A Comparative and Analytic Study of Senior Secondary School Chemistry Curricula of India and Abroad

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Abstract— The present new age learning of today's world is characterized by the ever increasing demands and expectations posed by the society on our education system. The scientific and technological revolution and knowledge explosion have great bearing on how our children make choices while selecting the subject stream at specialized level and how their parents and other influencing stakeholders pose on them to take up a particular subject group specially in senior secondary grades. If we look into the schooling processes closely, we find that despite all booms in other subject disciplines like chartered accountancy, management and other subject areas, science stream has still not lost its lustre. This paper presents a comparative analysis of the structural nuances of chemistry curriculum at senior secondary school levels in India and a few developed countries of the world. The paper delineates various programmes of science teaching and chemistry teaching specifically that have been conceptualized and implemented across some of the most advanced countries of the world in different periods of time. The purpose of juxtaposing the curricula of different countries is to have a comparative perspective in the context of senior secondary school chemistry curriculum. This may develop further insight into exploring various dimensions of curriculum in the comparative mode and bring out some useful and meaningful ingredients for future research in the area of science education and pedagogy of chemistry.

Key words: Chemistry Curricula

I. INTRODUCTION

The scientific and technological revolution and knowledge explosion have great bearing on how our children make choices while selecting the subject stream at specialized level and how their parents and other influencing stakeholders pose on them to take up a particular subject group specially in senior secondary grades.The +2 level or the senior secondary level of school system is the most crucial stage of school education because at this juncture specialized discipline based content-oriented courses are introduced. The +2 level implies 11^{th} and 12^{th} grades of schooling after passing 10^{th} grade or secondary school examinations. Students reach this stage after 10 years of general school education and opt for Chemistry with a purpose of pursuing their career in basic sciences or professional courses like medicine, engineering, technology and study courses in applied areas of science and technology at tertiary level. Therefore, there is a need to provide learners with sufficient conceptual background of Chemistry, which will make them competent to meet the challenges of academic and professional courses after the higher secondary stage.

In the past couple of decades, a great deal of teaching material has been brought into India from abroad and has been introduced in various schools, colleges and universities. However, this has not been used extensively due to various reasons. Therefore, while looking into the existing senior secondary level chemistry curriculum in India, it would be apt to situate it in the international context and have a look at some of the major curriculum development projects undertaken abroad and prevailing senior secondary chemistry curriculum of a few select countries, in order to have a better articulation of the strengths and weaknesses of our curriculum and thus outlining what ought to be done to enrich it further.

II. SCIENCE CURRICULAR PROJECTS IN INDIA AND ABROAD

The period after 1960 has seen a lot of curricular innovations across the countries. New courses were first produced in the United States of America and United Kingdom. This was followed by a worldwide spate of curriculum innovation activity. The early curriculum projects were initiated in response to educational and national needs of the respective countries. In the United States, Chemical Bond Approach (CBA) and Chemical Education Material Study (CHEM Study) were the forerunners, while in the United Kingdom, Nuffield 0-level and A-Level Chemistry projects were the first chemistry projects to have been initiated. These projects made a significant impact in their countries of origin, and also influenced the course of curriculum development in many other countries (Ingle & Ranaweera, 1984).

In these projects, due emphasis was placed on experimental aspect of chemistry. Laboratory-based inquiry teaching gained attention, giving students an awareness of the applications of chemistry in every-day life and in industry through a study of such topics as fibres, plastics, elastomers, detergents, drugs and insecticides. The following section describes some of the prominent senior secondary level chemistry curriculum projects undertaken at international level and the existing curricula in various countries.

III. CHEMICAL EDUCATION MATERIAL STUDY (CHEM STUDY)

The CHEM Study project started in USA in year 1960. The many applications of chemistry in everyday life and in industry led to the widespread concern in the USA that chemistry education at school level placed undue reliance on the acquisition of facts for their own sake, and was out of touch with modern developments in chemistry (Mohan, R. 2007). The CHEM study attempted to update chemistry in the light of latest developments in the subject, to organize content in unifying concepts and principles, to provide opportunities for laboratory work not only to supplement the theoretical knowledge but also to facilitate students in exercising scientific and critical modes of thinking, and to make students aware of the applications of chemistry in everyday life and in industry.

The study materials included textbooks, teachers' manuals, tests and films. Besides, some additional supplementary experiments and films were also suggested. The advantages of the CHEM study course were that it attempted to rectify the drawbacks of the traditional chemistry by updating the content in the light of new discoveries and by giving students opportunities for first-hand experience in the laboratory. It led to improvements in laboratory facilities and quality of in-service training of teachers. The present day senior secondary chemistry curriculum draws the most from the CHEM Study project's recommendations.

IV. CHEMICAL BOND APPROACH (CBA)

This project started in year 1959 in Eariham College, Richmond. Laurence Strong was the founder of this project. The CBA project focused curricular innovation for 16-18 years age-group of students. The practical part of chemistry was considered as vital for the fruitful transaction of chemistry. The initial materials consisted of 18 chapters of texts and 20 experiments. These were tested by use in 9 high schools in U.S.A. during 1959-60. Later it was revised in 1960-61 to be used in 75 high schools throughout the country. The actual adoption of this approach in the United States was limited, but it had a considerable influence in other countries.

V. THE NUFFIELD ADVANCED CHEMISTRY PROJECT (U.K.)

The Nuffield Advanced Chemistry Project (for senior secondary level students) began in October 1965 in the United Kingdom, following the completion of the Nuffield 0-level Chemistry Project for secondary level students.

The Project was set up to produce a teaching scheme, and an appropriate method of assessment, for schools entering candidates for the Advanced (A) Level Examination for the General Certificate of Education (GCE), which is normally taken at age 18, at the end of a two-year 'sixth-form' course. The course has a greater factual content, and every fact was assigned a purpose in the general development of the subject. The practical work had an integral part to play in the scheme; students were exposed to a much wider range of experimental techniques in chemistry.

VI. THE IPST CHEMISTRY CURRICULUM PROJECT, THAILAND

In Thailand, the Institute for the Promotion of Teaching Science and Technology (IPST) framed a new chemistry curriculum for grades 11 and 12, in 1960-66, keeping in mind the country's needs. The broad aims of the science course were to develop an understanding of the basic principles and theories of science; an understanding of the nature, scope and limitations of science; a scientific attitude; skills important for scientific investigation; and an understanding of the effects of science on the environment (Mohan, R. 2007). The chemistry course integrated text and laboratory manual in an effort to encourage teachers to teach chemistry as a learner-centred inquiry involving both theory and practice.

Besides the above, some locally based influential curriculum development took place in parts of North America and some European countries as well as in other parts of the world. All these had substantial impact on chemistry teaching in their respective countries. Yet, with the rapid pace of knowledge explosion, and fast scientific and technological development, the curricular reforms have also an everlasting significance.

VII. THE INDIAN CONTEXT

The problem of curriculum load was felt in India for the first time in 1975 soon after the introduction of the new curriculum under the 10+ 2 pattern of education. The NCERT set up a working group in 1983 to make a quick appraisal of the curriculum load. The Working Group submitted the report titled Curriculum Load at the School Level: A Quick Appraisal. The NCERT came up with the National Curriculum Framework in 2005 citing major recommendations for the school curriculum to be adopted.
The National Council of Education Research and Training (NCERT) has developed core syllabi in Science and Mathematics at the higher secondary level with an idea of providing a level-playing field to all students to join professional courses. As per the information from the Ministry of Human Resource Development, Govt. of India, 21 educational boards had earlier agreed to adopt a core curriculum in science and mathematics at secondary level following a consensus arrived on this issue at the Central Advisory Board of Education (CABE) meet in August 2009 to bring uniformity in these streams. In the meet, the CABE had emphasized the need for all states to modify their curriculum, syllabi and textbooks on the basis of National Curriculum Framework – 2005 (Indian Express, 2011). Accordingly, NCERT has developed core syllabi in Biology, Physics, Chemistry and Mathematics at higher secondary stage in collaboration with Council of Boards of Secondary Education and CBSE.

VIII. CHEMISTRY CURRICULUM AND ITS OBJECTIVES AT +2 LEVEL IN SOME SELECT COUNTRIES

The following section describes content, structure and objectives of some international chemistry curricula at senior secondary level.

IX. CAMBRIDGE INTERNATIONAL A & AS LEVEL CHEMISTRY

University of Cambridge International Examinations (CIE) is the world's largest provider of international qualifications and one of the most prominent examination system. The syllabus of Cambridge International A & AS Level Chemistry has been constructed with a compulsory Advanced Subsidiary core along with 'the Applications of Chemistry', and 'Practice of Experimental Skills'. The examinations are conducted for five papers. Out of the five, three papers are theory papers, ant the two papers are meant for chemistry experimental skills assessment.

In the assessment scheme, there is a greater weighting (54%) for skills (30 % for handling, applying and evaluating information, and 24 % for experimental and investigative skills) than for knowledge with understanding (46%). (UCIE, 2009).

The subject content has been organised under (i) Physical Chemistry, (ii) Inorganic Chemistry, and (iii) Organic Chemistry. Physical Chemistry has units namely Atoms, molecules and stoichiometry; Atomic Structure,

Chemical Bonding, States of Matter, Chemical energetics, Electrochemistry, Equilibria, and, Reaction Kinetics. Inorganic Chemistry has the following teaching units: The periodic table – chemical periodicity, group II, IV & VII elements, chemistry of transition elements & Nitrogen and sulphur. Organic chemistry contains Introductory topics such as structural formulae, displayed formulae, skeletal formulae and optical isomers; Hydrocarbons, Halogen derivatives, Hydroxy compounds, Carbonyl compounds, Carboxylic acids and derivatives, Nitrogen compounds, and, Polymerisation.

Practice of experimental skills: Candidates are required to be directed towards the practice of experimental skills throughout the whole period of their course of study. Candidates' experimental skills are tested separately. The practical examination tests the skills of manipulation of apparatus, presentation of data, analysis and evaluation.

A. Applications of Chemistry

This section of the syllabus is designed to allow candidates to use the chemical knowledge gained in the core syllabus to explore key areas of modern chemical science. It focuses on the applications of chemistry in research, industry and everyday life, and raises awareness of the associated ethical issues. The teaching of this section incorporates practical work. 'Applications of Chemistry' has three parts, all of which are compulsory: (i) The chemistry of life, (ii) Applications of analytical chemistry, and (iii) Design and materials.

B. Objectives

The objectives of the Cambridge International A & AS Level Chemistry have been outlined as the following: (i) to enable them to acquire sufficient understanding and knowledge to: (a) become confident citizens in a technological world, able to take or develop an informed interest in scientific matters; (b) recognise the usefulness, and limitations, of scientific method and to appreciate its applicability in other disciplines and in everyday life; (c) be suitably prepared for employment and/or further studies beyond A level; (ii) to develop abilities and skills that: (a) are relevant to the study and practice of science, (b) are useful in everyday life, (c) encourage efficient and safe practice, (d) encourage the presentation of information and ideas appropriate for different audiences and purposes, (e) develop self motivation and the ability to work in a sustained fashion; (iii) to develop attitudes relevant to science such as accuracy and precision, objectivity, integrity, enquiry, initiative, and insight; (iv) to stimulate interest in, and care for, the environment; (v) to promote an awareness about co-operative and cumulative activities of science; social, economic, technological, ethical and cultural influences on science; beneficial and detrimental effect of applications of science; (vi) to stimulate students, create and sustain their interest in Chemistry, and understand its relevance to society.

X. K-12 CHEMISTRY CURRICULUM IN THE USA

In United States of America, each of the fifty states has their own curriculum. So is the case for the chemistry curriculum at K-12 level (equivalent to +2 level in India). However, the focus on conceptual understanding in the core courses of different states is consistent with the approaches recommended in the National Science Education Standard and Benchmarks for Science Literacy. An analysis of the K-12 chemistry core curriculum of New York State is given below.

The core chemistry curriculum consists of Teaching Units having Key Ideas and against each key idea, major understandings are explicitly stated. The listed major understandings have a related skill and/or real-world connection to a specific content focus area. The 'Key ideas' in the teaching units are broad, unifying, general statements of what students need to know. The performance indicators for each key idea form the set of goals and assessment objectives. The curriculum also specifies laboratory settings and requirements in much detail. Laboratory curriculum is not framed in isolation; rather, it is integrated in core curriculum. Experiments are put in consonance with the major understanding of the key ideas of each unit as 'skills' to be mastered.

The K-12 chemistry core curriculum is an elaboration of the science content and its key ideas and performance indicators. The teaching units of the K-12 chemistry core curriculum are (i) Atomic Concepts, (ii) Periodic Table, (iii) Moles / Stoichiometry, (iv) Chemical Bonding, (v) Physical Behaviour of Matter, (vi) Kinetics and Equilibrium, (vii) Organic Chemistry, (viii) Oxidation-Reduction, (ix) Acids, Bases, and Salts, and (x) Nuclear Chemistry.

The Chemistry Core Curriculum for K-12 grade (equivalent to +2 levels of Indian system) presents major understandings that give more specific detail to the concepts underlying the performance indicators in Standard 4. In addition, portions of Standards 1, 2, 6, and 7 have been elaborated to highlight skills necessary to allow students to evaluate proposed explanations of natural phenomena (Harding, et al. 2006).

A. Objectives Of The K-12 Chemistry Curriculum (New York, Usa)

Objectives of K-12 chemistry curriculum in different states of USA have been outlined in their own specific ways. However, general objectives as well as the assessment objectives are consistent with the specified national standards. The New York state curriculum document has much elaborated list of objectives, having been categorized under specified standards for K-12 curriculum. The general objectives of the New York state chemistry core curriculum are outlined as the following:

Standard 1 (Analysis, Inquiry, and Design): Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seeks answers, and develops solutions.

Standard 2 (Information Systems): Students will access, generate, process, and transfer information using appropriate technologies.

Standard 6 (Interconnectedness: Common Themes): Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.

Standard 7 (Interdisciplinary Problem Solving): Students will apply the knowledge and thinking skills of

mathematics, science, and technology to address real-life problems and make informed decisions.

Standard 4 (The Physical Setting): Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

XI. The Ontario Chemistry Curriculum Grades 11 and 12 (Canada)

In Canada, all provinces have their own specific curriculum. However, every province ensures that their curricula are consistent with the Common Framework of Science Learning Outcomes, K to 12: Pan-Canadian Protocol for Collaboration on School Curriculum. The goal of Ontario secondary schools is to support high-quality learning while giving individual students the opportunity to choose programs that suit their skills and interests. One such noticeable and rich curriculum document is of Ontario province, which is being referred here.

'The Ontario Curriculum, Grades 11 and 12: Science, 2008' outlines three major goals of the secondary science program. These are: (i) to relate science to technology, society, and the environment, (ii) to develop the skills, strategies, and habits of mind required for scientific inquiry, and (iii) to understand the basic concepts of science. Every course in the secondary science program focuses on these three goals. The goals are reflected within each strand (topic or broad areas) of every course in the three overall expectations, which in turn are developed in corresponding sets of related specific expectations. The same three goals also underlie assessment of student achievement in science (MoE, Ontario, 2008).

A. Structure and Content of the Ontario Curriculum

Four types of courses are offered in the Grade 11 and 12 science program: university preparation, university/college preparation, college preparation, and workplace preparation courses. Students choose between course types on the basis of their interests, achievement, and postsecondary goals.

The science courses are organized in six distinct but related strands. The first strand (strand A) focuses on scientific investigation and experimental skills, which are similar for all courses; the remaining five strands (strands B through F) represent the major content areas for each course. The following table 1 presents the strands of Grades 11 and 12 Chemistry curriculum.

Grades 11 and 12 – Strands						
Course	Strand A	Strand B	Strand C	Strand D	Strand E	Strand F
Chemistry Grade 11, University (SCH 3U)	Skills of Scientific Investigation (Inquiry and Research)	Matter, Chemical Trends, and Chemical Bonding	Chemical Reactions	Quantities in Chemical Reactions	Solutions and Solubility	Gases and Atmospheric Chemistry
Chemistry Grade 12, University (SCH 4U)	Skills of Scientific Investigation (Inquiry and Research)	Organic Chemistry	Structure and Properties of Matter	Energy Changes and Rates of Reactions	Chemical Systems and Equilibrium	Electrochemistry
Chemistry Grade 12, College (SCH 4C)	Skills of Scientific Investigation (Inquiry and Research)	Matter and Qualitative Analysis	Organic Chemistry	Electrochemistry	Chemical Calculations	Chemistry in the Environment

Table 1: The Ontario Chemistry Curriculum Grades 11 And 12 (Canada)

B. Objectives of the Ontario Chemistry Curriculum

The general objectives of the Ontario curriculum, as derived from the overview part of the curriculum document, may be outlined as the following: To enable students to deepen their understanding of chemistry through the study of the properties of chemicals and chemical bonds; chemical reactions and quantitative relationships in those reactions; solutions and solubility; and atmospheric chemistry and the behaviour of gases; To develop analytical skills and investigate the qualitative and quantitative properties of matter; To investigate the impact of some common chemical reactions on society and the environment; To enable students to deepen their understanding of chemistry through the study of organic chemistry, the structure and properties of matter, energy changes and rates of reaction, equilibrium in chemical systems, and electrochemistry; To develop problem-solving and investigation skills to investigate chemical processes; To enable to communicate scientific information; To enable students appreciate the importance of chemistry in everyday life; To help students evaluate the impact of chemical technology on the environment.

XII. The New Zealand Senior Secondary Chemistry Curriculum

The senior secondary school chemistry curriculum of New Zealand has coined 'Key Concepts' in chemistry to build the chemistry content for the students of level 6, 7 and 8 or of school year 11, 12 and 13. These key concepts are the big ideas and understandings that are expected to be internalized by the students and remain with them, even long after they have left school (MoE, New Zealand, 2010).

The following are key concepts / big ideas in chemistry: (i) All matter is made of particles: The fundamental particle from which all matter is made is the atom. There are approximately 115 different atoms which form the building blocks of the molecular and ionic structures that make up all the known substances; (ii) The properties of materials derive from the identity and

arrangement of particles: Atoms come together to form bonds during chemical reactions. The properties of the resulting materials depend on which atoms are combined and the way they are arranged; (iii) Energy plays a key role in determining the changes that matter can undergo: Energy changes occur during physical and chemical transformations as the bonds between atoms or molecules are broken and new bonds are formed. Since energy can be neither created nor destroyed, energy will determine the changes that matter can undergo; and (iv) Chemistry is everywhere: Chemical transformations maintain the world around us. Most natural processes are based on chemistry and can be understood at a molecular level. For example, the chemical reactions occurring in cells will determine their structure and function and ultimately the nature of the organism to which it belongs.

A. Objectives of the New Zealand Chemistry Curriculum

The general objectives of the New Zealand chemistry curriculum are termed as overall achievement aims and are stated as: 'students develop understandings of the composition and properties of matter, the changes it undergoes, and the energy involved. They use their understanding of the fundamental properties of chemistry to make sense of the world around them. They learn to interpret their observations by considering the properties and behaviour of atoms, molecules, and ions. They learn to communicate their understandings, using the symbols and conventions of chemistry.

XIII. Senior Secondary Chemistry Curriculum in Australia

All the six states of Australia and two major mainland territories have their own specific science (chemistry) curriculum based on the guidelines of the Australian Curriculum, Assessment and Reporting Authority (ACARA).

The ACARA organises year 11 and 12 science curriculum around three interrelated strands or main ideas: science understanding; science inquiry skills; and science as a human endeavour (ACARA, 2009). The following section refers to the Western Australian Chemistry Curriculum at senior secondary level for analysis.

A. Structure and Content of the Curriculum

The course content, in the Western Australian Senior Secondary Chemistry Curriculum, is the focus of the learning program. It enables students to maximise their achievement of both the overarching learning outcomes from the Curriculum Framework and the Chemistry course outcomes. The course content is divided into seven areas: (i) macroscopic properties of matter; (ii) atomic structure and bonding; (iii) chemical reactions; (iv) acids and bases in aqueous solutions; (v) oxidation and reduction; (vi) organic chemistry; and (vii) applied chemistry.

The content areas have been divided between the A units and the B units. The A units include topics such as macroscopic properties of matter and atomic structure and bonding. The B units include such topics as acids, bases and organic chemistry, and the application of many of the concepts from the A units. The focus areas of these units are termed as: Chemistry and me; chemistry in my community; chemistry in and around the home; chemistry and the environment; chemical processes; chemistry and modern lifestyles. Practical skills are integrated aptly in these units to provide students a well-connected understanding of chemical processes in life and its importance.

B. Objectives of the Australian Chemistry Curriculum

The general objectives of the Australian curriculum are stated as the following: The Chemistry course equips students with a knowledge and understanding of chemistry to enable them to appreciate the natural and built environment, its materials, and interactions between them. The course helps students to predict chemical effects, recognise hazards and make informed, balanced decisions about chemical use and sustainable resource management. This enables students to confidently and responsibly use the range of materials and substances available to them.

XIV. Hong Kong Chemistry Curriculum and Assessment Guide

The Chemistry Curriculum and Assessment Guide (secondary level 4 – 6) of Hong Kong is one of the most meticulously prepared curriculum documents. This curriculum sets out specific guidelines for the three year senior secondary school level of Hong Kong schools. The curriculum framework for Chemistry embodies the key knowledge, skills, values and attitudes that students are to develop at senior secondary level. It forms the basis on which schools and teachers plan their school-based curriculum and design appropriate learning, teaching and assessment activities (HKEAA, 2007).

A. Curriculum Structure and Organization

The curriculum consists of 12 compulsory parts, 3 elective parts and an Investigative study in Chemistry. The topics of the Chemistry Curriculum are as the following:

Compulsory Part: (i) Planet earth; (ii) Microscopic world; (iii) Metals; (iv) Acids and bases; (v) Fossil fuels and carbon compounds; (vi) Microscopic world; (vii) Redox reactions, chemical cells and electrolysis; (viii) Chemical reactions and energy; (ix) Rate of reaction; (x) Chemical equilibrium; (xi) Chemistry of carbon compounds; and (xii) Patterns in the chemical world.

CORE		AHL		Options SL and HL	
Topic No.	Name of the Topic	Topic No.	Name of the Topic	Options	Options SL and HL
1	Quantitative chemistry	12	Atomic structure	A	Modern analytical chemistry
2	Atomic structure	13	Periodicity	B	Human biochemistry
3	Periodicity	14	Chemical Bonding	C	Chemistry in industry and technology
4	Bonding	15	Energetics	D	Medicines and drugs
5	Energetics	16	Kinetics	E	Environmental chemistry

6	Kinetics	17	Equilibrium	F	Food chemistry
7	Equilibrium	18	Acids and bases	G	Further organic chemistry
8	Acids and bases	19	Oxidation and reduction		
9	Oxidation and reduction	20	Organic chemistry		
10	Organic chemistry				
11	Measurement & data processing				

Table 2: The Ib Diploma Chemistry Courses

Elective Part (any 2 out of 3): (xiii) Industrial chemistry; (xiv) Materials chemistry; (xv) Analytical chemistry.

There are five major parts in each of the topics I to XV: (i) 'Overview', which outlines the main theme of the topic; (ii) 'What students should learn and should be able to' − lists learning objectives; (iii) 'Suggested Learning and Teaching Activities'; (iv) 'Values and Attitudes' − suggests some desirable values and attitudes that can be related to particular topics; (v) 'STSE Connections' − suggests interconnections between science, technology, society and the environment.

B. Objectives of the Hong Kong Chemistry Curriculum

The overall objectives of the curriculum are outlined as 'to enable students to: develop interest and maintain a sense of wonder and curiosity about chemistry; construct and apply knowledge of chemistry, and appreciate the relationship between chemistry and other disciplines; appreciate and understand the evolutionary nature of science; develop skills for making scientific inquiries; develop the ability to think scientifically, critically and creatively, and solve problems individually and collaboratively in chemistry-related contexts; discuss science-related issues using the language of chemistry; make informed decisions and judgments on chemistry-related issues; develop open-mindedness, objectivity and pro-activeness; show appropriate awareness of working safely; understand and evaluate the social, ethical, economic, environmental and technological implications of chemistry, and develop an attitude of responsible citizenship.

XV. THE INTERNATIONAL BACCALAUREATE DIPLOMA CHEMISTRY CURRICULUM

The Diploma Programme chemistry course includes the essential principles of the subject but also, allows teachers some flexibility to tailor the course to meet the needs of their students. The course is available at both standard level (SL) and higher level (HL), and therefore accommodates students who wish to study science in higher education and those who do not (IBO, 2007).

A. Content and Structure

The syllabus for the Diploma Programme chemistry course is divided into three parts: the core, the AHL (Additional Higher Level) material and the options. Students at SL are required to study any two options from A – G. Students at HL are required to study any two options from A – G. The Practical part (including investigation) of chemistry course has been assigned 25 percent weighting and the theory part – 75 percent of weighting. The syllabus detail is presented in the following table

B. Objectives of the IB chemistry curriculum

The objectives of the IB Diploma chemistry curriculum have been outlined as the following: It is the intention of the curriculum that students achieve the following objectives. (i) Demonstrate an understanding of: (a) scientific facts and concepts, (b) scientific methods and techniques, (c) scientific terminology, (d) methods of presenting scientific information; (ii) Apply and use: (a) scientific facts and concepts, (b) scientific methods and techniques, (c) scientific terminology to communicate effectively, (d) appropriate methods to present scientific information; (iii) Construct, analyze and evaluate: (a) hypotheses, research questions and predictions, (b) scientific methods and techniques, (c) scientific explanations; (iv) Demonstrate the personal skills of cooperation, perseverance and responsibility appropriate for effective scientific investigation and problem solving; (v) Demonstrate the manipulative skills necessary to carry out scientific investigations with precision and safety.

XVI. THE CBSE CHEMISTRY CURRICULUM AT +2 LEVELS IN INDIA

The existing CBSE (Central Board of Secondary Education) chemistry curriculum in India is broadly based on the National Curriculum Framework (2005) of NCERT. The theory component has been assigned 70 percent weighting and, 30 percent weighting has been given to the practical components. The course content of class XI chemistry has been divided into 14 units and the same has been assigned a total of 70 marks out of 100 marks examination system for the chemistry paper. The theory course has been prescribed to be covered in 178 periods of classroom teaching. The chemistry practical syllabus for class XI is supposed to be transacted in a total of 70 periods (60 periods for laboratory experiments and 10 periods for scientific projects). Similarly, the course content of class XII has been divided into 16 units, to be taught in 180 periods of classroom teaching and practical syllabus is supposed to be completed in a total of 68 periods (58 periods for laboratory experiments and 10 periods for scientific projects). The marks weighting in the external examination system has been outlined as the same as that of class XI.

The Practical part of the CBSE curriculum includes Volumetric Analysis, Salt Analysis, a few Content based experiments, and Investigatory Projects. The content of theoretical components of the CBSE senior secondary chemistry curriculum is given in the following table 1.3.

Class XI (Theory)		Class XII (Theory)	
Units	Topics	Units	Topics
I	Some Basic Concepts of Chemistry	I	Solid State

II	Structure of Atom	II	Solutions
III	Classification of Elements and Periodicity in Properties	III	Electrochemistry
IV	Chemical Bonding and Molecular Structure	IV	Chemical Kinetics
V	States of Matter: Gases and Liquids	V	Surface Chemistry
VI	Thermodynamics	VI	General Principles and Processes of Isolation of Elements
VII	Equilibrium	VII	p-Block Elements
VIII	Redox Reactions	VIII	d- and f- Block Elements
IX	Hydrogen	IX	Coordination Compounds
X	s-Block Elements	X	Haloalkanes and Haloarenes
XI	Some p-Block Elements	XI	Alcohols, Phenols and Ethers
XII	Organic Chemistry: Some basic Principles and Techniques	XII	Aldehydes, Ketones and Carboxylic Acids
XIII	Hydrocarbons	XIII	Organic Compounds containing Nitrogen
XIV	Environmental Chemistry	XIV	Biomolecules
		XV	Polymers
		XVI	Chemistry in Everyday Life

Table 3: Cbse Senior Secondary (+2 Level) Chemistry Course Structure

The following table 4 presents the detail of practical components of CBSE chemistry syllabus for class XI and XII.

Class XI (Practicals)		Class XII (Practicals)	
Units	Units / Topics	Units	Name of the Units / Topics
A	Basic Laboratory Techniques	C	Thermochemistry related Experiments
B	Characterization and Purification of Chemical Substances	D	Electrochemistry related Experiments
C	Experiments based on pH	E	Chromatography related Experiments
D	Chemical Equilibrium based Experiments	F	Preparation of Inorganic Compounds
E	Quantitative Estimation	G	Preparation of Organic Compounds
F	Qualitative analysis: Determination of one anion and one cation in a given salt	H	Tests for the functional groups present in organic compounds
G	Extra Elements – nitrogen, sulphur, chlorine, bromine and iodine in an organic compound	I	Characteristic tests of carbohydrates, fats and proteins in pure samples and their detection in given food stuffs
H	Investigatory Project	J	Titration of KMnO4 solution against a standard solution of: i) Oxalic acid, ii) Ferrous ammonium sulphate
Class XII (Practicals)		K	Qualitative analysis: Determination of one cation and one anion in a given salt
Units	Name of the Units / Topics	L	Investigatory Project
A	Surface Chemistry related experiments		
B	Chemical Kinetics related experiments		

Table 4: CBSE Senior Secondary (+2 Level) Chemistry Practical Course

A. Objectives of CBSE Chemistry Curriculum at +2 Level

The broad objectives of teaching Chemistry at Senior Secondary Stage are as the following (CBSE 2011): to promote understanding of basic facts and concepts in chemistry while retaining the excitement of chemistry; to make students capable of studying chemistry in academic and professional courses (such as medicine, engineering, technology) at tertiary level; to expose the students to various emerging new areas of chemistry and apprise them with their relevance in their future studies and their application in various spheres of chemical sciences and technology; to equip students to face various changes related to health, nutrition, environment, population, weather, industries and agriculture; to develop problem solving skills in students; to expose the students to different processes used in industries and their technological applications; to apprise students with interface of chemistry with other disciplines of science such as physics, biology, geology, engineering etc.; to acquaint students with different aspects of chemistry used in daily life; and to develop an interest in students to study chemistry as a discipline.

XVII. Discussion

The comparative structural details and description of chemistry curricula as presented above has some considerable contours to look at. The specificity of the chemistry curricula of the developed countries details the very nature of chemistry in daily use or chemistry in everyday life. These courses have been conceptualized in a manner so as to give students a practical exposure of the subject in terms of their usability and importance in human life – that too in everyday life. Practical components in the chemistry curricula of these countries have been attributed more importance and seemed to be connected to the theoretical contents of the subject. The chemistry curriculum in India needs to follow the same path and be more

practical, useful and must have a logically strong link between theory and experimental components of the syllabus.

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