Chapter – I

Introduction
# CHAPTER – I
## INTRODUCTION

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INTRODUCTION

Education could be seen as wings for the progress of the human being. It helps the individual to attain intellectual, physical and spiritual or emotional progress. In some ways, it helps the individual to live a happier life. For people without education, living comfortably turns difficult, especially in the modern world where specific skills are often needed to work. Besides, education is real wealth. Understanding how the world around us functions produces happiness, a kind of happiness that does not disappear. True education dignifies the individual.

In common usage the word 'science' is applied to a variety of disciplines or intellectual activities which have certain features in common. Usually a 'science' is characterized by the possibility of making precise statements which are susceptible of some sort of check or proof. This often implies that the situation with which the special science is concerned can be made to recur in order to submit them to check, although this is by no means always the case. There are observational sciences such as astronomy or geology in which repetition of a situation at will is intrinsically impossible, and the possible precision is limited to precision of description. A common method of classifying sciences is to refer to them as either exact sciences or descriptive sciences. Examples of the former are physics and, to a lesser degree, chemistry; and of the latter, taxonomical botany or zoology. The exact sciences are in general characterized by the possibility of exact measurement. One of the most important tasks of a descriptive science is to develop a method of description or classification that will permit precision of reference to the subject matter.

The fields of inquiry to which the general designation science may be appropriately applied are broadly divided into social science and natural science. The latter is further subdivided into biology and physical science.
Physical science is generally considered to include astronomy, chemistry, geology, mineralogy, meteorology, and physics. These overlap more or less, as illustrated by astrophysics, chemical physics, physical chemistry, and geophysics.

There is overlap likewise, between the physical and biological sciences, as seen in biochemistry, biophysics, virology, and the close relation between geology and paleontology. The boundaries implied in all such classifications are artificial and consist of regions where one field shades into another. (Das, 1990)

1.1. MEANING OF EDUCATION

Education in its broadest sense is any act or experience that has a formative effect on the mind, character or physical ability of an individual. In its technical sense, education is the process by which society deliberately transmits its accumulated knowledge, skills and values from one generation to another. The purpose of education is to develop the knowledge, skill, or character of students.

Teachers in educational institutions direct the education of students and might draw on many subjects, including reading, writing, mathematics, science and history. This process is sometimes called schooling when referring to the education of teaching only a certain subject, usually as professors at institutions of higher learning. There is also education in fields for those who want specific vocational skills, such as those required to be a pilot. In addition there is an array of education possible at the informal level, such as in museums and libraries, with the Internet and in life experience. Many non-traditional education options are now available and continue to evolve.

"The central task of education is to implant a will and facility for learning; it should produce not learned but learning people. The truly human
society is a learning society, where grandparents, parents, and children are students together.” - Eric Hoffer.

“No one has yet realized the wealth of sympathy, the kindness and generosity hidden in the soul of a child. The effort of every true education should be to unlock that treasure.” - Emma Goldman.

“The only purpose of education is to teach a student how to live his life, by developing his mind and equipping him to deal with reality. The training he needs is theoretical, i.e., conceptual.

He has to be taught to think, to understand, to integrate, to prove. He has to be taught the essentials of the knowledge discovered in the past-and he has to be equipped to acquire further knowledge by his own effort.” - Ayn Rand.

“The aim of education should be to teach us rather how to think, than what to think; rather to improve our minds, so as to enable us to think for ourselves, than to load the memory with the thoughts of other men.” - Bill Beattie.

“The one real object of education is to leave a man in the condition of continually asking questions.” - Bishop Creighton.

“The central job of schools is to maximize the capacity of each student.” - Carol Ann Tomlinson.

- **Education** is a concept, referring to the process in which students can learn something;
- **Instruction** refers to the facilitating of learning toward identified objectives, delivered either by an instructor or other forms.
- **Teaching** refers to the actions of a real live instructor designed to impart learning to the student.
• **Learning** refers to learning with a view toward preparing learners with specific knowledge, skills, or abilities that can be applied immediately upon completion (Aggarwal, 1992).

### 1.2. AIMS AND OBJECTIVES OF EDUCATION

The importance of aims and objectives of education is recognized by all the educational, professional, political, nonpolitical and religious associations, organizations and groups at various levels in their memoranda, letters and brochures. The aims and objectives of education, suggested in the documents, include individual as well as social aims, with emphasis of social transformation aiming at reconstructing society to make it modernized, productive, participative, and value oriented nation committed to its constitutional obligations. The aims are as following:

- Individual Development
- Social Transformation
- Modernization
- Productivity
- Community Participation
- Acquisition of Values

**Individual Development:** Development of an individual - physically, mentally and spiritually is well known aim of education. - Acquiring the capacities of understanding, appreciation and expression through word and act, are the fundamental aims of education. **Social and National Development:** Social, aim of education in equally important because an individual lives in society and has his obligations towards his nation.
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Social Transformation: Education should not merely equip an individual to adjust with society to its customs and conventions, but it should enable him to bring desirable changes in the society.

Modernization: Modernization of society in terms of scientific and technological advancement is a view which seems to be quite popular. Scientific and technological advances are, gaining momentum and conscious efforts are made to incorporate them into the development sectors. "New education policy of India should be built on the foundation of ancient spirituality and modern culture and technical sophistication. It should develop scientific temper and spirit of enquiry in the students".

Productivity: Some documents have insisted on linking education with productivity and thus making individuals as productive citizens to build a productive society. "It should bring about a social transformation, and enhance greater efficiency and productivity in all sectors: agri-cultural, industrial and service

Community Participation: In a democracy education without community participation is barren. This aim of education is, therefore voiced by a number of groups and organisations. The change that is envisaged on this front is that of Integrating education with community in all respects.

Acquisition of Values: Moral, cultural and spiritual values in education have been given immense importance in the Memoranda documents. One of the expressions emphatically point out that, "certain basic values as respect for others, responsibility, solidarity, creativity and integrity must be fostered in our children".

Emphasis should be given in cultivating good qualities like cooperation, good will, forgiveness, tolerance, honesty, patience etc. in order to encourage universal brother-hood and to prepare students worthy citizens of the country.
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Values of optimism and secularism, and service to the poor should be stressed on the young minds.

The aim of education is two-fold

(i) Development of the individual in society and

(ii) Consequent development of the society.

The aim of education in relation to individual may be spelt out as follows:

i) To produce full human personality with courage, conviction, vitality, sensitivity and intelligence so that men and women may life in harmony with the universe;

ii) To bring out the fullest potential of child and prepare him for life and its varied situations so that he becomes a cultured and responsible citizen dedicated in the service of community.

In relation to the society, the aim of education is to create:

i) A sane and learning society where made of material production will be such that no section of the society remains unemployed. In the Indian context such a made of production will be necessarily based on a decentralized economy utilizing all available manpower;

ii) A society where the conditions of work and general environment will offer psychic satisfactions and effective motivations to its members.

iii) A society reconciling technological and scientific advancement with general well-being and security of its members, enhancing joy of life and eliminating all forms of exploitation.
The broad objective of education should, therefore, be to look beyond the existing society and to develop men and women amenable to the advent of a sane and healthier society of tomorrow.

Eventually, the Indian education should aim at producing men and women of knowledge, character and cultural values and trained skills to achieve excellence in their career and life. Let us make it clear that we wish to prepare youth to march into the 21st century on the ideals of truth and non-violence as shown to us by our great leaders (Aggarwal, 1992).

1.3. FUNCTIONS OF SCIENCE

Natural science offers to society at large, as well as to the individual man of science, several distinct benefits. One is simply the existence of an organized body of knowledge, accessible to those interested in it; for science, like every other intellectual discipline, is to be valued in itself for the truth which it contains. Another is the existence of a body of men trained to appreciate this knowledge, and acquainted with the arduous work of gathering data and interpreting them; good scientific work demands that the man of science should aim to be energetic, humble, both constructive and critical, neither sterile nor credulous, accustomed to think before he acts and to act upon his conclusions. A third social benefit is conferred by the applicability of scientific knowledge to provide techniques for large-scale handling of matter, and hence for the improvement of the material conditions of life; properly used, this last function of science can confer real benefits, for example, by raising the life of the poor to a more tolerable standard (Narendera Vaidya, 1992).

1.4. CHEMISTRY EDUCATION

Chemistry education is a comprehensive term that refers to topics related to the study or description of the teaching and learning of chemistry in schools, colleges and universities. Topics in chemistry education might include understanding how students learn chemistry, how best to teach chemistry and
how to improve learning outcomes by changing teaching methods and appropriate training of chemistry instructors, within many modes, including classroom lecture, demonstrations and laboratory activities. There is a constant need to update the skills of teachers engaged in teaching chemistry and so chemistry education speaks to this need.

1.5. CHEMISTRY AND ITS SCOPE

A reasonable short definition of the scope of chemistry has been given as; chemistry is the integrated study of the preparation, properties, structure and reactions of the chemical elements and their compounds and of the systems which they form. Interpreted in the broader sense, this definition would include most of natural science, a consequence of the considerable areas of overlap which chemistry has with physical, biological, earth and material sciences.

Substructure of chemistry

The traditional substructure of physical, organic, inorganic, and sometimes analytical chemistry has origin in the past activities of chemists and still continues to determine how chemistry is taught. Another possible subdivision would be the following The structure and physical properties of pure substances, chemical transformations and applications of chemistry to complex systems. Application of chemistry would include such fields of current activity as molecular biology, material science and geochemical phenomenon.

Rise of Chemical Science

The scientific method emerged in the 16th century with the realization, that investigation must supplement logic and intuition in probing nature. This viewpoint which owes its initiation to scientists like Bacon, Boyle, Galileo, Hooke, Newton and others, recorded its early successes in astronomy and mechanics. The method came to be gradually applied to chemical behaviour of matter, thanks to the pioneering efforts of Antoine Lavoisier in the late 18th century and this marked the birth of chemical science as we know it today.
1.6. IMPACT OF CHEMISTRY IN LIFE

Chemistry as considered an important subject in school curriculum as many professional and applied courses, directly or indirectly use the knowledge of chemistry. Moreover, the present age is the era of science and more number of people is being employed in scientific pursuits which require knowledge of chemistry. Chemistry education is also necessary because of its immense value in the students' individual life as well as in society. Chemistry has made a significant contribution in the fields of drugs fuels, agriculture, animal farming, fibres etc.

In addition to these there are many other inter-disciplinary areas where the contribution of chemists is significant. In the area of environmental pollution, chemists are finding better method of analysis and solutions to get rid of pollution. There is the entire area of marine chemistry to investigate new sources for food and chemicals. The involvement of chemists in real life problems has been pointed out in the previous section. In this section we take up a few specific areas in some details.

Drugs

Many a substances from natural sources have been used since times immemorial for treatment of diseases. For example, an extract from the bark of poplar, olive or willow trees was recommended more than two thousand years ago by Hippocrates—the father of medicine — for treating fever. At present we can isolate and purify the drug from natural sources and establish their chemical structure. Sparsely occurring substances can be synthesized in the laboratory and in this way made available in abundance. More over even such drugs which do not occur in nature have also been obtained by synthesizing them in the laboratory. Aspirin (Acetyl salicylic acid) is one of the earliest synthetic drugs. Salvarsan was synthesized for treatment of syphilis. Some other prominent synthetic drugs are Sulpha drugs, antibiotic, anesthetics, antimalarial and wonder drug cortisone.
Food

Chemist have done a lot to increase food grain production and helped to bring about green revolution. *Synthetic fertilizers* were developed which provided the essential elements for growth of plants. The use of these fertilizers led to higher yield of plants. *Insecticides, weed killers, fungicides* developed by chemists have contributed a lot to increase the availability of food grains for the mankind. In many countries farmers use laboratory made chemicals as *defoliants*. For example, magnesium chlorate when applied to ripened cotton crop causes the leaves to fall off thus making harvesting much cheaper and faster. Chemicals are also used in animal farming. For example, 'Manrlate'-a new insecticide-used as a dip or as a spray- kills blood sucking hornfiles which attack cows. This step alone leads to 10% increase in milk supply.

1.7 AIMS AND OBJECTIVES OF TEACHING CHEMISTRY

In order to accomplish the task of teaching chemistry, it is essential for us to be very clear about the purpose of teaching chemistry. If we have a clear idea of what is to be achieved then it would be easier to implement any prescribed course in chemistry. This clarity of purpose would also be quite helpful in measuring the effectiveness of teaching chemist. The aim of teaching chemistry refers to the advantages that can be drawn or purposes that can be served by the study of chemistry. The important aims of teaching chemistry are as follows:

**Knowledge Aim**

The teaching of chemistry should increase the knowledge of the individual and such an increase in knowledge should help him in understanding himself and his environment. Thus this knowledge should help him, in his daily life.
Practical Aim

The knowledge gained should be of practical use to an individual. The individual should not only know the principles and facts but should be able to use these principles in understanding his environment. For this the knowledge should be related to the materials with which the pupil is familiar and should not be based on obsolete devices and ideas.

Development of Scientific Attitude

Chemistry being a physical science it aims at the development of scientific attitude among the learners. It should be helpful in removing the superstitions, false beliefs, wrong notions spread in the society and cultivate the habits of proper reasoning, observation and experiment action. One of the major aims of chemistry like any other science subject is to develop scientific attitude and science related values amongst students. It should train the student in the method of science and should help develop in scientific temper.

Cultural Aim

Present day civilization owes much to the development of chemistry and for any further development we have to strive for progressive improvement in the study of chemistry.

For this the chemistry be taught in schools in such a way as (i) to grasp the progress in the field of chemistry (ii) apply it for enhancement of our cultural heritage and development of civilization and (iii) appreciate the study of chemistry in the progress and development of culture and civilization.

Social Aim

The study of chemistry should help inculcate social virtues among the students for leading a well adjusted social life and contributing significantly towards welfare and progress of society. It should imbibe in him essential social qualities and virtues for becoming a responsible useful citizen.

Vocational Aim

The knowledge of chemistry in the present day world is essential for almost all the professions and vocations. To achieve the vocational aim we
must prepare our students for the different occupations and vocational courses. This knowledge should also provide them proper opportunity for adoption of some chemistry hobby and engage themselves in small scale industries and self employment projects.

**Utilization of Leisure Time**

The knowledge of chemistry should be useful to an individual to learn ways and means of utilizing his leisure hours more fruitfully.

**Psychological Aim**

Teaching of chemistry provides to an individual various opportunities for satisfying his varying psychological needs and this help him grow and develop as a well balanced individual.

**Skill Aim**

Like any other science subject, the teaching of chemistry should aim to develop useful skills pertaining to scientific observation, experimentation and practical use of scientific facts and principles.

**Criteria for Selection of Aims**

Thurber and Collette have proposed the following criteria for selection of aims...

(i) *Usefulness* The knowledge gained should be useful to the students in their lives.

(ii) *Timeliness* The knowledge given should be concerned with materials/objects with which student is familiar.

(iii) *Fitness* The knowledge should fit into sequence that leads him to broad objectives.

(iv) *Appropriateness* The learning should be appropriate for maturity and background of the students.

(v) *Practicability* It means that experience required for development of learning should be possible.
The chemistry team of the institute for the Promotion of Teaching Science and Technology (IPST) in Thailand formulated the following broad aims which they felt valid for any science course.

1. To develop an understanding of the basic principles and theories of science.
2. To develop an understanding of the nature, scope and limitations of science.
3. To develop a scientific attitude.
4. To develop skills important for scientific investigation,
5. To develop an understanding of the consequences of science on man and his physical and biological environment.

Aims of chemistry curriculum should be as follows:

(i) To make students interested in chemistry.
(ii) To familiarize the students with the important role played by chemistry in their life.
(iii) To develop in students a scientific culture.
(iv) To provide a training to students in methods of science,
(v) To emphasize upon students the role of chemistry on social behaviour.
(vi) To prepare students for those vocations which require a sound knowledge of chemistry.
(vii) To increase students understanding to such a level that he can understand various concepts and theories which unify various branches of chemistry (Yadav, 2006).

To achieve these aims we have to proceed systematically. For achieving these aims, these are usually divided into some definite, functional and workable units named as objectives. Objectives are, therefore, the ways and means of achieving the aims in a more practical and definite way. Objectives are the specific and precise behaviourial outcome of teaching a particular topic in chemistry. The objective of a topic in chemistry help in realising some
general aim of teaching chemistry. The characteristics of a good objective are as under:

(i) It should be specific and precise.

ii) It should be attainable.

Probably the most common educational objective in the acquisition of knowledge. By knowledge, we mean that the student can give evidence that he remembers either by recalling or by recognizing, some idea or phenomenon which he has had experience in the educational process. Knowledge may involve more complex processes of relating and judging.

Another important objective is development of intellectual abilities and skills. This has been labeled as 'critical thinking' by some, 'problem solving' by others.

Arts or skills + knowledge = ability 'Arts and skills' refer to modes of operation and generalized technique for dealing with problem. The arts and skill emphasize the mental processes of organizing and recognizing material to achieve a particular purpose. Intellectual abilities refer to situations in which the individual in expected to bring specific technical information to bear on a new problem.

Objectives are the specific and precise behavioural outcomes of teaching a particular topic or lesson of chemistry. Objectives actually control other factors of chemistry teaching to a great extent, therefore more emphasis be laid on writing objectives in behavioural terms for each unit of class room instructions in chemistry (Yadav, 2006).

1.8. ROLE OF CHEMISTRY TEACHER

The major role can be played by the chemistry teacher in developing scientific attitudes among his students and this he can do by manipulating various situations that infuse among the pupils certain characteristics of scientific attitudes.
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He can also help in developing a scientific attitude among his students if he possesses and practices various elements of these attitudes. The practical examples given by the teacher leaves an indelible mark on the personality of his students.

Teacher can use one or more of the ways for developing scientific attitude among his pupils,

(i) Making use of Planned Exercises: A large number of exercises for development of certain scientific attitudes are reported by various journals and magazines. Teacher can frequently use such exercises for developing certain scientific attitudes among the pupils. He can also make use of cuttings from newspapers and science magazines and can display such materials on bulletin board so that it is used again and again for direct teaching. Exercises which are always included in good text books can also be used by the teacher for developing scientific attitude among his pupils.

(ii) Wide Reading: On the basis of a study conducted by him, Curtis reported, that those pupil who engage themselves in wide' reading in science, develop scientific attitudes more than those who study only one textbook. Thus a teacher should encourage his students to read library books and supplementary books on chemistry. For this it is essential that each school at least has a science corner in its library. The teacher himself must be in habit of making proper use of science library so that his students get encouragement for use of science library the teacher himself is familiar with the latest new titles in his subject and be willing to share his joys of new readings with his pupils. He should refer some suitable books to his students.

Writing about teachers, Rabinder Nath Tagore has observed, "A teacher can never truly teach unless he is still learning himself. A lamp can never light another unless it continues to burn its own flame. The teacher who has come to the end of his subject, who has no living traffic with his knowledge, but merely repeats his lessons to his students, can only load their minds. He cannot quicken them".
(iii) **Proper use of Practicals Period:** A student of chemistry gets many an opportunities for learning scientific attitudes during his practical periods. It is for the teacher to properly use such opportunities for developing scientific attitudes amongst his pupils. Teacher should take extra care to state the problem of the experiment and should present hypotheses on solution.

He should practice the proper method of testing the hypotheses. He should actively participate in discussion and interpretation of results after the experiment. He must inculcate in his students the habit to postpone judgments in the absence of sufficient evidence to support a hypothesis.

(iv) **Personal Example of the Teacher:** Personal example of the teacher is perhaps the single greatest force that is helpful in inculcating the scientific attitudes amongst his pupils. Psychologists have found a great tendency amongst the students to copy their teachers. In this regard some have stated, "As is the teacher, so is the student". It is therefore essential that chemistry teacher is free from bias and prejudices while dealing with his pupils. He should have an open mind and be critical in thought and action in his everyday dealings. He should be totally free from superstitions and unfounded beliefs and should be objective and impartial in his approach to his everyday problems. He should be truthful and should have faith in cause and effect relationship.

(v) **Study of Superstitions:** There are different types of superstitions that still prevail in Indian society. Simply taking of these superstitions and calling them bad and out of date will not leave a lasting impression on the minds of the pupils. It will be more useful if the teacher can encourage at least a few of his students to carry out practicals on some popular superstitions such as that the presence of a broken mirror in any home leads to disharmony in that home or that if a cat crosses the way when we are going out for some work, then the work will not be done on that day etc. etc. Such beliefs can easily be discarded by a student if he keeps a broken mirror at his home and finds to his satisfaction that it has not created any type of disharmony in his home. Similarly, other superstitions and misbelieves can be tested and easily
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discarded by a student of chemistry. Various researches carried out in the field have drawn the same conclusion \textit{i.e.} by practical survey and study of such common beliefs; students have developed permanent mind-sets or attitudes towards such superstitions.

(vi) \textit{Co-curricular Activities in Chemistry:} Various co-curricular activities such as organizing science club, hobbies club, chemistry society, organizing scientific tours and excursions etc. can be taken up by chemistry teacher. Such activities should be properly organized by chemistry teacher under his direct supervision but students be given enough freedom to plan their activities.

It will help inculcate in students some desirable scientific attitudes. Co-curricular activities may include making of chemistry charts and models, making of improvised chemistry apparatus etc.

(vii). \textit{Atmosphere of the Class:} A proper atmosphere in the class room provided a desirable atmosphere for inculcating of certain scientific attitudes in the pupils. By a proper class atmosphere we mean that the room is properly arranged and suitably decorated in such a manner that it provides an incentive to the pupil to inculcate the habit of cleanliness and orderliness. In addition to such a congenial physical atmosphere of the class room, the teacher's behaviour also contributes to the development of proper class room atmosphere. For inculcating the scientific attitudes amongst his pupils teacher should encourage them in their various activities. He should also take care to see that his lessons content are such as to encourage the students to ask a large number of intelligent questions. He should feel pleasure in answering and explaining such questions and must not snub his pupils for asking so many questions.

\textbf{Qualities of Chemistry Teacher}

We all know good teachers when we see them and bad teachers too. There were only a few, but they all had the following qualities in common of a teacher.
A Chemistry Teacher presents concepts related to chemistry to high school students in public or private schools. To be employed as a Chemistry Teacher, a bachelor's degree in chemistry and a high school teaching certification will be required. The duties of a Chemistry Teacher include creating lesson plans, preparing and delivering lectures, creating and supervising laboratory activities for students, evaluating student performance, maintaining classroom records, meeting with parents, teachers and other professionals and participating in campus events. Depending upon the expectations of the employing school, additional research, supervisory or organizational duties may also be required of a Chemistry Teacher.

Arguably, the most important duo of skills for a Chemistry Teacher is enthusiasm for science and the ability to inspire the same enthusiasm in high school students. Additional skills necessary for success as a Chemistry Teacher are creative thinking, problem solving and managing one's time well (Yadav, 2006).
1.9. STATEMENT OF THE PROBLEM

In the era of examinations, present day students have to remember a number of names, facts, ideas and concepts. In chemistry learning they have to remember names of elements, reactants and products, their procedures, experiments, equations, structures, etc., while describing a procedure of chemical reaction more number of chemical substance come repeatedly. Here there may be chance to confuse which substance comes where. To avoid this confusion and also be clear during exam time, memory enhancing strategies were used. It helps to keep all these names clearly in mind and order. Different complicated chemical structures should be remembered in chemistry. Memory enhancing strategies are used to memorise all these structure. Apart from the memory strategies, relaxation techniques like meditation, Alpha breathing, mind power music and mind machine helps to enhance memory, minerals like Iron, Iron, Iodine and zinc in the food which we eat also helps to improve memory.

The main purpose of the study is to enhance the achievement in chemistry of engineering students with the help of memory strategies and Relaxation Techniques cum Nutrition. In order to enhance the chemistry achievement by improving the memory of the students this study is undertaken. Thus the problem identified a “Effect of Memory Enhancing Strategies on Chemistry Achievement among Engineering Students”.

1.10. NEED AND SIGNIFICANCE OF THE STUDY

Chemistry & Education: Universities and colleges provide teaching and training for bright young people in the basics of chemical science and engineering, both for students specializing in chemistry and for others who need the underpinning experience of chemistry for their own particular scientific, professional or technical education.
Of course, provision of an educational training in chemistry does not begin at university. It starts at primary school with an introduction to observation and embryonic interpretation of phenomena and continues through early, middle and later schooling. There are deep worries within the chemistry community that the educational provision in science in some countries is lacking in appropriate resourcing and basic training, particularly in mathematical skills and in developing a familiarity with the philosophy of physical science.

Schools and school teachers, universities as teachers of teachers and adult teaching institutions all have a major contribution to make in improving society's knowledge of science and technology. Science teaching must be better funded and empowered through better training to deliver higher standards in science education. Education must continue for our workforce throughout the working life. Education must be seen as a European matter - a fundamental basis for a modern society.

Fortunately, in most countries in Europe chemistry and chemical engineering are highly regarded as professions. However, in some countries this is not the case, with adverse consequences for practitioners of the sciences and public perception of its activities and benefits. Much more effort must be put into the careful training and selection of science teachers, particularly chemistry teachers, and into the promotion of a more balanced view of the benefits as well as the responsibilities of chemistry as a science.

An improved standard of general science education for all is essential for future success. Without knowledge of basic scientific matters, of concentration, of risk and probability, and of the properties of materials and molecules, a science-based industrial society cannot function democratically. As we see daily in our media, a society with widespread scientific ignorance is all too easily influenced by facts incorrectly reported or interpreted in an unbalanced way.
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Wider scientific education and more effective programmes to increase public recognition of the positive role of chemistry in wealth creation and improving the quality of life are needed. Such programmes might usefully be initiated in consultation with the partners of the All Chemical Engineers. Academic institutions and the chemical industry accept that it is necessary to demonstrate that the advanced technology used in industry is both safe and responsibly managed.

1.11. CHAPTERIZATION

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