF, Center of Advanced Study in Education, M.S. University of Baroda. India

Vishwakarma,R.(2001). A study of the Problems of Chemistry Teachers in Higher Secondary Schools of Vadodara.

John, O.O. (1996) A study of the perception regarding chemistry teaching learning process of the standard XI student of English medium schools of Baroda city, unpublished M.Ed., Dissertation. Baroda : M.S. University of Baroda.

Begum (1990) A study on problems of teaching new science syllabus for standard VII in Andhra Pradesh and their impact on pupils.

Epko. J. (1991) Chemistry laboratory safety skill and practices : Student's self evaluation in selected secondary school in AKWA, Ibom state , India education review, vol. 26 (2) :107-15.

Sood, J.K (2005). Teaching of Science .Agra: Rakesh Graphic Printers

Textbook of Science Std. IX (GSEB) and Std. IX (CBSE)

Textbook of Chemistry Std. XI (CBSE) and Std. XI (NCERT)

Webliography

1. http://allperiodictables.com/ClientPages/AAEpages/aaeTeachInquiry.html
2. http://answers.ask.com/Science/Chemistry/why_is_the_periodic_table_important
3. http://wiki.answers.com/Q/Why_is_the_periodic_table_so_important
4. http://www.biologylessons.sdsu.edu/ta/classes/lab2/TG.html
5. http://www.chemicalelements.com/
6. http://chemistry.about.com/library/blperiodictable.htm
7. http://chemistry.about.com/od/k12gradelessons/a/periodictable.htm
8. http://www.ehow.com/info_12067525_periodic-table-lesson-plans-8th-grade.html#ixzz1nMKrI1Cu
9. http://www.ehow.com/about_5417280_importance-periodic-table.html
10. http://en.wikipedia.org/wiki/Periodic_tab
11. http://ezinearticles.com/?How-to-Memorize-Using-the-Association-Technique&id=1850027
12. http://www.flatworldknowledge.com/pub/basics-general-organic-and-bio/421592#
13. http://www.flatworldknowledge.com/pub/basics-general-organic-and-bio/421592#
14. www.icca-at-dubai.org/dbfiles/WHAT-IS-CHEMISTRY.pdf

(15) http://www.pbs.org/wgbh/nova/teachers/activities/3114_origins.html

15. http://www.todayinsci.com/M/Mendeleev_Dmitry/MendeleevDmitry-Quotations.htm
16. http://www.webelements.com

Appendix 1

Questionnaire for

Higher Secondary Students

Appendix 1

Questionnaire for Higher Secondary Students

- **Read the following questions and answer in the space provided.**

1. **Which topics in chemistry do you find difficult? List the topics and also mention the reasons for the same.**

2. **What are the common problems that you face while studying Chemistry (Theory)?**

3. **What problems do you face while performing chemistry experiments in the laboratory?**

4. **How do you solve your conceptual / theoretical / content based difficulties related to chemistry?**

5. **How do you overcome the problems faced by you while performing experiments in the chemistry laboratory?**

6. **What are the activities that you and your classmates normally do during the chemistry theory sessions? (What activities do you do in the class?)**

7. **Do you like Chemistry? Why?**

8. **Any other comments/ observations that you would like to make with respect to the problems faced by you in learning Chemistry.**

Appendix 2

Unstructured Interview Schedule

For Teachers

Appendix 2

Unstructured Interview Schedule for Teachers

- **Questions**

1. Which are the concepts /topics in Chemistry that students find difficult?

2. Which are the common errors that the students make?

3. How do the students overcome the problems that they have in the topics related to Chemistry?

4. Do you conduct any remedial teaching session?

5. What the problems that students face in the laboratory?