State Curriculum Framework-2011

Position Paper

on

Science

School Education Department
Telangana, Hyderabad.

State Council of Educational Research & Training,
Telangana, Hyderabad.

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Vision of the State

The vision of the State is that ALL children should receive high quality education and become responsible citizens with an acute sense of the other. They should be aware of their environment and think about it critically. They should listen carefully and speak fearlessly. They should be able to understand what they hear and read; but they should also be able to questions it. Teachers should promote these skills, provide meaningful teaching learning processes in natural and friendly environment that enable children to express themselves freely and ask questions. Teachers are collaborative learners and reflective practitioners. Parents and community should have a sense of ownership and participate in the life of the school. In a world which is becoming increasingly instrumental, materialistic and competitive, school should become a space for reflection, cooperation and promotion of human and ethical values.

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EXECUTIVE SUMMARY

Today in 2011, with dreams of making India a developed country, it is acknowledged that we must become knowledge creating / generating society not just knowledge using Society. The teaching of Science in schools should prepare the young minds to face challenges, analyse and try to solve them. On the one hand inventions and discoveries made in the field of science improve the way of living and quality of life of its citizens and on the other hand it helps us understand the world rationally and helps us check and correct our prejudices and biases. Thus it is correct to say education in science fosters the spirit of inquiry that helps all of us to find solutions to problems and to rise above narrow minded, dogmatic and superstitious behavior.

For the above said to happen it is important that science teaching aims towards developing critical scientific thinking abilities, nurturing scientific attitudes and promoting scientific temper. It also needs to involve creating an understanding of the process by which scientific knowledge grows.

Currently teachers attempt to pass on maximum information to the students. Students are generally only listening passively and the classroom process emphasis is on memorization of definitions and scientific facts. The content is limited to textbooks and is considered as the final word. The whole emphasis from parents, students and teachers is on good marks. The other problems are:

- Non-availability of relevant materials as kit for doing experiments.
- Non-availability of adequate and capable teachers leading to inadequate discussion and support to children.
- No time for the teacher to self reflect and analyse the way students are thinking and presenting and to use that in the plan.
- Teachers' have insufficient preparation to teach Science and there are no support mechanisms to help them in the school.
- The lack of clarity on objectives of Science teaching leads to an over emphasis on rote memory and information recall in assessment.

What is Science?

It is a process of constructing knowledge. This process depends both on making careful observations of phenomena and on inventing theories for making sense out of those observations. Change in knowledge is inevitable because new observations may challenge prevailing theories. It demands evidence and is both a blend of logical reasoning and imagination to form a theory or explanation.

The essential feature of science is the spirit of enquiry and discovery and so it becomes the basis for science teaching. The activities and experiments must be designed to nurture and channel curiosity, ask questions, make observations and lead to an open argumentation that leads to evolve the acceptable, accurate solution/conclusion in a democratic way.

Objectives of Science teaching

The main objectives of Science teaching at primary stage are to maintain the curiosity about the world and have the child engage in exploratory and hands on activities that would lead to the development of basic cognitive and psychomotor skills. The criteria for identifying the content at the primary stage are relevance, meaningfulness and interest to the child.

Science education at elementary level should provide a gradual transition from an exposure to ideas of Science through environmental studies of the primary stage to elements of science including its concepts, processes and methods.

At the Secondary Stage concepts principles and skills of science would now appear appropriately but stress should be on use of concepts, on the ability to investigate and on comprehension and not on mere formal definitions.

We must point out science education today does not have enough examples from practical life. As a result, we are not able to use concepts in our daily life. The practical implications for life are totally distinct from the textbooks. It is not surprising that the students who are good at using ideas with the help of the textbook get puzzled by similar issues in daily life.

Teaching learning of Science

A variety of teaching learning methods need to be adopted by the teacher to develop process skills among children. These methods include relevant and interesting projects for involve data collection, analysis, reporting, reasoning and inference.

The teacher's role, largely, is not to give answers but to guide children so that they arrive at the answer through processes of exploration and discussion.

Assessment

There are two specific major deficiencies in the current examination system of science. The science papers do not attempt to assess understanding of the subject. They contain formal questions, which can be handled by rote learning. There are no occasions for thinking, for discussions, no challenging problems are posed and no experiment based questions. Secondly, the board examinations are held on a fixed date for the whole year of learning. This feature coupled with the exaggerated importance attached to the external examination leads to a lot of stress in the run up to and the post examination scenario.

There is a need to overcome the notion of textbook-based evaluation. Assessment needs to include elements that the textbooks do not contain. The scope of evaluation should be widened by adding non-formal and co-curricular elements.

In sciences, it is necessary that every test item should make the learners think and/or experiment. The tasks for assessment should be challenging. There must be open ended questions in the exam.

Chapter - 1

Introduction

"The quality of science teaching has … to be raised considerably so as to achieve its proper objectives and purposes, namely, to promote an ever-deepening understanding of basic principles, to develop problem-solving and analytical skills and the ability to apply them to the problems of the material environment and social living, and to promote the spirit of enquiry and experimentation. Only then can a scientific outlook become a part of our way of life and culture."

'Education and National Development', Report of the Education Commission 1964-66. NCERT, 1971, p. 12.

The task laid out before us by the Kothari Commission more than 40 years ago continues to be a challenge even today. In 2011, with dreams of making India a developed country, it is acknowledged that we must become a knowledge creating/generating society and not continue to be just a knowledge using society. The teaching of science in schools should prepare young minds to face challenges, analyse and try to overcome them. While the teaching of this subject is influenced by social, cultural, political and economic perspectives, it has a large component that comes from basic rational principles and observations that are broadly the same across all kinds of diversities in geography, social background and culture. It has in that some key elements that give an understanding of how things in nature, including ourselves, work.

It is observed that the economic development of a country is, to a large extent influenced by its strides in science and technology. On the one hand inventions and discoveries made in the field of science improve the way of living and quality of life of its citizens and on the other hand it helps us understand the world rationally and helps us check and correct our prejudices and biases. Even though all technological uses of science are not beneficial and all questions studied not appropriate for rational, just and equitable society, by and large science is critical for both physical development of the country as well as that of the minds and sensibilities of its people. It is imperative to promote this field of knowledge right from the early stages of schooling.

Our Constitution has recognized the importance of developing scientific temper in all citizens. We may say education in science fosters the spirit of inquiry that helps all of us to find solutions to problems and to rise above narrow minded, dogmatic and superstitious behaviour. There is an ever increasing demand for science education in the society as it opens up more and better employment opportunities including avenues for self – employment. All this makes this subject a vital part in a child's education both for her personal benefit but also for social gains. In fact, it can be strongly argued that human civilization owes its development to the spirit of inquiry. Inherent curiosity and

ability for systematic observation of Nature and experimentation is a part of our cultural heritage too.

1.1 Critique: State of Science Education in Schools of Andhra Pradesh

Teaching science should aim towards helping students develop their understanding of science and its concepts. It must also involve developing critical scientific thinking abilities, nurturing scientific attitudes and promoting scientific temper. It should aim towards creating an understanding of the process by which scientific knowledge grows.

It certainly cannot be information based only reduced to memorization and recall. Most of the studies in Andhra Pradesh have revealed that presently the science classes are teacher dominated. The teachers attempt to pass on maximum information to the students. Students are generally only listening passively and the classroom process emphasis is on memorization of definitions and scientific facts. Memorization of these is taken to be the same an understanding of scientific concepts and examinations test only the ability to reproduce the memorized information. Students get no opportunity to do experiments with their own hands or even see a demonstration. Even though a lot of kit material has reached schools most of it lies under lock and key unutilized. Thus science is reduced to being a boring subject to be learnt by rote with no exciting intellectual challenge for the students.

1.2 The Challenges before Us

A critical observation of present state of science education reveals that there are many practices in the system which are contrary to the aims and objectives of Science Education. They present a major challenge before us if we have to transform teaching of science in our schools to achieve the social and national goals stated above. We need to analyze the reasons for these and come up with some suitable solutions. The following are some of these challenges:-

(1) Teacher Perceptions about Science Education

- The objective of Science teaching is to make the child know all scientific facts.
- The content that is in the textbooks is final. No other materials are available for learning other than the textbooks. The only objective is to understand and learn what is there in them.
- Scoring good marks in an information based memory-recall science test is a yardstick for quality of science knowledge.

- Making children participate in experiments, projects and field trips is time consuming process and therefore not worth doing.
- It is not possible to assess acquisition of process skills by students in normal classroom condition.
- The purpose of homework (or) assignment is to make a child memorize the correct answers to questions explained in the classroom.

(2) Expectations of parents and school authorities

- Parents only want their children to score good marks in the science test.
- School authorities insist that the science teacher adopt particular strategies to see that parents' aspirations of good marks be addressed.

(3) Limitations of Science Curriculum, Syllabus and Teaching–Learning materials

- The teachers are using only the textbook as the sole resource for teaching of science.
- The present science curriculum and syllabus does not support teaching of science as development of concepts, ability to observe, analyse, hypothesize and deduce and develop a critical attitude.
- While the textbooks do have some suggested activities to do, these activities are not expected to have any direct bearing on the learning process.
- The understanding is that children not doing these activities may not suffer any shortcoming in their learning. Hence teachers are under no compulsion to ensure that experiments and activities are done in the class.
- The information content of the textbooks is often very dense and cryptic with no attempt to ensure readability and understanding at the level of the class or age of the children.
- There is a lack of proper concept mapping with concepts being introduced in no logical or hierarchical sequence. Very often new terms or concepts appear in text assuming that children are familiar with them without confirming whether they have appeared with proper introduction and explanation in earlier chapters or previous classes.
- Thus the burden of inability to understand restricts the possibility of children engaging with the subject matter and the discipline of science in a constructive manner forcing them to resort to memorization without understanding for the purpose of the examination. The cheap guidebooks available in the market act as

convenient replacements for the textbook providing readymade answers to be mugged.

- The examination system also tests only this memorized knowledge once inducing children to forget whatever they learnt or memorized for the exam leading to students in higher classes having very little memory of what they learnt in earlier classes. No gradual consolidation of conceptual understanding or knowledge base takes place resulting in total lack of confidence and interest in the subject as students move to higher classes.
- There is a lack of other teaching –learning material including simple age appropriate readers for promoting further enquiry and self learning. This reinforces sole dependence on the textbook.
- The presentation of the subject matter and illustrations in the textbook also needs attention and improvement.

(4) Lack of Teacher Preparation and Utilisation

- Most teachers from Upper Primary stage onwards are themselves not familiar with the subject matter and lack conceptual understanding. They lack confidence in doing experiments themselves or guiding children in doing activities. Teacher training programmes have not been able to fill these gaps.
- In high schools where separate teachers for life sciences and physical sciences have been appointed, the tendency is to divide the syllabus into two parts and teach them independently. Though the approach up to Class X is one of integrated science, the two teachers are not able to work as a team to neither give an integrated perspective to the students nor assist each other in organizing experiments and other activities.

(5) Logistical and Infrastructural Challenges

- Non-availability of relevant materials such as kit for doing experiments, library for books, etc.
- Lack of enough competent, capable and adequately trained teachers leading to inadequate activity, discussion and support to children.
- No time for the teacher to reflect and analyze the way students are thinking and presenting and to use that in evolving or modifying her teaching plan.
- Lack of effective support mechanisms to help the teachers with insufficient preparation to teach science.

- Lack of clarity on objectives of science teaching right down to the grass root level leading to an over emphasis on rote memory and information recall in assessment.

1.3 Activity–based Science Teaching: Elusive Goal

The policy guidelines for teaching of science in our country have emphasized in some measure the process of learning by doing since the early seventies. This approach, however, has not become common as it requires a capability in the system that does not yet exist. It has also been felt that this requires too much material and also discussions that would take long time.

It may be emphasized that we are not here talking about mere mechanical activity to aid teaching but an approach that uses both mind and hands. The entire science class should be imbued with a spirit of enquiry. It must make and pose questions, think systematically and arrive at possible conclusions. Thinking must blend with continuous discussion and creative imagination. Children must not just learn concepts in science but develop enquiry and critical thinking. The open ended questions would engage the young minds to grapple with and develop understanding imbued with logical / systematic argumentation. In addition to all this, it has been recognized that we cannot disregard the potential of science to influence social understanding and consider its promotion as a social endeavour. The National Curriculum Framework (NCF) 2005 has also emphasized a similar approach to teaching of science.

1.4 The NCF 2005 Perspective: The Six Validity Criterion

In developing a vision for science education three factors have to be involved: the learner (child), the environment – physical, biological and social (life) in which the learner is embedded, and the object of learning (science). Good science education can be regarded as one that is true to all three of them. On basis of this the NCF 2005 suggests some basic criterion for validating a science curriculum as listed below:

a) *Cognitive validity* requires that the content, process, language and pedagogical practices of the curriculum are age appropriate, and within the cognitive reach of the child.

b) *Content validity* requires that the curriculum must convey significant and scientifically correct content. Simplification of content, which is often necessary to adapt the curriculum to the cognitive level of the learner, must not be so trivialized as to convey something basically flawed and/or meaningless.

c) *Process validity* requires that the curriculum engage the learner in acquiring the methods and processes that lead to generation and validation of scientific knowledge, and nurture the natural curiosity and creativity of the child. Process validity is an important criterion since it helps in 'learning to learn' science.

d) *Historical validity* requires that science curriculum be informed by a historical perspective, enabling the learner to appreciate how the concepts of science evolve with time. It also helps the learner to view science as a social enterprise and to understand how social factors influence the development of science.

e) *Environmental validity* requires that science be placed in the wider context of the learner's environment, local and global, enabling him/her to appreciate the issues at the interface of science, technology and society, and preparing him / her with the requisite knowledge and skills to enter the world of work.

f) *Ethical validity* requires that the curriculum promote the values of honesty, objectivity, co-operation, freedom from fear and prejudice, and develop in the learner a concern for life and preservation of environment.

Thus any discussion on science education would reflect our understanding of the nature of science, how children learn and the context of the wider environment.

Chapter - 2

What is Science?

2.1 Science as a Process of Constructing Knowledge and Nature of Scientific Knowledge

Over the course of human history, people have developed many interconnected and validated ideas about the physical, biological, psychological, and social worlds. Those ideas have enabled successive generations to achieve an increasingly comprehensive and reliable understanding of the human species and its environment. The means used to develop these ideas are particular ways of observing, thinking, discovering meaningful patterns and relationships, building conceptual models, theorizing, experimenting, and validating. These ways represent a fundamental aspect of the nature of science and reflect how science tends to differ from other modes of knowing. Understanding nature of science itself has been a challenging task as it emerges from a complex interjection of philosophy, history, sociology and psychology of science and its practice.

Some important aspects of nature of science are:

- Science presumes that the things and events in the universe occur in consistent patterns that are comprehensible through careful, systematic study. However, nature is not simply revealed to us as we see it. There is much more to it to be discovered in fine structures or simplifying complexities of phenomenon through constructing concepts which are totally abstract in nature expressed as mathematical entities. More often, our intuitive concepts based on direct experience get overthrown giving rise to very counter-intuitive concepts that defy simplistic metaphorical understanding. Learning science calls upon teachers and students to come to grips with and understand such concepts very early. Concepts like force, inertia, cells, atoms and molecules, mass, energy, electric current, etc. all fall in this category.
- Science also assumes that the universe is, a vast single system in which the basic rules are everywhere the same. Knowledge gained from studying one part of the universe is applicable to other parts. For instance, the same principles of motion and gravitation that explain the motion of falling objects on the surface of the earth also explain the motion of the moon and the planets.
- Science is a process of constructing knowledge. The process depends both on making careful observations of phenomena and on inventing theories for making sense out of those observations. Consequences of theories are deduced through devising qualitative or mathematical models based on rational arguments leading to their verification or falsification through observations and controlled experiments giving rise to principles, theories and laws governing the physical

world. Interestingly enough, what we choose to observe is in turn dictated by the tentative conceptualization or theorization prevailing at that time. Philosophers of science describe this as 'observations are theory-laden.

- Speculation and conjecture also have a place in science, subject to subsequent verification by relevant observations and/or experiments**.** There is an important creative element in practice of science.

- Scientific ideas are subject to change making science a dynamic, expanding body of knowledge. Change in knowledge is inevitable because new observations may challenge prevailing theories, as the domain of human experience expands. The laws of science are never viewed as fixed eternal truths. Even the most established and universal laws of science are always regarded as provisional, subject to modification in the light of new observations, experiments and analysis.

- Feynman, a famous scientist said "Scientific knowledge is a body of statements of varying degrees of certainty -- some most unsure, some nearly sure, none *absolutely* certain." He further goes on to say, "Of all its (science) many values, the greatest must be the freedom to doubt." Indeed scepticism has been an important characteristic of scientific thinking and has played an historic role in progress of science.

- Most scientific knowledge is durable. For example, in formulating the theory of relativity, Albert Einstein did not discard the Newtonian laws of motion but rather showed them to be only an approximation of limited application within a more general concept. Continuity and stability are as characteristic of science as change is, and certainty as prevalent as tentativeness.

- Science cannot provide complete answers to all questions. There are many matters that cannot be usefully examined in a scientific way. There are, for instance, beliefs that, by their very nature, cannot be proved or disproved (such as the existence of supernatural powers and beings, or the true purposes of life). For scientific investigation to be possible it must be possible to ascribe to the phenomenon a consistent conceptual framework that lends itself to logical analysis leading to systematic observation and/or experimentation.

- Systematic inquiry is fundamental to the process of generating scientific knowledge. Science asks three basic questions-

  What is there?

  How does it work?

  How did it come to be this way?

- Scientific inquiry is not easily described apart from the context of particular investigations. There simply is no fixed set of steps that scientists always follow, no one path that leads them unerringly to scientific knowledge. There are, however, certain features of science that give it a distinctive character as a mode of inquiry. Although those features are especially characteristic of the work of professional scientists, everyone can exercise them in thinking scientifically about many matters of interest in everyday life.
- Science demands evidence. Fundamentally, the various scientific disciplines are alike in their reliance on evidence, the use of hypothesis and theories, the kinds of logic used, and much more. The validity of scientific claims is settled by referring to observations of phenomena. Hence, science concentrates on getting accurate data.
- Science is a blend of logic and imagination. Scientific concepts do not emerge automatically from data or from any amount of analysis alone. The assumption has to be connected with conclusions through scientific arguments that conform to the principles of logical reasoning. Sometimes discoveries in science are made unexpectedly even by accident and often by leaps of imagination.
- Science explains and predicts. The predictions may be about evidence from the past that has not yet been found or studied. A theory about the origins of human beings, for example, can be tested by new discoveries of human-like fossil remains. This approach is clearly necessary for reconstructing the events in the history of the earth or of the life forms on it. It is also necessary for the study of processes that usually occur very slowly, such as the building of mountains or the aging of stars.
- Science requires accurate record keeping, peer review and replicability. New knowledge must be reported clearly and openly.
- Science is not authoritarian. Theories are judged by their results: When someone comes up with a new or improved version that explains more phenomena or answers more important questions than the previous version, the new one eventually takes its place. The history of science reveals both an evolutionary and revolutionary character.
- Science is a complex social activity. Scientific work involves many individuals doing many different kinds of work and goes on to some degree in all nations of the world. Men and women of all ethnic and national backgrounds participate in science and its applications. These people—scientists and engineers, mathematicians, physicians, technicians, computer programmers, librarians, and others—may focus on scientific knowledge either for its own sake or for a

particular practical purpose, and they may be concerned with data gathering, theory building, instrument building, or communicating.

- While not everything from different cultures would qualify as scientific knowledge, people from all cultures have contributed to science in some way or the other. This can be attributed to human endeavor to arrive at reliable validated knowledge in different cultures.

- Science has been part of social and cultural traditions and in turn scientific ideas have been rooted in the social and cultural milieu. An important contribution of science has been the way it has been reshaping our worldview. For example, till hardly four hundred years ago everybody believed the earth to be the centre of the universe with the sun and the moon going round it. Today, even if it might apparently not seem so, every child grows up with the knowledge that the earth is orbiting round the sun and is definitely not the centre of the universe.

- While technology definitely predates science, there has been a close relationship between technology and science, particularly over last four centuries. In fact, it would not be wrong to describe modern technology as applied science as much of technology around us is based on basic principles of science. Technological solutions are guided by design, aesthetics, economics and other practical considerations as also by scientific principles.

- The very definition of progress has come to be linked with advances in science and technology. New fields of work and production have emerged while traditional fields have been transformed beyond recognition like agriculture, manufacturing, construction, transport, communication and entertainment. People are faced with a fast-changing world demanding flexibility to adapt to new demands and creativity to take advantage of new opportunities. Science education has to rise to meet these expectations.

2.1 Implications for Teaching of Science

The essential feature of science is the spirit of enquiry and discovery and so it must become the basis for science teaching. An understanding of science can begin only with a definite minimum of basic factual knowledge and vocabulary and some real experience of investigation coupled with a knowledge and understanding of the ways in which scientific methods are used. Science teaching must engage and encourage the children who are by nature curious and question everything. They come to school with a fairly rich knowledge of their immediate environment. Thus the basic ingredients are available to expose them to the exciting world of exploration and discovery and the mysteries of nature. Such a beginning provides a sound platform to build upon their

understanding, knowledge base and analytical and operative skills making their journey of learning science exciting and fruitful.

It is understood from the nature of science that it is not just a body of knowledge but a process of constructing knowledge. Therefore, science teaching must not be didactic. Often it is the scientist's discovery/invention that is highlighted in content and never the background how he/she arrived at that discovery/invention. The process how they arrived at it is crucial to develop conceptual understanding and inculcate the scientific method of enquiry. Hence this process needs to be emphasized in the teaching process and textbooks.

Science is a systematic, careful and committed inquiry through experimentation for verification or validation. The activities and experiments must be designed to nurture and channel curiosity, ask questions, make observations and lead to an open argumentation evolving acceptable, accurate solution/conclusion in a democratic way. It is vital that children are prepared through science teaching to attempt to construct knowledge and engage in continuous enquiry to satisfy their innate curiosity.

Science and technology is ever expanding and progressing by constant questioning, experimentation, verification or validation leading to development of new theories, inventions or improved versions of the existing ones. Thus the qualities of openness and flexible attitude, to be tolerant of criticism, and to accept others views need to be fostered.

Knowledge and understanding of scientific concepts and phenomenon do not emerge automatically. They are fruits of labour of some scientist or group of scientists with commitment to know the unknown. The children are to be encouraged to develop such commitment to conduct their projects in a systematic and analytical way.

Chapter - 3

The Student Learner and the Context

The only organism on the earth is able to think is human being. Man particularly children are very curious to nature. Children wants to play it, find it, and explore it, Child has in innate potentialities to do so. Every activity in our daily life has a systematic structure and function either it is a children play or a elder activity. There are enormous fields of knowledge in our surroundings cooking food, plants flowing, playing with kites, birds flying, water boiling, foddering, rain, ill health, agricultural practices, using technological instruments etc are all in the experiential orbit of the children.

Children shows interest to make things for example clay modelling paper toys etc. They also able to formulate rules and regulation for the games that they play in groups. By exploring such natural environmental experiences children can construct knowledge on their own. Child participate in any daily life activity there they observe the process and curious about the results, mean while they guess about it. Finally they come to conclusion. In this way child acquire knowledge from her immediate environment. The way child learn from his experiences is Science.

When the child experience with in a situation she observe the process what is going on, and establishing a relationship or a new bond with that by identifying similarities or dissimilarities. Child is eager to share here experiences with others. This shows that child has the ability to explain, conclusions, understanding ability of the process are all improves along with her age .Children at up-level are able to understand causes of the effects. They can do simple experiments on their own. Science learning should promote analytical thinking at high school level. Because their understanding about abstract concepts is widen. So children at that level participate in laboratory activities. Science education amalgamate these innate ability of the child with school curricular activities. The purpose of science learning is to develop the innate potentialities of the children towards nature. science education should promote concern towards biodiversity and apply that thinking in their daily life. this makes children nature friendly humanistic personals

Chapter – 4

Science as the subject in the curriculum

(Curriculum at different stage)

As per the general aims objectives content pedagogy and assessment would differ across different stages. While deciding gradation of science curriculum it must be borne in mind that a majority of the students study science as a compulsory subject up to class –X in Andhra Pradesh. Although most of these children are not going to train as professional scientists or technologists in their latter career, they need to become scientifically literate. The science curriculum up to class – X should be oriented more towards developing awareness among the learners about interface of science, technology and society besides being able to look at the world in a rational manner and apply principles of science to daily life. It should stress not only the content of the science but also the process skills and their linkage with the experiences and daily life.

Primary Stage

The main objectives of science teaching at this stage are to maintain the curiosity about the world and have the child engage in exploratory and hands on activities that would lead to the development of basic cognitive and psychomotor skills. All this would be through language, observations, recording, differentiation, classification, inference drawing, reading and making illustrations, design and fabrication of simple things, estimation and measurement. The curriculum should also help the child internalize values of cleanliness, honesty, co-operation, concern for life and environment at the primary stage.

During this stage,

1) Children should be encouraged to explore their immediate environment without too much focus. For example, in the first two years this exploration can be without the aid of a specific science textbook. The book on language can contain topics that induce the child to look around and develop a familiarity with their surroundings.
2) Science education can be a part of environmental studies from class III to V so that children can examine and relate to their world holistically.

The assessment of Science at this stage should aim at checking the knowledge acquired as well as the skills developed. Some not obvious skills only language comprehension and reading ability, ability to work in groups, etc.

The criteria for identifying the content at the primary stage are relevance, meaningfulness and interest to the child. The content should provide opportunities to deal with the real and concrete world of the children, rather than a formal abstract world.

The present practice of introducing ideas and concepts pertaining to science and social science as environment studies should be continued and further strengthened, with opportunities for children to observe, explore and relate to environment closely. It is, therefore, essential for the curriculum, syllabus and textbook developers of both the 'sciences' and 'social studies' groups to work together.

Scientific concepts to be taught at this stage should be chosen so as to make sense of everyday experiences. Apart from simple experiments and hands on experiences, an important pedagogical practice at this stage is to engage the students (in groups) in meaningful investigations – including particularly the problems they perceive to be significant and important. This may be done through discussions in the class with the teacher, peer interactions, gathering information from newspapers, talking to knowledgeable persons in the neighbourhood, collecting data from easily available sources, doing simple experiments and carrying out simple investigations in the design of which the students have a major role to play.

Upper Primary Stage

Science education at this stage should provide a gradual transition from an exposé to ideas of science through environmental studies of the primary stage to elements of science including its concepts, processes and methods.

Scientific concepts to be taught at this stage should be chosen so as to be related to the child's life and to help the child acquire a better sense of her everyday experiences.

The emphasis on the process skills of science should continue through the upper primary stage to enable children learn how to learn for themselves so that they could carry on learning to even beyond school.

The examination should assess the child's practice and problem solving skills, ability to analyze data, application of learnt knowledge, development of concepts, understanding, reading and making graphical representations and solving simple numerical exercises.

The Technology component of Science Curriculum could include design and fabrication as well as practical knowledge about common mechanical and electrical devices and about local specific technologies.

1. Science education should remain as general science for class VI to VII.
2. At this stage group activity, peer group interaction allowing the child to articulate her formulations, questions, etc.
3. Children should be engaged in learning the principles of science through familiar experiences and to start recognizing the relationship of science and technology with society.

4. For example, students should be encouraged to make very simple working models using locally available materials.

Secondary Primary Stage

At the Secondary Stage concepts principles and skills of science would now appear appropriately but stress should be on use of concepts, on the ability to investigate and on comprehension and not on mere formal definitions. The organization of science content must be around what is close to children and the curricular load needs to be substantially reduced from the present to make room for aiding concept development and for the elements of design.

Relation with Other Subjects

When we want to relate learning of concepts to the experiences it becomes difficult to separate them into small pieces. Analysis of even experiments would cut across many concepts and thoughts sometimes across topics and even disciplines. Therefore, it is important to keep this in mind. The linkage of different aspects of the idea located in different disciplines makes it richer and nuanced. So in the sense of choosing themes and in the sense of deepening the relationship with the concept it is essential that the disciplines within science be visualised as linked and science be looked in terms of its relationships with other disciplines as well.

Application of Science in Daily Life

While organizing curriculum for teaching of science we should include all the essential aspects of the science subject needed by a child in meeting the general requirements of his day-to-day life. For this purpose attempts are to be made to take all essential and useful topics related with the day-to-day life activities and needs from all the different branches and areas of science. And then integrate them in a cohesive way for being used in a generalized way in ones day-to-day life. From early morning when we wake up, there are so many phenomena that excite our curiosity initiating us to think about how those things occur. We also see that science is with us every day. Children in washing face, brushing our teeth, noting time, reading in light and countless other things recognize the use of technology. Modern science and technology have changed our lives in many dramatic ways. Airplanes, automobiles, communication satellites, computer, plastics and T.V. are only a few of the scientific and technological inventions that have transformed human life.

Development of nuclear energy as source of power, development of better varieties of plants and highly effective fertilizer, development of antibiotics and new drugs which help to control may infections, diseases and also studies on anatomy and physiology have led to emerging new surgical operations and to invention of life caring machines that can do the work of organs as lungs, kidneys etc. Their impact on our life is

a double edged sword and students must recognize the need to balance the use of technology in their lives.

We must point out science education today does not have enough examples from practical life. As a result, we are not able to use concepts in our daily life. The practical implications for life are totally distinct from the textbooks. It is not surprising that the students who are good at using ideas with the help of the textbook get puzzled by similar issues in daily life.

Science education does not develop the ability to analyze or discuss the possibilities to solve the problems that the individual and the society faces, and fails in creating an attitude that is required for solving a problem. There is also no scope for developing scientific awareness. Nothing is learnt of science if the child does not pass through stages of observation, data collection, data analysis, arriving at a conclusion, calculation and inference. Study of science should further pass through phases like locating an issue, its analysis, experimentation and observation. By taking up projects that are research-oriented, and undergoing the process of arriving at an inference, identifying mistakes and gaps child learns science and about life. The learner should pass through all the stages that the scientists pass through including temporary hypothesis formulation. Science education at present does not create such a favourable circumstance for any of this.

Chapter -5
Academic Standards

For teaching science as a subject in school education we need to put the objectives of science teaching for various stage of school education. The expected goals (?) of different stages of science education are as below:

Primary Stage

At primary stage the child is engaged in joyfully exploring the world around her and harmonizing with it. The objectives at this stage are to nurture the curiosity of child about the world. To achieve this, the child should be engaged in exploratory and hands on activities.

Children in grades 1 and 2 are expected to observe their environment, which they are naturally inclined to do, and express themselves through talk (asking questions, describing things), drawing, and making things. At this stage simple exercises in quantitative thinking including simple measurements are to be introduced.

In grade 3, in addition, reading and writing ability improves, and the child will express themselves also through writing. The child can make estimations and measurements, ask questions, and make reasoned guesses. Exploration of the environment continues to be an important part of the science curriculum.

In grades 4 and 5 reading and writing skills improve; quantitative thinking gets strengthened. Some basic concepts, at the experiential level, are developed; the child engages in simple systematic investigations, which include reasoned guesses and ways of testing them through reasoning, discussion and activities and experiments. Make systematic observations guided by the teacher as necessary. Some of these will be student initiated. The teacher will guide children; we wish to emphasise that guidance is not to be interpreted as instructions. Design and crafting, measurements, estimations, are an integral part of the science experiments and activities. Transitions of concepts become more evident.

In grades 6-8, children grapple with some basic concepts in science, many requiring more advanced mathematical skills than those of the primary years. They become more articulate in oral and written communication. They become more able, particularly in grades 7 and 8, to handle abstract concepts. Investigations requiring more advanced skills than in the primary years, and perhaps of longer duration, are Carried out. They work well in groups.

In grades 9 and 10, children are able to handle greater levels of abstractions and more complex ideas; mathematical skills and language ability have improved. They

continue to carry out investigations, are able to organize data, and interpret the results to answer a question; they are able to reason and justify their conclusion. They become more skilled in design and fabrication, and in handling apparatus.

Throughout grades 1 to 10, the quality of questions (trying to resolve conflicts between what is taught and what is observed, for instance) changes, reflecting higher order thinking.

Throughout grades 1 to 10 teachers and curricula facilitate the development of these skills and processes through activities, field trips, involving children in doing experiments, drawing attention to aspects in the environment and through questioning and sustained discussion involving all children in the class.

ACADEMIC STANDARDS - LEARNING OUT COMES

CONCEPTUAL UNDERSTANDING

This is not a mere understanding about principles, formulae and experiments. Children are able to compare, classify, explain, reasoning, explain cause and effects, give examples. These are can be done by children through conceptual understanding.

ASKING QUESTIONS AND MAKING HYPOTHESIS

Children are curious in nature. They should ask questions for conceptual clarity. This promotes the habit of inquiry for making hypothesis.

EXPERIMENTATION

Children satisfy only when they prove their hypothesis to know either it is wrong or right. for this experimentation is needed. Children able to do experiments with in the school or out side school environment by using available material.

INFORMATION SKILLS

Children fond of collecting information and material what they wan in their surroundings. science teaching should develop data collection, recording and reporting, analyzing information on data, conclusion, generalization, presentation of information through tables or graphs among children. this makes the m to explain their understandings about various concepts in a scientific way.

COMMUNICATION THROUGH DRAWING AND MAKING THINGS

Children are able to represent their conceptual understanding through drawing. They are able to explain them by using proper scientific terminology. Children also can make different models by using clay, waste materials etc.

APPRECIATION AND AESTHETISENCE

Children are able to understand reality of nature. They ready to accept and respect the things that encounter in their daily life. They should be able to understand the discrimination between good and bad, and judge them. This makes the children aesthetic perspective personals

CONCERN TOWARDS BIODIVERSITY- APPLICATION IN DAILY LIFE

Ultimate aim of science learning is to understand the diversity of nature. Children are able to show concern towards biodiversity in the sense of environmental protection. They should follow that in their daily life situations.

Chapter -6

Assessment

The examination system occupies a centre place in our entire education system and has become so stifling that it ought to be debated in detail and transformed radically.

There are two specific major deficiencies in the current examination system of science. The science papers do not attempt to assess understanding of the subject. They contain formal questions, which can be handled by rote learning. There are no occasions for thinking, for discussions, no challenging problems are posed and no experiment based questions. Secondly, the board examinations are held on a fixed date for the whole year of learning. This feature coupled with the exaggerated importance attached to the external examination leads to a lot of stress in the run up to and the post examination scenario.

Article 29 (2) (H) in chapter-5 of Right to Education Act says that emphasis should be on the child's comprehension and its assessment without stress. It suggests evolving a strategy that assesses conceptual understanding, initiative creativity, ability to work with colleagues and not just responding to known questions, with well formed remembered answers. RTE also suggests CCE (Continuation Comprehensively Evaluation)

What is CCE?

The CCE or Continuous and Comprehensive Evaluation system refers to a school – based evaluation of students that covers all aspects of development in a student. Continuous assessment while teaching learning means regular but stress-less assessments, frequent tests as part of regular class analysis of learning gaps, applying corrective measures, retesting and giving feedback to students and the teachers doing their self-evaluation, etc. Comprehensive besides covering the entire program for the discipline is also attempts to cover both the scholastic and the co-scholastic aspects of a student's growth and development.

Change Needed in the Assessment System

Need to bring in continuity in evaluation and assessment. The scope for this assessment should be broad based.

- Tracking learning progress and gaps in students regularly to make appropriate changes in the program.
- Employing a variety of measures for teaching based on learning needs and potential of different students. Respecting diversity and desisting from using negative comments on the learner's performance.

- Using the regular activities for assessment of learning and involving learners in the learning process actively.
- Recognizing and encouraging broader abilities of students. Respecting those who do not excel in academics but perform well in co-curricular areas. We need to give the student an opportunity to improve.
- The process of assessment must include both peer and self assessment. The assessment criteria as well as assessment results must be shared with the student in a manner that enables him to feel positive and improve.
- We should overcome the notion of textbook-based evaluation. Assessment needs to include elements that the textbooks do not contain. The scope of evaluation should be widened by adding non-formal and co-curricular elements.
- In sciences, it is necessary that every test item should make the learners think and/or experiment. The tasks for assessment should be challenging. There must be open ended questions in the exam.
- It is not correct to ascertain the future of the child on the grounds of time-bound examinations and on mere scores. No child should be deprived of the opportunity of continuing education. There must be opportunities for her to take the exam at his / her convenience.
- There is a need to bring in total change in the process of evaluation. Self-designed exam papers will be more reliable and more innovative. They must also include group activities and projects as a part of examination.
- It may be useful to gradually move towards examinations that are like open-book exams. Test items should be designed accordingly and should relate to real life and experiences of the children.
- Progress reports should reflect all-round development of the child.
- Anecdotes and portfolios should be maintained.

The entrance examinations for engineering and medicine have tests that include problem solving and critical reasoning abilities. These examinations are however, also becoming an Instrument of social divide. The directional gap between the conventional board examination paper and the national level exams is very large. This gap encourages a flourishing coaching industry. This gap can be reduced by discouraging rote learning and emphasizing problem solving.

Summary of Proposed Key Reforms in Examination

- The examination should not create fear or stress to the student.
- Evaluation should be continuous and comprehensive and it should be the part and parcel of daily teaching learning process. It should not be restricted to rote memory.
- The examinations should not be restricted / limited to writing but extended to assessment tools like observation, discussion, note- taking / recording, collection of opinions etc. the assessment should not only be teacher - based but also on peer groups, parents and other.

There should be co-ordination among learning evaluation and objectives. Students' notebooks, their written exhibits and all their other objects should be treated as assessment inputs. For self- evaluation of students, quality remarks check - list should be utilized.

There is no need to test all the teaching items taught in the classroom. But only some important items must be checked comprehensively at random. After evaluation action plan for improvement of the child and the school should be prepared.

Chapter -7
Teaching Learning Strategies / Methods

Teaching Methods

Teaching of science should not be mechanical and involve mere reading aloud of the textbook by the teacher, explaining the content, and preparing for exams.

A variety of teaching learning methods need to be adopted by the teacher to develop process skills among children. These methods include relevant and interesting projects for involve data collection, analysis, reporting, reasoning and inference.

The teacher's role, largely, is not to give answers but to guide children so that they arrive at the answer through processes of exploration and discussion. However one has to keep in mind that all facts and concepts or ideas cannot be left for the child to fathom or discover for herself. The materials may have to help her in that and tell her some of these unambiguously (for example, that matter is made up of atoms; that bacteria exist, etc.). In Design and Fabrication units each child must have his/her own ideas. Children are to be encouraged and supported, and not given readymade solutions by the teacher.

The teacher has to provide an environment in the classroom that encourages children to learn through activity, experiment and discussion (with peers as well as the teacher).

Teacher must be equipped to have open ended discussions in the classroom and be able to support and encourage a process that supports guided inquiry and promotes learning.

Children must be interested in the activity and therefore the context for the dialogue must be set up. Questions need to be asked not only after an experiment or activity, but also before, in order to set the stage and provide context, and to enhance participation.

The teacher has to provide a democratic and non-discriminatory environment in the classroom for free expression of ideas and promoting collaborative work.

The Classroom should have resource material for activities and experiments etc. in sufficient quantity for each child or small group of children in the class. The teacher himself / herself has to develop skills in handling the equipment and apparatus and help children in developing these skills. Children need to be involved in management of these materials.

Libraries should be made used effectively by giving home work / exercise to the learners they need to attend library and refer various reasonable books and material from library. Specific interventions need to be introduced to ensure students to go library and read science books and attempts to be made to encourage and evaluate what books the children have read and learnt and discussed with their co-learners.

Chapter -8

Teaching Learning Material

Science deals with nature and the environment around us. The teacher and learner of science can draw upon various rich resources available from our social Physical and Biological environment. Effective science teaching requires a recourse rich classroom. We must remember that classroom may be either indoor or outdoor.

These resources need to be available close at hand to children and not be one per class. This implies that they have to be easily available and inexpensive. The nature of tasks children have to do using them must be such that they get them to think and learn to conduct experiments. Their easily acceptability is also decided by their availability, accessibility and their costs.

We must remember that that the text Book is the 1st hand available resource for a science teacher, it should be prepared and used effectively. The Qualities of a good science book are enlisted here under.

- The text book should give ample scope to the learner to engage with it with various strategies and activities.
- Basically the text book need to give room for
  - Context questions and situations
  - Scope for thought provoking questions
  - Questions and tasks of exploration and asking the elders or from the library.
  - These could also include situational activities and projects with the task. "Do this (description of the task) and tell the class what you have learnt?"
- Leaving place for the learner to write answer and do exercise and drawing labelling, then and there in the Text book.
- Along with text books writing in good manner we have to produce supplementary Reading Material for teachers and students, work books for learners, working cards or sheets to involve children in learning. Teachers books (Guide) have to be prepared with required elements that support teacher.
- Experiments and activities are the basic for learning of science. List of specific activities and experiments to be conducted for each class have to be prepared along with guiding notes to the teacher to take the activities successfully. Necessary arrangements need to be made to equip each school with required science Laboratory material equipments and instruments to entertain activities and experiments effectively.

Chapter -9

Teacher Preparation and Support

The issue of teacher preparation has been discussed and debated for a long time. The present models of teacher preparation have not really succeeded to empower the science teachers. Therefore it is imperative to restructure teacher preparation. A renewed effort towards preparation of good quality teachers should gain priority.

In science education the teacher needs to be confident in this conceptual understanding, knowledgeable about, how society perceives science, about how children learn and about how children learn.

More over steps and strategies need to be taken up to develop in the teacher competence and confidence to conduct science experiments successfully.

Classroom Management:

School Management and other authorities' needs to be sensitized to the expectation what an excited energized activity based classroom looks like.

Science teacher preparation curriculum should emphasize process skills and methodological aspects of science and should be informed by historical and developmental perspectives of science. Teachers training must follow the same principles of science pedagogy as is advocated by them for the schools. The entire training must thus involve teachers taking up challenges, problems, conducting experiments, observing, recording, inferring, reading carefully, discussing and debating, articulating ones view, etc.

A mechanism of peer group interaction among teachers for concepts must get formed within school and between schools modes of academic exchanges.

In service programmes need revamping. The quality and efficacy of in-service programmes needs to be improved and based on needs.

Teachers get about 60 days of vacation in a year. A part of this should be meant for professional improvement. The holiday in-service programmes should be organized during these breaks. However, they may be compensated suitably by providing leave.

'The Value of Science', *The Pleasure of Finding Things Out: The Best Short Works of Richard Feynman* (1999, pp. 141-149).