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"Role of youth in implementation of climate change initiatives is important"

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Contents

EDITORIAL

The current issue comprises articles from various fields of science contributed by researchers and academicians from the field of science education and knowledge to help young science enthusiasts and our readers.

In the article 'Inculcation of Values through Science Experiments at the Secondary Level' the authors highlight that a large number of values can be developed among learners through various science experiments. Some of the values which can be inculcated are minute observation, analytical thinking, patience, self confidence, etc.

The article 'Convergence of Science and Humanism' states that emphasis upon science and technology today has produced a materialistic civilisation and consumer culture in which the higher values of mankind especially the spiritual well-being is ignored. The author, therefore, wants to conceptualise a new concept of science that is holistic in approach towards mankind and transcends the sphere of the rational.

In the article 'Scientific Attitude and Gender Differences in Biology', the findings of the study indicate that no gender disparity exists in the scientific attitude of male and female students in biology and that scientific attitude in biology comes from gender bias.

The major findings of the study 'Responsiveness of NCERT Science Textbooks at the Secondary Stage Towards Environmental Concerns and Issues' show that the NCERT science textbooks at the secondary level are responsive towards the environmental concerns and issues to a certain extent but there is still a lot of scope for inclusion and integration of environmental content.

In the article 'Problem Based Learning in Basic Physics - XII' authors say that the fundamentals of physicas can be cleared through problem based learning.

In the article 'Protecting the Planet: Role of the Youth' the author talks about the role of young people and their active participation in protecting and improving environment. Youth of today can create awareness in societies, run educational programmes towards conserving our environment and promote renewable energy and can work towards environment-friendly practices.

In the article, 'Computational Physics with Spreadsheet – II', the author discusses how the spreadsheet becomes an efficient means of generating data from the known mathematical relations.

In addition to the articles and research papers, there are some informative and fun science snippets given in the 'Science News' and 'Web Watch' sections for our readers. We wish our readers a very productive and happy reading.

INCULCATION OF VALUES THROUGH SCIENCE EXPERIMENTS AT THE SECONDARY LEVEL

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Science is a systematic study and knowledge of natural and physical phenomena. In this era, scientific education is much emphasised in all societies the world over. The main goal of science education is to prepare the right type of environment for the individual, to allow learners grow physically, mentally and spiritually in order for them to develop harmoniously over time together with fellow human beings. According to *NCF-2005,* a teacher should act as a facilitator and not as a transformer of contents where they can think, realise, analyse and develop their own way of learning something beyond the textbook. The *National Curriculum Framework* for school education brought out by NCERT (2005) mentions that school education in the country seems to have developed some kind of neutrality towards the basic values. The *National Policy on Education* (NPE) (1986) has clearly emphasised the need of learning of science as a part of general education without compartmentalising into its different disciplines. The NPE (1986) reflects the government's desire to make readjustments in the curriculum in order to make education a forceful tool for the cultivation of social and moral values. Science operates through its processes. Hence, science teaching is to be different from that of the other subjects. Mere question answer method will not be enough. Thinking based upon keen and minute observations with the help of activities/experiments skill is to be generated amongst the learner. Teaching-learning of science needs to be characterised by focused emphasis on processes of science. Learning of science increases the spirit of enquiry, creativity and objectivity along with aesthetic sensibility. It aims to develop well-defined abilities of knowing, doing and being. It also nurtures the abilities to explore and seek solution to the problems related to environment and daily life situations and to question the existing beliefs, prejudices and practices in society. Science concerns itself with the fundamental knowledge of universe, world and its environment. In the light of NCF, it is now being felt that technology (science of mechanical and industrial arts) is increasingly influencing our quality of life. Hence, there is a need to promote values through technology infused science using practical skills at the upper primary and secondary stages. The main objective of this article is to develop practical skills in order to enrich the science teachers in learning the systematic performance of science experiments to relate the science concept values effectively at the school level.

Key words: Value, science and technology, practical/experiment skill, scientific process.

Introduction

Science teaching through value education and society is indispensable. Society equips education with the values to be transmitted while science education exposes each generation of young people to the existing beliefs, norms and values of their culture. This demands a careful selection of the values that would help to integrate the society and promote the mutual relationship between man and his environment. Science operates through its processes. Hence, science teaching is to be different from that of the other subjects. Mere question answer method will not be enough. Thinking based upon keen and minute observations with the help of activities and experiments, skill

is to be generated amongst the learner. Teaching- learning of science needs to be characterised by focused emphasis on the processes of science which may consist of the following steps,

(i) Careful observation

(ii) Sensing of problems

(iii) Making hypotheses

(iv) Literature survey or consulting teachers or a friend

(v) Identification of a particular problem

(vi) Experimentation for seeking solution

(vii) Data collection and analysis

(viii) Interpretation of data

(ix) Drawing inferences

(x) Modification of hypotheses and scope for further studies.

In our classroom teaching, we will have to perform activities for removal of misconceptions, if any, and develop and strengthen the concepts on the basis of seeing, doing and thinking. This will lead to the development of one very important value, i.e., truthfullness besides the other related values of critical thinking and reasoning. The experiment should be so designed that its results are clearly interpretable. Interpretation becomes difficult if the variables are not identified and suitably controlled. The initial design of the experiment must be carefully looked into so that some of the possible sources of error can be located and steps are taken in the design to correct them. Before actually starting the experiment, a list of materials required must be prepared and procured. It would also be convenient if a method of recording the data has been decided upon, so that the necessary tables, etc., could be prepared before the experiment is started. During the experiment, accurate observations must be made and duly recorded, exactly as they happen. The data collected should be arranged in a methodical manner so that interpretations would be facilitated. The results and conclusions of the practical experiment will have to be presented finally as a report. There are a number of ways in which the experiments can be modified and improved. If these practical skills can generate ideas not only for improvement of the suggested designs but also for new experiments, their purpose would be amply served. Science teachers at the school level must be trained properly to perform some basic experiments in order to inculcate scientific temperament and appreciation for science. Use of the practical skills for science concepts may be helpful to understand several scientific terms which include the following:

1. To stimulate an interest in science.
2. To improve experimental and communicational skills and to develop scientific attitude and interests.
3. To inculcate divergent thinking and cooperative attitude among students.
4. To establish a sound fundamental knowledge of facts and principles.
5. To satisfy scientific curiosity.
6. To encourage independent thinking.
7. To make use of the environment.
8. To practice critical thinking.
9. To develop problem solving techniques.

10. To make scientific principles more meaningful.
11. To increase self-confidence.

The value of experiment skill for science concepts can make the study of science more exciting, enjoyable and educational. This provides an opportunity to teachers and learners to get a first hand experience of the process involved in scientific concepts at the school level. It represents method of helping learners explore their special interests in depth. The findings are often far more valuable to the students who are involved than the information presented in regular class periods.

Values: The word, value is derived from the Latin word, '*Valeric*' meaning to be strong and vigorous. Value means 'worth', 'importance' and 'utility'. To be of value is to have certain virtues. A widely accepted definition considers value to be conceptions of the desirable influencing selective behaviour. A value is a belief upon which a man acts by preference. Values are attributes that confer on man humanism and peace. Values are concepts that conserve, comfort, promote and protect life. They shape the moral personality of an individual. Values enhance the finer side of one's potential. A value is a real relationship between a person and an environmental situation which evokes an appreciative response in the individual. Kireet Joshi (1981) mentions that the education that promotes among youth the values of self-control, discipline and right habit of thought and conduct is necessary. True education is a man making education. Values foster peace, order, dignity, grace and delight. Value in one word is the divine side of a man. Real education should become an instrument of social change and national development. It should move towards humanism, liberalism and universalism.

Any human activity, thought or idea, feeling, sentiment or emotion which could promote self-development of the individual in all its dimensions could be said to constitute a value. Value should also confine to the welfare of the larger social units, such as, the family, the community, nation and ultimately the whole world of which the individual is a member. Value education is not simply a matter of choosing a set of values from among competing values and then transmitting them to the students but internalizing those values in one's personal life.

The National Policy on Education (1986) lays emphasis on value education. The NPE clearly reflects the government's desire to make readjustments in the curriculum in order to make education a forceful tool for the cultivation of social and moral values. *National Curriculum Framework for School Education* brought out by NCERT (2005) mentions that school education in the country seems to have developed some kind of neutrality towards the basic values. The curriculum further emphasises that a comprehensive programme of value inculcation must start at the earliest stage of school education as a regular part of the school's daily routine. The entire educational process has to be such that the boys and girls of this country are able to know 'good', to love 'good' and to do 'good', and grow into mutually tolerant citizens.

SCIENCE PRACTICALS AND VALUES—
A five-days training programme (24–28 October 2015) on practical skills for secondary science

teachers of the western states (Madhya Pradesh, Maharashtra, Gujarat, Chhatishgarh, and Goa) were conducted by the authors for the implementation of NCF (2005) in their respective states. The participants were taken to the chemistry laboratories at the Regional Institute of Education, Bhopal for conducting a few simple science activities and experiments to discuss whether some values can really be developed by performing some experiments. The following experiments were conducted:

1. Determination of pH of various solutions.
2. Determination of chemical properties of metals and non metals with oxygen and nature of their oxide.
3. Separation of mixture compound (by sublimation method).
4. Cleaning of muddy water.
5. Separation of two immiscible liquids

Participants of the groups were of the view that a large number of values can be developed among learners through various science experiments, provided they are conducted scientifically. The values, which the groups feel can be inculcated through science experiments, are:

1. Systematic procedure
2. Keen and minute observations
3. Analytical thinking
4. Scientific attitude
5. Open mindedness
6. Mutual cooperation
7. Patience
8. Sense of belongingness
9. Social concern
10. Self-confidence, etc.

Details of a few simple experiments along with a list of various values developed through each of them are given below:

Determination of pH of Various Solutions

Principle: pH of solutions (lemon juice, tomato juice, baking soda and washing soda solution) can be determined with the help of pH paper. A substance is said to be acidic if its pH lies below 7 to 1 and alkaline if pH lies above 7 up to 14. The pH bears a spectrum of colours corresponding to different pH values.

Mental Processing: Preparation of given fruits and salts solutions keeping a solution in mind.

Procedure: The pH of solution can be determined by dipping the pH paper in the solution and matching the colour thus obtained with the standard colours indicated on the pH paper. When the fruit juices of commonly available fruits like lemon, orange, tomato, baking soda and washing powder solutions were used for determination of their pH, the results as given in Table 1 were obtained by the participants. The values which can be developed as a result of this activity as reported by the participants are given below:

1. Keen observation
2. Confidence
3. Mutual cooperation
4. Scientific temper
5. Reasoning
6. Truth

Table 1: pH and colour change with pH paper of different solutions

S. No.	Fruit juice/ solution	Colour change	pH
1.	Lemon	Orange	4
2.	Tomato	Orange	4
3.	Baking soda	Dark green	9
4.	Washing soda	Dark blue	11

Determination of Chemical Properties of Metals and Non Metals with Oxygen and Nature of Oxide

Principle: When magnesium ribbon/metal burns in the air (burner) it forms magnesium oxide. If MgO dissolves in water it forms Mg $(OH)_2$ which turns red litmus blue.

$2Mg+O_2 \rightarrow 2MgO$

$MgO+H_2O \rightarrow Mg(OH)_2$

Whereas, when sulphur is burnt in the air it forms sulphur dioxide or sulphur trioxide. Sulphur dioxide when dissolved in water forms sulphurous acid, which turns blue litmus red.

$S+O_2 \rightarrow SO_2$

$SO_2+H_2O \rightarrow H_2SO_3$

Mental Processing: Metals and non metals occur in ore and mineral forms. They contain different types of properties which indicate their specific behaviour or character during an experiment.

Procedure: Hold magnesium ribbon using tong and burn it on a Bunsen burner. Collect the ash in a watch glass; note its colour and state. Dissolve the collected ash in 15 mL distilled water in a beaker and check the nature of this solution with red litmus. For sulphur take a deflagrating spoon with sulphur powder and burn, and immediately introduce in the gas jar containing water, cover the lid tightly. When the fumes cover the whole jar remove the deflagrating spoon. Shake and stir the jar gently, so that the gas gets completely dissolved in water. Check the nature of the solution with blue litmus.

Values Developed

1. Reasoning
2. Problem solving
3. Systematic approach
4. Critical thinking
5. Learning by doing
6. Decision making
7. Scientific temper

Separation of Mixture Compound (by Sublimation Method)

Principle: Some substances change directly from solid to vapour state on heating and on cooling vapour changes into solid. This phenomenon is called sublimation.

Mental Processing: Thinking, reasoning and changing the state of the substance.

Procedure: The mixture of two compounds (Iodine and sand) was taken and its physical properties were observed. One compound was found to be soluble in water having unique smell. The smell resembled that of iodine. We were told that one of the compounds converts into gaseous state directly on heating. The mixture was taken in a beaker and placed on a tripod stand. Cold water and an ice containing conical flask kept were on beaker. On heating, iodine changed

into vapour directly and condensed into a solid substance on the surface of the conical flask from where it was collected easily. Sand was left as is inside the beaker. In this way, the two compounds got separated.

Values Developed

1. Patience
2. Thinking
3. Reasoning
4. Systematic approach
5. Critical thinking
6. Confidence
7. Pleasure
8. Mutual cooperation

Cleaning of Muddy Water

Principle: Aluminum cations present in the potash alum fasten the process of coagulation as a result of which heavy suspended particles settle down at the bottom of the container.

Mental Processing: Thinking of a solution and cleaning.

Procedure

1. Treatment of muddy water with a small amount of alum to coagulate the smaller insoluble particles and allowing them to settle down at the bottom of the container.
2. Decantation.
3. Separation of impurity to get pure water.

Values Developed

1. Societal concern
2. Sense of belongingness
3. Patience
4. Development of a procedure
5. Development of reasoning and critical thinking
6. Importance of pure water
7. Problem solving ability

Separation of Two Immiscible Liquids

Principle: This experiment is based on the principle of difference of specific gravity. The Liquid with low specific gravity remains in the upper layer while the one with higher specific gravity remains in the lower layer.

Mental Processing: The liquids provided were clear. Each of them left some mark on the walls of the container, one of them having an offensive odour.

Procedure: Name the two liquids A and B and took 20 mL of each with the help of a measuring cylinder in a beaker. Two layers are formed. Then this solution of two immiscible liquids are transferred to a separating funnel kept on our seat. The two liquids are shaken vigorously and then allowed the separating funnel to remain undisturbed for some time on a tripod stand till two distinct immiscible layers appeared. Open the pinch-cock of the funnel and transfer the lower layer in one beaker and upper layer in the other beaker. Thus two layers of immiscible liquids are separated.

Values Developed: After completion of this simple activity we feel that the following values can be inculcated:

1. Handling of the glass apparatus and successful separation of the two liquids develop self-confidence.
2. Initiation for performing other scientific experiments.

3. Understanding of the environment and applying application of this principle in daily life.
4. Development of reasoning and logical thinking.
5. Development of scientific temper.
6. Patience ultimately leading to truth.
7. Seeking solution of problems.

Educational Implication and Inculcation of Values

1. It develops the observation skill and insight of a person.
2. It proves that whole is always important than parts.
3. We had a whole situation and on its overall observation we succeeded in reaching a logical conclusion.
4. Such type of an activity develops handling of apparatus, reasoning, scientific attitude and creativity.

CONCLUSION

The teachers and the practitioners for inculcation of values through science teaching can think of such types of classroom activities and problems in science and technology. However, it may be remembered, it is not an overnight exercise. Values are learnt or inculcated by a long and continuous process. Values can be inculcated only when we practise them, follow them in schools, colleges and society. Students consider teachers as their models. Therefore, before taking up the task of value inculcation amongst our students, we teachers, teacher educators and administrators will have to present ourselves as models for our students and rid ourselves from the clutches of politics and selfish motives.

REFERENCES

Abrahams, I., and R. Millar, 2008. Does Practical Work Really Work? A Study of the Effectiveness of Practical Work as a Teaching and Learning Method in School Science. *International Journal of Science Education*. Vol. 30, No. 14.

Joshi, Kireet. 1981. A Report Submitted to the Government of India on *Training of Teachers in the Light of Value-oriented Education.*

Keys, C. W. 1998. A Study of Grade Six Students Generating Questions and Plans for Open-ended Science Investigations. *Research in Science Education*. Vol. 28. pp. 301–316.

Lunetta, V. N., A., Hofstein and M. P. Clough. 2007. Teaching and Learning in the School Science Laboratory. *An Analysis of Research, Theory, and Practice.* In Abell, S. K., and Lederman, N. G. (Eds.), *Handbook of Research on Science Education* (393–431). Lawrence Erlbaum Associates. Mahwah: NJ.

MHRD. 1986. *National Policy on Education* (1986). New Delhi: MHRD, Government of India.

NCERT. 2005. *National Curriculum Framework for School Education*. NCERT. New Delhi.

——. 2005. Textbooks of Science for Classes IX, X. New Delhi: NCERT.

Venkataiah, N. 1998. *Value Education*. APH Publishing Corporation, New Delhi.

White, R. T., and R. F. Gunstone, 1992. *Probing Understanding*. Falmer Press. London.

Woolnough, B. E., and T. Allsop. 1985. *Practical Work in Science*. Cambridge University Press. UK.

CONVERGENCE OF SCIENCE AND HUMANISM

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Science by its very nature delves deep into the mysteries of physical and biological world. But the prevailing rational scientific approach on its own fails to comprehensively unravel many mysteries due to inherent limitations of rational-logical approach. Search for true knowledge and to enquire into the trans-empirical realities the scientists will have to transcend logic to ensure complete happiness leading to physical, mental and spiritual satisfaction of human beings. Man and his world cannot be fully appreciated within the limited sphere of reasoning, experimentation and observation. Engineering of the inner world would call for contemplation, meditation and intuition.

This would require a synthesis of two aspects of human life, namely, material and spiritual. Physical, intellectual and spiritual development must go hand in hand to maintain balance. Purely intellectual or heavily material culture bears in its heart the seed of death. Exclusive emphasis upon science and technology today has been able to produce only a materialistic civilisation and consumer culture in which the higher values of mankind especially the spiritual well-being is ignored. It has led to the present crisis of humanity. The author, therefore, suggests that a complete reversal of direction is necessary to conceptualise a new concept of science that is holistic in approach towards mankind and that transcends the sphere of the rational.

Key words: *Scientific humanism, trans-empirical, pillars of education*

Science and Humanism

Gandhiji diagnosed seven social sins. 'Science without Humanity' was one of them. Thus in his opinion, it is a sin if science considers itself as omnipotent and forgets the human being. Humanism on the other hand lays ultimate faith in humanity. Humanism believes that human beings possess the power or potentiality of solving their own problems. Of course they solve these problems relying primarily upon reason and scientific method. We also term it as Scientific Humanism. Scientific Humanism, as a matter of fact, must represent 'a synthesis between humanism and scientific spirit'.

Science is an interesting discipline. Learning of science becomes meaningful if we are rational in thinking, ready to analyse things and happenings critically, believe in doing and experimenting and are ready to revise in the face of new evidences. Scientists are always open to new ideas. With the progressive refinement of technological tools, science becomes more exact and thus reaches nearer to truth. There is no denying of the fact that it is science alone that can solve the problems of hunger, poverty and conditions of insanitation and illiteracy. It can remove many social evils like that of superstition and forgetting our customs and traditions. Science can explore and utilise vast resources and stop their wastage by

recycle and reuse. Proverbially, science has conquered the planet. It has explored the moon, overcome the natural limits of travel and communication. It stands at the dawn of a new era ready to move further into space and perhaps inhabit other planets. With the help of science we can control our environment, markedly reduce diseases and extend our life-span. The most vital and positive changes that it has brought about has been the development of the scientific outlook in man. Einstein with his rare foresight had commented long ago that the unleashed power of atom is bound to change everything. And now we find ourselves in a situation that requires the evolution of a common humanity founded on a comprehensive view of man which alone can guarantee the survival of mankind.

Science has brought about changes in every field of life but not all of them have been for the good of humanity. Exclusive emphasis upon science and technology has been able to produce only a materialistic civilisation. The prevailing consumer culture ignores the higher values of mankind. It has led to a crisis situation wherein humanity is faced with the threat of nuclear war, exhaustion of earth's natural resources, imbalance in the eco-system, environmental pollution and widespread moral degeneration. Jawaharlal Nehru declared at the 1947 Science Congress that the vital role of science in India is to fight ignorance, poverty and disease, and function as a powerful instrument to bring about a social transformation, so that millions could live longer and happier lives. He says humanity cannot live on reactors alone. The great path of science is to be tempered by something and that something is spirituality. Indeed, "Technology without spiritual life is blind and spiritual life without technology is lame". If the world is not to destroy itself, there is need for human values for survival and for scientific temper and rational outlook.

The prevailing rational scientific approach alone may not be able to solve many mysteries of nature. One must realise the limitations of rational-logical approach. Search for true knowledge may require the scientists to transcend logic to ensure complete happiness – external happiness and internal happiness leading to physical as well as mental satisfaction of human being. The present day scientific culture at best can be termed as lop sided because it leads the humanity to complete materialism with the total neglect of life values like tolerance, unity in diversity, peaceful living, divinity of mankind and respect for all forms of life. This has resulted in the culture of violence, creating fear through terror and distrust among fellow human beings. The answer may lie in the synthesis of two aspects of human life, namely material and spiritual. Erwin Schrodinger maintains "Our science – Greek Science – is based on objectification, ...But I do believe that this is precisely the point where our present way of thinking does need to be amended, perhaps by a bit of blood-transfusion from Eastern thought".

We find that on one hand, science is an ongoing quest for the knowledge of reality as much as it is accessible to reason and experience. On the other hand, it has no means to enquire into the trans-empirical realities. Science, therefore, has been always honest enough to be silent about the spiritual realm which is beyond its scope. Hence the rejection of trans-empirical reality on the basis of scientific knowledge based on empiricism is in itself an unscientific attitude. Denial of the supernatural and the non-empirical realm of reality on the basis of our partial knowledge of natural empirical

world has no justification either in science or in human experience. Within a human being, both the spiritual and temporal aspects have to be perfectly harmonised. Education was defined by Gandhiji as "Drawing out of the best in man – body, mind and spirit." For a balanced development of an individual his physical development, intellectual development and spiritual development must go hand in hand. Purely intellectual or heavily material culture bears in its heart the seed of death. Arnold Toynbee predicted " It is already becoming clear that a chapter of world history which had a Western beginning will have to have an Indian ending if it is not to end in the self destruction of the human race."

In spite of all the scientific and technological advancements resulting in vast materialistic achievements, man is hardly able to rest upon secure foundations. As the world shrinks and it becomes 'one world' or a 'global village' through technological unification, the forces that make for destruction are intensified. In spite of all pervading rational outlook it is hard to ignore that there is something beyond the scientific positive knowledge. The ideal of world peace can be realised only if modern scientific thought admits the fact that the universe has a divine origin and that man has a trans-empirical dimension as well. Swami Vivekananda firmly believed that India could be saved only by preserving its spirituality and cultural heritage.

The very survival of mankind depends on creating a new kind of social institution and tradition without which the new knowledge of science would bring the ultimate disaster. It is by continuously striving to make man the focus of science, that we imbue it with a sense of values, without which science may act as a destroyer of mankind instead of being a liberator. Albert Einstein put it, "a passionate sense of social justice and social responsibility would tell us that statements of scientific facts and relations cannot produce ethical directions which are so badly needed for the world today."

Scientists and technologists particularly in developing countries need to seriously deliberate upon the vision of Acharya Vinoba Bhave of a true scientific society. In his view "a true scientific society will be one where men will build houses of one storey rather than ten, and see that each house has open space around it so that light and air can enter. Science will improve health so much that medicines will scarcely be needed, though the very best remedies will be available if need should arise. There will be doctors, but their services will not be much in demand. Good spectacles will be available, but men of scientific outlook will take care of their eyesight. In the same way aero planes will continue to fly, but they will be needed only occasionally; men will prefer to walk, and in a scientific world there will be little need of artificial lighting, for people will prefer to spend the night sleeping under the stars. Science will not be used to deprive man of healthful bodily labour, but to lighten his burdens and to increase his vitality and vigour."

The fact of life is that the exclusive emphasis upon science and technology today has been able to produce only a materialistic civilisation and consumer culture in which the higher values of mankind are ignored. It has led to the present crisis of humanity. Pollution of air, water and land has become a universal problem. Diseases associated with urban living have increased, noise and congestion add to physical and mental distress. The reliance of modern technology upon the combustion of fossil fuel has brought an increase in atmospheric carbon dioxide. There is a significant increase in the amount of waste products. Unfortunately there

is grossly inadequate facilities for their scientific disposal. The land upon which man depends for his food has been seriously impaired. Well meaning scientists have to change these trends to save humanity.

Man's concern for a peaceful life and harmonious coexistence with his fellow-beings seems to have been never so explicit before the modern age. The International Commission on Education in its Report 'Learning the Treasure Within' talks of one of the pillars of education in this millennium as 'Learning to live together'. To deprive man of his essential transcendental dimension which finds its expression in his religious and spiritual experiences, is to reduce him to something less than what he really is. Many thinkers lay great importance to the achievements of science and technology while they totally disregard the genuine religious and spiritual experiences of saints and seers. The scientific community refuses to take into account the supernatural and extra-empirical facts of reality in its interpretation of man and the world. Obviously a partial view of existence based upon the rational and empirical findings of science can yield only a distorted picture of human reality. A philosophy which does not take into account all the facts of experience whether physical, psychological and spiritual will always be proved inadequate to lead mankind to a life of happiness and peaceful existence.

Further the organised religion is found to be a challenge to the idea of world community. War and global terrorism have marred the modern world more than ever before. Humanity is living perhaps through the most dangerous period in all its history. A deep feeling of insecurity has gripped us all. Man must and will always have some form of religion because to live without faith is impossible. We are aware of the emptiness of our life but we are not able to find a way out of it. The dogmas of traditional religions cannot solve our problems anymore. This is because they have neglected the deeper humane element. The cause of present tension is the lack of adjustment between science and humanism. Science has to be coordinated with the spirit of humanism and that is the most urgent need of mankind today.

In this world of science and technology one confronts with the artificial environment, observes the sophisticated manipulation of machines and techniques but alas the human element is gradually being eliminated. We may recall that in the medieval period the world was considered a sacred order established by god. Every natural resource in the form of plant, bird, or animal, the sun, moon, and stars, the waters and the mountains all were seen as God's creation. Consequently these were considered sacred. A great deal of effort in the mediaeval medieval world went into preserving, fostering and nourishing the sense of realities which we now call supernatural. The highest activity was contemplation. But intoxicated by scientific power and technological superiority we have destroyed this world. At present our society is man-made, not a divine order. It represents a projection of the human mind that has cut its links with the divine. Its ideals are purely temporal and finite and concern only the material welfare of its members. We are told that we can exist in this world only on condition that we adapt ourselves to it. The inorganic technological world seeks to eliminate whole emotional areas of our life. It only demands that we be a new type of being – a type that is not human, has no heart, no affection, no spontaneity, and is as impersonal as the metals and processes of data manipulation in which it is involved.

Fortunately scientists themselves now admit that the best of their theories are but hypotheses. They are aware that these, far from being reached inductively on the basis of objective data, are for the most part simply postulated as the most probable explanation or interpretation of certain data. Also this again is done in accordance with a particular model which the scientist in question happens to have accepted. Basically, scientific theories, or hypotheses, or explanation or scientific truths are statements which either can be verified with reference to empirical evidence or experiment or at least cannot be shown to be false with reference to such evidence or experiment.

The above clearly directs us to critically examine and determine the characteristics and limitations of the scientific reasoning because knowledge of science and technology is primarily based on rational analysis. This reasoning is limited to the material and to the conceptions. Man and his world cannot be fully appreciated within the limited sphere of reasoning, experimentation and observation. Such a science gets restricted to the outer world only. For engineering of the inner world, one has to take recourse to contemplation, meditation and intuition.

Rational science believes in the pursuit of knowledge through senses and intellect. We know sensory knowledge is deduced from sense experience and is probable knowledge. Sense perceptions are often distorted. Observations are always subjective. Since knowledge of modern science is not taken as a matter of deduction but as a result of observation and experimentation they are truth that are contingent and probable and therefore, negation is always possible. Science of inner self, on the other hand insists on development of faculties of intuition. Spiritual science crosses the borders of sense and knowledge. It crosses the borders of intellectual knowledge. It, instead, believes in growing inward, discovering inner self, inner unity through inner vision and intuition. Hence, reducing man to the level of what the reason can perceive or understand about him is to dehumanise him.

If our society is to recover its health, science and humanism must converge by declaring the welfare of mankind as its central theme. Similarly we must get away from a religion that does not have respect for the dignity of man and the rights of human personality. That religion has no place in society which has lost the power of creative expression in conformity with the needs and demands of our age. No religion can hope to survive if it does not satisfy the scientific temper of ours and foster the unity of the world. What is needed today is the preservation of the precious substance of religious reality by translating it in terms and needs of our own day. As a matter of fact there should be only one religion in the world and that should be the religion of humanity.

A complete reversal of direction is necessary to conceptualise a new concept of science that is holistic in approach towards mankind and that transcends the sphere of the rational. Let me end with the saying of Leov Tolstoy "The highest wisdom is one. The highest wisdom knows but one science – the science of the whole, the science that explains the whole creation and the place of man in it."

Keeping in view the inhuman social realities of present day society, it may be concluded that the scientific intelligentsia should come together and review the science curriculum based on a balanced and holistic approach in search for the ultimate truth and meaning of life. Science and

technology education should transform itself into a complete philosophy of life capable of bringing about genuine happiness and universal peace and harmony through recognition of the material, rational as well as spiritual and transcendental dimensions of reality.

References

JALALUDDIN, A. K. AND U. MALLIK. 1983. *Science and Man – An Anthology*. NCERT, New Delhi.

SEN GUPTA, M. 1980. Nehru the Humanist (cash award under Nehru National Solidarity Awards 1979) *National Solidarity Journal*. Delhi.

SINGH, T.D. (ED.). 2010. *Towards a Culture of Harmony and Peace*. Bhaktivedanta Institute, Kolkata.

SCIENTIFIC ATTITUDE AND GENDER DIFFERENCES IN BIOLOGY

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The purpose of this study was to examine the effect of gender on scientific attitude of higher secondary school students in biology. A sample of 300 students, studying in Class XI was chosen from six higher secondary schools of Varanasi city affiliated to CBSE under the administration of either CBSE or Banaras Hindu University. Relevant data were gathered with the help of a tool 'Action - Affection -Thinking Style Questionnaire' (AATSQ) developed by Singh, P. N. (1988). Statistical analysis was made by calculating mean, standard deviation and t-test. The finding of the study indicates that there is no significant difference between scientific attitude of male and female students in biology at formal operational stage.

Key words: *Scientific attitude, biology, formal operational stage.*

Introduction

In all developing countries, science and technology are essential for economic and technological advancement and much attention is given to the teaching, learning and achievement in science subjects, such as, biology, chemistry, mathematics and physics.

Taking cognizance of the importance of science and technology, especially in science subjects, such as, biology is taught in higher secondary schools here to prepare a base for any scientific and technological development.

Biology is one of the subjects which is very important in the well-being of a nation since without knowledge in biology, individuals will not become doctor, radiographers, human physiologists, biochemists, scientists, etc.

For the achievement in biology, students have to develop their cognitive abilities with the help of learning experiences provided by the teachers. For this, the development of scientific attitude is necessary. Today, science is not only conceived as a systematised body of knowledge, but scientific method and scientific attitudes are also supposed to be its important components.

Rationale of the Study

The advancement of technology depends upon the emergence of the scientific knowledge, methods and attitudes. It provides opportunities to develop all intellectual abilities like sense of meaningful observation, facts, reasoning and purposeful thinking among students.

Inculcating the scientific attitudes and developing problem solving abilities are major objectives of science teaching. But our young boys and girls are being alienated from science subjects on a large scale for which they continue to be deprived of the acquisition of scientific attitudes (Johnson, 2006).

Research on science education shows a declining trend in the number of students

pursuing education in science and science related fields. But individual interest in science education is very important for learning sciences. The scientific attitudes have an effect upon student's selection of different subjects and also on their interest and achievement in the scientific knowledge (George, 2000).

It helps in developing scientific mind which is *sine qua non* for achievement in science. It relates human life with the total environment in general. It is a disposition towards a certain object or person, which is based on judgement of facts. It is prompted by actual and factual states of conditions in which we do not employ our emotional and sentimental considerations. Keeping in mind the vision for the advancement of science and technology, the educationists, biologists and policy makers have emphasised the need of scientific attitudes so that the learners may contribute in national development.

Scientific Attitude and Gender

Gender issues have been a major focus of science education. Research has shown that boys have more positive attitude than the girls, as well as higher achievement scores (Rosier and Barkis, 1990). Over twice as many boys have future interest in science than girls (Catasambis, 1995). The same results of females having a less positive attitude toward science than males are found in many studies (George, 2000). Also, Raimi and Adeoye's (2002) findings reveal that there is a significant difference between males and females in terms of their attitude towards integrated science in favour of males.

Research studies have identified a number of factors influencing students' attitudes towards science in general. These can be broadly defined as gender, personality, structural and curriculum variables. Of these the most significant is gender for, as Gardner (1995) argued, sex is probably the most significant variable related towards pupil's attitude to science. This view is supported by Schibeci (1984) in his extensive review of the literature, and more recent meta-analysis of a range of research studies by Weinburgh (1995) covering the literature between 1970 and 1991. The summarised numerous research studies to show that boys have a consistently more positive attitude to school science than girls, though this effect is stronger in physics than in biology. Thus, it is clear from an extensive literature on the subject, mainly as a result of a serious consideration and investigation of the problem in the 1980s, is that girls' attitudes to science are significantly less positive than boys' (Hendley, et al., 1996; Breakwell and Beardsell, 1992; Erickson and Erickson, 1984; Harding, 1983; Harvey and Edwards, 1980; Johnson, 1987; Kahle and Lakes, 1983; Smail and Kelly, 1984). More recent studies have been undertaken by Jones, et al. (2000) and Sjoberg, (2000) using questionnaires with large samples which have also supported this finding.

Thus, a series of review of the related studies on gender differences provides contrasting findings. However, the factors behind these differences are not clear. Hence, gender differences on scientific attitude require further study, especially within an Indian classroom. Here, the investigator has taken the sample at formal operational stage of Piaget, et al., 1960.

The present study takes supposition that there is effect of gender on scientific attitude in biology among higher secondary school students in India.

Research Question

The following research question was in mind of the investigator while dealing with the problem:

Is there any effect of gender on formation of scientific attitude in biology?

Operational Definition of the Term

Scientific attitude: In the present study, scientific attitude has been defined in terms of the following six components:

(1) Rationality

(i) Tendency to test traditional beliefs.

(ii) Seeking for natural causes of event and identification for cause-effect relationship.

(iii) Acceptance of criticism.

(iv) Challenge of authority.

(2) Curiosity

(i) Desire for understanding new situations that are not explained by the existing body of knowledge.

(ii) Seeking to find out the 'why', 'what', and 'how' of an observed phenomenon.

(iii) Giving emphasis on the questioning approach for novel situations.

(iv) Desire for completeness of knowledge.

(3) Open-mindedness

(i) Willing to revise opinions and conclusions.

(ii) Desire for new things and ideas.

(iii) Rejection of singular and rigid approach to people, things and ideas.

(4) Aversion to Superstitions

(i) Rejection of superstitious beliefs.

(ii) Acceptance of scientific facts and explanations.

(5) Objectivity

(i) Observation free from personal judgement.

(ii) Interpretation without making any modification in present social, economic and political conditions.

(6) Suspended Judgement

(i) Unwilling to draw inference before evidence is collected.

(ii) Unwilling to accept things and facts that are not supported by convincing proof.

(iii) Avoiding quick judgment and confusion.

Objective of the Study

The main objective of the study was as follows:

To find out the effect of gender on the scientific attitude in biology of Class XI students.

Research Hypothesis

The following hypothesis was framed for the present research study:

HR1: There is a difference between scientific attitudes in biology of male and female students.

Null Hypothesis

The following null hypothesis was tested at 0.05 level of significance:

Ho1: There is no significant difference between scientific attitude in biology of male and female students.

Method of the Study

The descriptive survey method was used in this research study.

Tool of the Study

Relevant data were gathered with the help of the following tool:

'Action - Affection - Thinking Style Questionnaire' (AATSQ) by Singh, P. N. (1988).

Population of the Study

Students belonging to Class XI biology group of different higher secondary schools affiliated to CBSE and under the administration of either CBSE or Banaras Hindu University of Varanasi city constituted the population of the study.

Sample of the Study

The sample of the present study consisted of 300 students of Class XI of six different higher secondary schools of Varanasi city affiliated to CBSE and under the administration of either CBSE or Banaras Hindu University. Both male and female students were included in the sample. The sample was selected by random sampling technique.

Finding of the Study

The finding of the study in relation to the objective is presented below:

Objective: To find out the effect of gender on scientific attitude in biology of Class XI students.

Hypothesis tested: Hypothesis H01 was tested to meet Objective 1.

Table 1

Mean and S.D. of Total Sample for Data Variables

S. No.	Variable	Mean	S.D.	N
1.	Scientific attitude	68.61	11.34	300

Table 1 shows the mean and standard deviation of total sample (N=300) for data variable.

Table 2

Mean and S.D. of Male Students for Data Variable

S. No.	Variable	Mean	S.D.	N
1.	Scientific attitude	68.62	11.65	202

Table 2 shows the mean and standard deviation of male students (N=202) for data variable.

Table 3

Mean and S.D. of Female Students for Data Variable

S. No.	Variable	Mean	S.D.	N
1.	Scientific attitude	68.61	10.75	98

Table 3 shows the mean and standard deviation of female students (N=98) for data variable.

Effect of Gender on Scientific attitude

To find out the effect of gender on scientific attitude, t-test was used. Mean and S.D. of

Table 4

Significance of the Difference between Mean Scores of Scientific Attitude of Male/Female Students

S. No.	Gender	N	Mean	S.D.	t-value	L.S.
1.	Male	202	68.62	11.65	0.0073	p→0.05
2.	Female	98	68.61	10.75		

Class XI male/female students for scientific attitude scores and results of t-test are given in Table 4.

From Table 4, it is evident that mean scores of male (68.62) and female (68.61) for the scores on scientific attitude do not differ significantly at 0.05 level ('t' (298) =1.97, p←0.05). Therefore, the null hypothesis that there is no significant difference between scientific attitude of male and female students is not rejected.

Discussion

The result of this study showed that there is no statistically significant difference between scientific attitude of male and female students in biology at the higher secondary stage. From the review of the related studies, it has been found that gender is one of the important factors that influence scientific attitude at formal operational stage (Colley, et al., 1994; Francis and Greer, 1999 and Joyce and Farenga, 2000). But these findings are not significant in this study.

Conclusion

It has now been demonstrated conclusively that social and economic development of a country is closely linked to the educational level of its female population (UNESCO, 2005). It is evident from the findings of the study that no gender disparity exists in the scientific attitude of male and female students in biology of higher secondary school students. This implies that scientific attitude in biology is free from gender bias.

Recommendation

Indian society is traditionally religious in nature. Its material progress can be achieved only by developing scientific attitude among its citizens. For this, the study of scientific attitude and other relevant variables is necessary. The problem of the present study itself is an area which needs thorough evaluation and careful probing. Schools run by state governments may be included in the study. Further a comparative study of both may be conducted.

References

Breakwell, G. M., and S. Beardsell. 1992. Gender, Parental and Peer Influences Upon Science Attitudes and Activities. *Public Understanding of Science*. Vol. 1, No. 2. pp. 183–197.

Catasambis, S . 1995. Gender, Race, Ethnicity and Science Education in Middle Grades. *Journal of Researcher in Science Teaching*. Vol. 32, No. 3. pp. 243–257.

Colley, A., C. Comber and D. Hargreaves. 1994. School Subject Preference of Pupils in Single Sex and Co-educational Secondary Schools. *Educational Studies*. Vol. 20, No. 3. pp. 379–386.

Erickson, G., and L. Erickson. 1984. Females and Science Achievement: Evidence, Explanations and Implications. *Science Education*. Vol. 68, pp. 63–89.

Francis, Leslie J. and Johan E. Greer. 1999. Attitude Toward Science Among Secondary School Pupils in Northern Ireland: Relationship with Sex, Age and Religion. *Research in Science and Technological Education*. Vol. 17, No. 1. pp. 67–74.

Gardner, P. L. 1995. Measuring Attitudes to Science. *Research in Science Education*. Vol. 25, No. 3. pp. 283–289.

George, R. 2000. Measuring Change in Students Attitude towards Science Overtime. *Journal of Science Education and Technology*. Vol. 9, No. 3. pp. 213–225.

Harding, J. 1983. Switched Off: *The Science Education of Girls*. Longman, New York.

Harvey, T. J., and P. Edwards. 1980. Children's Expectations and Realisations of Science. *British Journal of Educational Psychology*, Vol. 50, pp. 74–76.

Hendley, D., S. Stables and A. Stables. 1996. Pupils' Subject Preferences at Key Stage 3 in South Wales. *Educational Studies*. Vol. 22, No. 2. pp. 177–187.

Johnson, S. 1987. Gender Differences in Science: Parallels in Interest, Experience and Performance. *International Journal of Science Education*. Vol. 9, No. 4. pp. 467–481.

Jones, G., and Howe, A. et al. 2000. 'Gender Differences in Students' Experiences, Interests and Attitudes towards Science and Scientists. *Science Education.* Vol. 84, No. 2. pp. 180–192.

Joyce, B.A., and S. J. Farenga, 2000. Young Girls in Science: Academic Ability, Perceptions and Future Participation in Science. *Roeper Review*. Vol. 22, No. 4. pp. 261–262.

Kahle, J.B., and M. K. Lakes, 1983. The Myth of Equality in Science Classrooms. *Journal of Research in Science Teaching*. Vol. 20, pp. 131–140.

Piaget, J., B. Inheder and A. Szemiraka. 1960. *The Child Conceptions of Geometry*. Basic Books, New York.

R. A. Schibeci. 1984. Attitudes to Science: An Update. *Studies in Science Education*. Vol. 11, pp. 26–59.

Raimi, S. A., and , F. A. Adeoye. 2002. Gender Differences among College Students as Determinant of Performance in Integrated Science. *African Journal of Educational Research*. Vol. 8, No. 1&2. pp. 41–49.

Rosier, M. J., and D. K. Barkis. 1990. The Scientific Literacy of Australian Students: Science Achievement of Students in Australian Primary and Lower Secondary. Australian Council for Educational Research. *Research Monograph*. Vol. 39. Hawthorn, Victoria.

Singh, P. N. 1988. Construction and Standardisation of a Test of Scientific Attitude. Ph.D. Thesis in Education, BHU, Varanasi, India.

Sjoberg, S. 2000. Interesting all Children in 'Science for all'. In R. Millar, J. Leach, & J. F. Osborne (Eds.). *Improving Science Education.* (pp. 165–186). Buckingham, Open University Press.

Smail, B. and A. Kelly. 1984. Sex Differences in Science and Technology among 11-year-old School children: II - Affective. *Research in Science and Technology Education*. Vol. 2, pp. 87–106.

UNESCO. 2005. *Scaling up Good Practices in Girls' Education*; UNESCO, Paris.

Weinburgh, M. 1995. Gender Differences in Student Attitudes toward Science: A Meta-analysis of the Literature from 1970 to 1991. *Journal of Research in Science Teaching*. Vol. 32, No. 4. pp. 387–398.

RESPONSIVENESS OF NCERT SCIENCE TEXTBOOKS AT THE SECONDARY STAGE TOWARDS ENVIRONMENTAL CONCERNS AND ISSUES

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The science curriculum at the secondary stage is of great significance in the way that many of the students might not be opting for science at the senior secondary level. Consequently, the secondary science curriculum should help learners develop an attitude which could not only help build a sense of scientific enquiry in whatever they do in their lives but also sensitises them towards their own environment. The curriculum should offer them experiences that could make them responsible for their own activities and empower them to critically look at others' activities from the perspective of environment. Also, considering the present degrading environmental conditions and the relation between science and environment, the secondary science curriculum should provide learners with ample opportunities to engage meaningfully with contemporary issues and concerns related to environment. As the textbooks are one of the most widely used representations of the curriculum, the present research paper attempts to present a critical analysis of the secondary science NCERT textbooks for its responsiveness towards environmental issues and concerns.

Key words: *Environment, environmental education, environmental issues, science curriculum, science textbooks.*

Introduction

Science has a very close association with the environmental concerns and issues in the contemporary world. This is not only because the scientific inventions and discoveries have positive or negative impact on the environment but also because science helps us in understanding the environment per se. Our understanding of the environment varies from being the immediate environment to the local surroundings and widening to the world at large. The understanding of the immediate environment starts with primary science through explorations and discussions about one's environment and extending it to understand others' environment. At the secondary stage, the focus shifts towards understanding the issues and concerns from a scientific perspective that is by applying the concepts of science. The issues and concerns are located in our society and hence cannot be discussed from a single perspective as many other factors may be involved in it. This is one of the reasons that science shares a mutual relationship with society where both influence each other in several ways. Thus, the societal issues and concerns provide the context to understand the environment as well as other concepts in science learning whereas science provides the conceptual understanding behind it. Hence, science classrooms are expected to offer opportunities to the learners to engage with the environmental issues and

concerns for discovering as well as better understanding of the scientific concepts associated with them. Also, in a science classroom it is important to discuss the interrelationship between science and society for understanding the realities and conditions created through the interplay of various factors (economic, political, social) prevailing in a society which is indicative of the fact that science alone may not be a response to the issue in hand. Similarly, science textbooks should present the environmental issues and concerns as part of the contents, activities, illustrations and assessments that support the teachers and provide them the exemplary frameworks for creating holistic learning experiences for children. *NCF-2005* also recommends the infusion of environmental issues within different curricular areas including science. According to *NCF-2005*, at the primary stage the learners should be exploring the world but by secondary stage they should be able to identify the issues at the local environment and discuss those issues. The other dimension is that as we all know about the immense potential of science to empower one with its discoveries and inventions which could be either constructive or destructive. The last century has witnessed many wars using many scientific inventions including the nuclear weapons which has not only caused massive casualties but has also caused devastating effects on our environment. Many of inventions that we are using in our daily lives have been interfering with the natural environment and impacting our environment adversely both locally as well as globally. On the other side, science has contributed in monitoring, analysing, and predicting environmental changes. Indeed, this proves that we should look at the scientific advances critically so that we can use them optimally and sustainably such that there is harmony between the present needs and the necessities of the future generations. The engagement with the environmental issues and concerns in a science classroom should encourage students to think and act sensitively and critically as they are to the future. This necessitated the researchers to study the science textbooks for analysing its responsiveness in nurturing the students' creativity, critical thinking and sensitivity towards the environmental issues and concerns. The important fact that also needs to be mentioned here is that from the immediate basic essentials of life like food, shelter, access to drinking water, to all other important issues by which we get affected like health, energy resources, biodiversity, environment conservation, climate change, global warming, etc.; all have a strong science component to it. And everyone should have their opinions as well as access so as to take part in the regional, national or international debates or to get their voice heard. And such scientifically–environmentally aware citizens could only be created by providing them with a strong foundation at their school level. Since not everyone goes on to become a scientist, it is very important to provide them with a science curriculum at the secondary level which educates them about all these issues.

Historical Journey of Environmental Education

The modern environmental education movement gained momentum only in the late 1960s and early 1970s. In the *Phi Delta Kappan* in 1969, one of the first articles about environmental education as a new movement appeared which was authored by James A.

Swan. The *Journal of Environmental Education* in 1969, authored by William B. Stapp was the journal in which a definition of 'Environmental Education' first appeared. The first Earth Day on 22 April, 1970 — a national teach-in about environmental problems — paved the way for the modern environmental education movement. Internationally, environmental education gained recognition when the UN Conference on the Human Environment held in Stockholm, Sweden, in 1972, declared environmental education must be used as a tool to address global environmental problems. The United Nations Educational, Scientific and Cultural Organization (UNESCO) and United Nations Environment Programme (UNEP) created three major declarations that have guided the course of environmental education. They are the Stockholm Declaration, the Belgrade Charter and the Tbilisi Declaration. The Stockholm Declaration (June, 1972) was the declaration of the United Nations Conference on the Human Environment. The document was made up of seven proclamations and 26 principles to inspire and guide the peoples of the world in the preservation and enhancement of the human environment. The Stockholm Conference produced, among others, the Human Environment Declaration, with environmental guidelines to the participating countries' governments contained in the World Action Plan, and, in particular, recommending the establishment of an environmental education international programme directed at the common citizen's qualification training, in order to enable citizens to manage and control their environments. The conference granted education the status of key element for confronting the emerging worldwide environmental crisis. The Belgrade Charter (October, 1975) was the outcome of the International Workshop on Environmental Education held in Belgrade, Yugoslavia (now Serbia). This charter was built upon the Stockholm Declaration and added objectives, guiding principles and goals of environmental education programmes. This charter is important in the history of environmental education as it extended the role of environmental education programme to the general public. Tbilisi Declaration (October, 1977) is a milestone for the history of environmental education. The venue of this conference was in URSS held by UNESCO in collaboration with PNUMA (UNEP), and this granted environmental education the status of international policy. It established principles and general guidelines for programmes to be prepared all over the world. Since then, what is now called environmental education, focus its efforts on informing and providing the necessary knowledge to make people aware of environmental problems. Awareness-training, consciousness-raising and participation are key words and include, the following goals respectively: to awaken individuals and collectivises to environmental problems; to give meaning to these problems by relating them to daily life; and to offer the indispensable knowledge so that individuals may be able to undertake actions on behalf of their environment and quality of life.

The Tbilisi Declaration noted the unanimous accord in the important role of environmental education in the preservation and improvement of the world's environment, as well as in the sound and balanced development of the world's communities.

The Tbilisi Declaration updated and clarified the Stockholm declaration and the Belgrade Charter by including new goals, objectives, characteristics, and guiding principles of environmental education. Again in 1992, at the United Nations Conference on Environment and Development, known as Rio-92, the importance of environmental education as a tool for a qualitative change in mankind's behaviour towards the environment was reaffirmed. Agenda 21, the document proposed by this Forum, includes a chapter specifically dedicated to this theme, entitled 'Promoting Environmental Education', which deals with the redirection of environmental education towards sustainability. The topics related to environment and sustainable development were also discussed at the Cairo Conference on Population (1994), the Copenhagen Conference on Social Development (1995), the Beijing Conference on Women (1995), and the Istanbul Conference on Habitat (1996) which highlight the importance their on the international agenda (Radhika Iyengar and Monisha Bajaj, 2011). But to be successful in reaching this goal, environmental education should be taught not only in formal schools but also at the so-called non-formal and informal spaces. For consciousness-raising and sensitisation to happen in a wider spectrum, programmes must be established both at formal educational places and at teacher training schools and courses, and at places designed for non-formal and informal education. Within formal education, we already find environmental education as part of the school disciplines, but what we need to see is that it should be given equal importance with other school subjects.

Environmental Education in Indian Context

The national policies and planning on education eventually determine what course a curriculum and simultaneously a textbook and the classroom pedagogies would take. The importance of environmental issues in science could be understood by referring to the criteria for a science curriculum given by *NCF-2005*. Out of the six aims, as prescribed by the *NCF-2005* for an ideal science curriculum, two are related to environment and ethical issues that expect the science curriculum to contextualise the various issues related to science, society and environment. They are:

(a) 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.

(b) Ethical validity requires that the curriculum promote the values of honesty, objectivity, cooperation, freedom from fear and prejudice, and develop in the learner a concern for life and preservation of environment.

This clearly implies that environmental validity on one hand seeks to contextualise the concepts in science by locating them within the leaner's environment whereas the ethical validity requires the learner to develop values that encourage sensitivity, creativity and a critical outlook towards changes in

one's environment. According to the *NCF-2005*, "At the secondary stage the students should be engaged in learning science as a composite discipline, in working with hands and tools to design more advanced technological modules than at the upper primary stage, and in activities and analysis on issues surrounding environment and health" (pp. 48–49). The National Focus Group Position Paper on Teaching of Science also states that "While deciding on gradation of science curriculum, it must be borne in mind that a majority of students learning science as a compulsory subject up to Class X are not going to train as professional scientists or technologists in their later careers; yet they need to become 'scientifically literate', since several of the social, political and ethical issues posed by contemporary society increasingly revolve around science and technology. Consequently, the science curriculum up to Class X should be oriented more towards developing awareness among the learners about the interface of science, technology and society, sensitising them, especially to the issues of environment and health, and enabling them to acquire practical knowledge and skills to enter the world of work" (p.11). According to *NCF-2005*, the present status of environmental education in schools had its genesis in the National Policy on Education (NPE) 1986 (modified in 1992), in which 'Protection of the Environment' is stated as a common core around which a National Curriculum Framework (NCF) would be woven. The National Policy on Education 1986 emphasised the need to create awareness of environmental concerns by integrating it in the educational process at all stages of education and for all sections of society. Accordingly, the National Curriculum for Elementary and Secondary Education: A Framework (1988) presented the NCERT's view that the school curriculum should highlight the measures for protection and care of the environment, prevention of pollution and conservation of energy. In consonance with these documents, Environmental Studies was introduced as a subject at the primary level. The topics related to environment were suitably infused with different science and social science subjects at all school stages. Understanding of the environment in its totality, both natural and social, and their interactive processes, the environmental problems and the ways and means to preserve the environment was one of the General Objectives of Education as per National Curriculum Framework, 2000.

Aims and Design of the Study

The aims of this research are:

1. To analyse the science textbooks at the secondary level for identifying the contents, activities and questions related to environmental issues.
2. To study various opportunities that secondary science textbooks offer to learners for developing their thinking about environment and environmental issues on the basis of analysis of the textbooks.
3. To do a comparative analysis of the Class IX and X textbooks for their environmental content.

The textbook content analysis was done using a grid that was designed on the basis of the 'cognitive process domain' of Revised Bloom's Taxonomy as it is based on different kinds of thinking in which a learner can be engaged with or the learners generally engage in. Thus,

the contents including the text, activities, illustrations, questions were analysed on the basis of their potentiality to engage learners to think in various ways including critical and creative thinking that *NCF-2005* envisages. Also, as the Revised Bloom's Taxonomy is based on the contemporary theories and approaches of learning including constructivism (Amer, 2006) which has been emphasised in *NCF-2005*, hence it seemed to provide a valid framework for meeting the objectives of the present study. The revision of the Bloom's taxonomy in 2001 provided us with a more dynamic system of classification and the Knowledge category was named Remember, the Comprehension category was named Understand, Synthesis was renamed Create and was also made the top category, and the remaining categories were changed to their verb forms: Apply, Analyse, and Evaluate. Taking these six categories as the main descriptors, sub descriptors were framed in the form of questions. These sub descriptors had specific questions to identify and assess the components of all the descriptors present in the textbook. Thereafter analysis was done using this content analysis grid by examining the text and looking one by one for the evidences for each descriptor. The evidences identified for each descriptor has been described or quoted class wise in tabular form.

Analysis and Interpretation

There is a tendency in the education system that most of the contents, activities, etc., are framed in such a way that expects a mere recall from the learners. Thus a deliberate attempt was made by the researchers to analyse the potentiality of the contents of the secondary science NCERT textbooks from the perspective of the Bloom's taxonomy which also reflects the *NCF-2005* as it states that there should be 'systematic experimentation as a tool to discover/verify theoretical principles, and working on locally significant projects involving science and technology, are to be important parts of the curriculum at this stage' thereby focusing on creative thinking (p. 49). The content analyses of the chapters and contents of the Class IX and X textbooks have been done below in a tabular form on the basis of the grid evolved by the researchers:

Descriptors	Class IX	Class X
1. Remembering		
1.1 Does the textbook provide enough illustrations, examples to list, define, identify recognise the environmental concerns?	There are opportunities given in some chapters like the chapter 'Natural Resources' where topics like air pollution, water pollution, ozone layer depletion have been dealt with examples, illustrations and figures to enable children to identify the environmental concerns. For example, in the topic air pollution, it has been	Some chapters in the textbook like 'Our Environment', 'Management of the Natural Resources' give a lot of examples to illustrate the importance of our environment and the hazards that it is facing. For example, examples have been cited to discuss the biodegradable and non-biodegradable substances. Their definitions have also been given. The meaning of the three R's, i.e., reduce, recycle and reuse, is also discussed in detail.

	written that burning of fossil fuels produces different oxides of nitrogen and sulphur which are dangerous for inhalation and also cause acid rain. The definition of air pollution has also been given. In the topic water pollution, it has been listed in points what effects or changes in water accounts to water pollution. For showing the ozone hole, satellite pictures of the ozone hole over Antarctica in the year 1980, 1985 and 1990 are given.	On page 268, in the Box "Do You Know?", the following paragraph is given in which the case of River Ganga has been presented discussing the various causes leading to its water getting polluted. Also, it describes various ways for gauging the quality of water: **Pollution of the Ganga** As you can see, there are some measurable factors which are used to quantify pollution or the quality of the water that we use for various activities.... *Largely untreated sewage is dumped into the Ganges every day. In addition, think of the pollution caused by other human activities like bathing, washing of clothes and immersion of ashes or unburnt corpses. And then, industries contribute chemical effluents to the Ganga's pollution load and the toxicity kills fish in large sections of the river.*
1.2 Does the text provide scope for the children to perform simple tasks or experiments in groups, so that they can share their experiences with each other that helps them to develop a holistic understanding of their environment and hence in remembering the facts in a better way?	Some task and group activities could be included where the children in groups can visit places around their school or in their neighbourhood to study the various environmental issues. This will help them develop a better understanding of their immediate environment.	The text provides some activities to be done in groups. The activities provide learners to recall from their experiences and think critically about the use of certain materials that may be harmful. Such as Activity 16.4 (p. 269): • Have you ever visited a town or village after a few years of absence? If so, have you noticed new roads and houses that have come up since you were there last? Where do you think the materials for making these roads and buildings have come from? • Try and make a list of the materials and their probable sources. • Discuss the list you have prepared with your classmates. Can you think of ways in which the use of these materials be reduced?

1.3 Does the textbook provide enough scope for the students to construct and internalise the knowledge through personal experimentation and observation?	There are several activities followed by some questions in the textbook for the students to construct and internalise their understanding about environmental concerns. Such as Activity 14.6 (p. 193) • Organisms called lichens are found to be very sensitive to the levels of contaminants like sulphur dioxide in the air. As discussed earlier in section 7.3.3, lichens can be commonly found growing on the barks of trees as a thin greenish-white crust. See if you can find lichens growing on the trees in your locality. • Compare the lichen on trees near busy roads and trees some distance away. • On the trees near roads, compare the incidence of lichen on the side facing the road and, on the side, away from the road. This activity is followed by a question "What can you say about the levels of polluting substances near roads and away from roads on the basis of your findings above?" This helps the students in eflecting and understanding the facts and concepts in a very holistic manner. Another Activity 14.12 (pg. 199) is given where the students could search and find out about the facts and in the process may also learn some new information. • Find out what the consequences of global warming would be. Also, find out the names of some other greenhouse gases.	Several activities in the text are given through which the students could construct their own understanding and knowledge through experimenting, observing and discovering on their own. Such as Activity 15.5 (p. 261): • Collect waste material from your homes. This could include all the wastes generated during a day, like kitchen wastes (spoilt food, vegetable peels, used tea leaves, milk packets and empty cartons), waste paper, empty medicine bottles/strips/bubble packs, old and torn clothes and broken footwear. • Bury this material in a pit in the school garden or if there is no space available, you can collect the material in an old bucket/flower pot and cover with at least 15 cm of soil. • Keep this material moist and observe at 15-day intervals. • What are the materials that remain unchanged over long periods of time? • What are the materials which change their form and structure over time? • Of these materials that are changed, which ones change the fastest? This activity would help the students to discover the difference between biodegradable and non biodegradable substance through personal experimentation as well as know the examples which otherwise they would have needed to rote learn.

2. Comprehension (understanding)		
2.1 Does the textbook provide an understanding about the facts mentioned in the book regarding environment so that the learner can describe, explain, paraphrase, give their own examples, summarize, interpret and discuss those issues? – through group discussions – through assignment – through internet search	A few questions have been given in the text which gives them an opportunity to express their personal experiences related to the environmental issues. Such as, Question No. 3 (pg 201). List any three human activities which would lead to an increase in the carbon dioxide content of the air. This question helps the students to think critically and understand the human activities which could give rise to environmental issues.	The textbook does provide opportunities to the students to understand the issues and express their own ideas in the form of activities such as, Activity 15.2 (pg. 257) Use the library or internet to find out more about biodegradable and nonbiodegradable substances. • How long are various nonbiodegradable substances expected to last in our environment? • These days, new types of plastics which are said to be biodegradable are available. Find out more about such materials and whether they do or do not harm the environment. This activity promotes the learners to search and understand about the nature of the different types of pollutants.
3. Application (Applying)		
3.1 Does the text provide opportunities to the students to predict certain situations about the environment upon reading the content?	In few chapters, some activities have been given which provide students the opportunities to predict certain situations about the environment upon reading the content. Such as Activity 14.1 (p. 190): • Measure the temperature of the following: Take (i) a beaker full of water, (ii) a beaker full of soil/sand, and (iii) a closed bottle containing a thermometer. Keep them in bright sunlight for three hours. Now measure the temperature of all three vessels. Also, take the temperature reading in shade at the same time.	The textbook provides some activities and paragraphs through which students get an opportunity to predict certain situations about the environment. Such as, Activity 15.1, (p. 256): You might have seen an aquarium. Let us try to design one. • What are the things that we need to keep in mind when we create an aquarium? The fish would need a free space for swimming (it could be a large jar), water, oxygen and food. • We can provide oxygen through an oxygen pump (aerator) and fish food which is available in the market.

	This activity is followed by some questions: 1. Is the temperature reading more in Activity (i) or (ii)? 2. Based on the above finding, which would become hot faster – the land or the sea? 3. Is the thermometer reading of the temperature of air (in shade) the same as the temperature of sand or water? What do you think is the reason for this? And why does the temperature have to be measured in the shade? 4. Is the temperature of air in the closed glass vessel/bottle the same as then temperature taken in open air? (i) What do you think is the reason for this? (ii) Do we ever come across this phenomenon in daily life?	• If we add a few aquatic plants and animals it can become a self-sustaining system. Can you think how this happens? An aquarium is an example of a human-made ecosystem. • Can we leave the aquarium as such after we set it up? Why does it have to be cleaned once in a while? Do we have to clean ponds or lakes in the same manner? Why or why not? This activity provides the students with the insights for analysing, applying and foreseeing certain real life issues.
3.2 Are the students getting opportunities to apply or relate the concepts to real life contexts?	Some activities and paragraphs are given in the text by which the students might be enabled to apply the concepts in real life situations upon reading it. Such as Activity 14.4 (p.192): • Collect information from newspapers or weather reports on television about rainfall patterns across the country. Also find out how to construct a rain gauge and make one. What precautions are necessary in order to get reliable data from this rain gauge? Now answer the following questions: • In which month did your city/ town/village get the maximum rainfall?	Upon reading the text, the students could be enabled to determine some real life situations of the environmental issues. For example, Activity 16.3, (p. 268): • Check the pH of the water supplied to your house using universal indicator or litmus paper. • Also check the pH of the water in the local water body (pond, river, lake, and stream). • Can you say whether the water is polluted or not on the basis of your observations? Activities like these not only help the students to relate to the different dimensions of the concept of water pollution but they also help them in applying their understanding to their basic necessities of availability of pure drinking water.

	• In which month did your state/ union territory get the maximum rainfall? • Is rain always accompanied by thunder and lightning? If not, in which season do you get more of thunder and lightning with the rain? These activities and questions stimulate the students to think and apply the larger concepts of climate change through simpler tasks of the day-to-day lives.	
4. Analysing		
4.1 Is there enough content that enables the students to classify, categorise the different changes that are taking place in our environment?	Some paragraphs with specific topics like Air Pollution on page 192 and Water Pollution on page 194 have been given in the book but there is a scope for including other categories of pollution as well. Also if we talk about the pollutants, the different types of pollutants that pollute the environment have been covered briefly.	The text has given some activities to the students for enabling them to classify and categorise different types of pollutants around them. For example, Activity 16.4 on page 269: • Have you ever visited a town or village after a few years of absence? If so, have you noticed new roads and houses that have come up since you were there last? Where do you think the material for making these roads and buildings have come from? • Try and make a list of the materials and their probable sources. • Discuss the list you have prepared with your classmates. Can you think of ways in which the use of these materials be reduced? Definitely the textbook does not provide for a clear categorisation of the pollutants, which may be because it is expected for a Class X student to know all these from the knowledge gained in the previous classes but it helps the students in analysing the different categories of pollutants that are being added up by the day-to-day human activities.

4.2 Do the contents enable the students to draw inferences that may help them to identify the causes behind a particular environmental issue upon reading the book? – through field visits or interviews – through activities given at the end of the chapter or between the text – through debating	There are some activities which could enable the students in developing an analytical ability. Such as Activity 14.4 on page 192. • Collect information from newspapers or weather reports on television about rainfall patterns across the country. Also find out how to construct a rain gauge and make one. What precautions are necessary in order to get reliable data from this rain gauge? Now answer the following questions: • In which month did your city/ town/village get the maximum rainfall? • In which month did your state/ union territory get the maximum rainfall? • Is rain always accompanied by thunder and lightning? If not, in which season do you get more of thunder and lightning with the rain? Activity 14.5 on page 192: • Find out more about monsoons and cyclones from the library. Try and find out the rainfall pattern of any other country. Is the monsoon responsible for rains the world over? These activities build the abilities to think and discuss among themselves the causes behind certain environmental issues.	The contents of the textbook to some extent enable the students to draw inferences that may help them to identify the causes behind a particular environmental issue upon reading the book. For example, Activity 15.7 given on page 263: • Find out what happens to the waste generated at home. Is there a system in place to collect this waste? • Find out how the local body (panchayat, municipal corporation, resident welfare association) deals with the waste. Are there mechanisms in place to treat the biodegradable and non-biodegradable wastes separately? Another example is Activity 15.8 on page 263: • Find out how the sewage in your locality is treated. Are there mechanisms in place to ensure that local water bodies are not polluted by untreated sewage. • Find out how the local industries in your locality treat their wastes. Are there mechanisms in place to ensure that the soil and water are not polluted by this waste? Such activities not only enable the students to analyse the causes of the issues related to our environment but they also help them understand how society comes to play a role in the environmental issues.
5. Evaluation (Evaluating)		
5.1 Does the textbook provide the space for the expression of students own opinions about the environmental issues	There are some questions given in the text through which the students could express their opinions about the environmental issues. Some of them are: Question No 5 (Pg. 202).	Some questions are given in between the text as well as at the end of the chapters through which the students may express their own opinion about the various issues related to our environment. Such as (pg. 273):

– by the exercises at the end of the chapter? – by the questions in between the text contents?	We know that many human activities lead to increasing levels of pollution of the air, water-bodies and soil. Do you think that isolating these activities to specific and limited areas would help in reducing pollution? Question No 3. (pg.194). Do you know of any activity which may be polluting this water source? Question No 5. (Pg. 193). List any three human activities that you think would lead to air Pollution. These activities provide the scope to the students to think and be evaluative in the manner that could help them in shaping their thoughts and opinions.	1. Why should we conserve forests and wildlife? 2. Suggest some approaches towards the conservation of forests. Questions (1, 2, 3 & 7) at the end of the chapter on page nos. 278 and 279: – What changes would you suggest in your home in order to be environment-friendly? – Can you suggest some changes in your school which would make it environment friendly? – We saw in this chapter that there are four main stakeholders when it comes to forests and wildlife. Which among these should have the authority to decide the management of forest produce? Why do you think so? – On the basis of the issues raised in this chapter, what changes would you incorporate in your lifestyle in a move towards a sustainable use of our resources?
5.2 Whether the textbook provides contents/ activities where the students get opportunity to critique or opine about the information based on a set of valid criteria? – through classroom discussions – through debates – by taking surveys, interviews	There is a scope for some content for the students to get opportunity to critique or opine about the information based on a set of valid criteria through classroom discussions or through debates or by taking surveys and interviews.	The following contents of the text enable the students to find opportunity to defend their opinions by making judgments' about the information, validity of ideas or the quality of work based on a set of criteria in the textbook. Activity 16.7 (pg.273) Debate the damage caused to forests by the following – (a) Building rest houses for tourists in national parks. (b) Grazing domestic animals in national parks. (c) Tourists throwing plastic bottles/ covers and other litter in national parks. Another example is Activity no 16.8, on page no 273:

		Villages suffering from chronic water shortage surround a water theme park in Maharashtra. Debate whether this is the optimum use of the available water. Such debate related activities helps the students to think and give their views on some larger issues of human-animal conflict, biodiversity etc and enable them to evaluate the gravity of the situation.
6. Creation		
6.1 Does the textbook provide opportunities for the students to enhance their creativity by inventing, designing, modifying some models that could contribute effectively to the environment?	The textbook provides some opportunity for some model designing activity which could further encourage the students for some more innovative ideas. Such as Activity 14.1 (pg. 190) • Measure the temperature of the following: Take (i) a beaker full of water, (ii) a beaker full of soil/sand and (iii) a closed bottle containing a thermometer. Keep them in bright sunlight for three hours. Now measure the temperature of all 3 vessels. Also, take the temperature reading in shade at the same time. Activity 14.2 on page 190. • Place a candle in a beaker or wide mouthed bottle and light it. Light an incense stick and take it to the mouth of the above bottle. • Which way does the smoke flow when the incense stick is kept near the edge of the mouth? • Which way does the smoke flow when the incense stick is kept a little above the candle? • Which way does the smoke flow when the incense stick is kept in other regions?	The textbook provides some activities to the students for enhancing their creativity. Such as Activity 16.11 (p. 277): • Coal is used in thermal power stations and petroleum products like petrol and diesel are used in means of transport like motor vehicles, ships and aeroplanes. We cannot really imagine life without a number of electrical appliances and constant use of transportation. So can you think of ways in which our consumption of coal and petroleum products be reduced? One more such activity can be found on page no 263, Activity 15.7 • Calculate how much waste is generated at home in a day. • How much of this waste is biodegradable? • Calculate how much waste is generated in the classroom in a day. • How much of this waste is biodegradable? • Suggest ways of dealing with this waste.

	These activities not only help the students in understanding the role of atmosphere in climate change and the movement of air but they also help in igniting the spirit of creative learning.	Such activities help the students to think alternative ways and methods for calculating and controlling the waste generation at their immediate environment.
6.2 Does the textbook give the scope to the students for some original, new thinking or a new outlook for the same environmental concerns given in the text?	A few questions are given in the text, which tries to instigate some new thoughts. For example, Question 5 on page 202: We know that many human activities lead to increasing levels of pollution of the air, water-bodies and soil. Do you think that isolating these activities to specific and limited areas would help in reducing pollution? Activities like these help the students to think out of the box and develop a new way to look at the most common day-to-day issues.	Some activities seem to promote original, new thinking which can be demonstrated by the given Activity 16.2 (p. 267): • There are a number of organisations that seek to spread awareness about our environment and promote activities and attitudes that lead to the conservation of our environment and natural resources. Find out about the organisation(s) active in your neighbourhood/ village/town/city. • Find out how you can contribute towards the same cause. Stimulating the students to think of their own ways to solve the environmental issues and contribute to their share of duties would definitely be said to be a very creative activity.

Comparative Analysis of Textbooks along with Interpretation

Descriptors	Comparison of textbooks
1. Remembering	
1.1 Does the textbook provide enough illustrations, examples to list, define, identify recognise the environmental concerns?	The textbook of Class IX as well as of Class X provide enough illustrations for the students to list, define, identify, recognise the environmental concerns, but the Class X textbook could be said to be more enriched in the activities and information regarding the environmental topics.
1.2 Does the text provide scope for the children to perform simple tasks or experiments in groups, so that they can share their experiences with each other that helps them to develop a holistic understanding of their environment?	The Class X textbook contains some activities which give opportunities to the children to perform simple tasks or experiments in groups, so that they can share their experiences with each other and develop a holistic understanding of their environment, whereas in the Class IX textbook

	there is a scope for the inculcation of more such activities and contents.
1.3 Does the textbook provide enough scope for the students to construct and internalize the knowledge through personal experimentation and observation?	There are several activities in both the textbooks so that the students could construct and internalize their knowledge on the environment. Although, while the Class IX textbook focused more on learning through observing, the Class X textbook involved the students in personal experiences and experimentation.
2. Understanding	
2.1 Does the textbook provide an understanding about the facts mentioned in the book regarding environment so that the learner can describe, explain, paraphrase, give their own examples, summarise, interpret and discuss those issues? – through group discussions – through some assignment – through internet search	The Class X textbook provides some opportunities for these through internet search and the Class IX textbook also addresses these by providing the student with some questions to ponder upon these issues.
3. Applying	
3.1 Does the text provide opportunities to the students to predict certain situations about the environment upon reading the content?	Both the textbooks of Classes IX and X provide the students with some activities which could assist them in predicting what could happen next, after doing the activities. The contents would have been more enriched by providing the students with an opportunity to think upon the direct relation of science and scientific contents with the different types of pollution and pollutants around.
3.2 Are the students getting opportunities to apply or relate the concepts to real life contexts?	Both the textbooks of Classes IX and X have some activities, upon doing which the students might be enabled to apply or determine the real life situations.
4. Analysing	
4.1 Is there enough content that enables the students to classify, categorise the different changes that are taking place in our environment?	Both the textbooks of Classes IX and X could have more contents or activities to categorise the different changes that are taking place in our environment. They have been covered briefly in both the textbooks. For example, discussing sound pollution in the chapter "Sound" of Class IX would have made the chapter more responsive to the students and their abilities to analyse the different changes that are taking place in our environment.

4.2 Do the contents enable the students to draw inferences that may help them to identify the causes behind a particular environmental issue upon reading the book? – through field visits or interviews – through activities given at the end of the chapter or between the text – through debating	The Class IX textbook contains a few activities through which the students could identify, make inferences and then support generalisations about issues related to the environment. The Class X textbook also encouraged and instilled in the minds of the students to be analytical about certain environmental issues.
5. Evaluating	
5.1 Does the textbook provide the space for the expression of students' own opinions about the environmental issues? – by the exercises at the end of the chapter – by the questions in between the text contents	The Class IX textbook contains a few contents through which the students could shape their opinions or become predictive or evaluative about their views on a certain environmental issues. The Class X textbook contains come exercises and activities for the same.
5.2 Whether the textbook provide contents/ activities where the students get opportunity to critique or opine about the information based on a set of valid criteria? – through classroom discussions – through debates – by taking surveys, interviews	The Class IX textbook provides some questions in the exercises through which the students could opine their views on the environmental issues. The Class X textbook also contains some questions which require expressing one's own view and opinion on the topics.
6. Creation	
6.1 Does the textbook provide opportunities for the students to enhance their creativity by inventing, designing, modifying some models that could contribute effectively to the environment?	Both the textbooks of Classes IX and X provide the students with some model preparing activities through which the students could give their imaginative minds a way to create and accomplish something new on their own.
6.2 Does the textbook give the scope to the students for some original, new thinking or a new outlook for the same environmental concerns given in the text?	The Class X textbook seems to have more activities and exercises then the Class IX textbook which could foster some new, original, thinking or a new outlook for the environmental concerns given in the text.

Discussion, Conclusion and Suggestions

The major findings of this study show that the NCERT science textbooks at the secondary level are responsive towards the environmental concerns and issues to certain extent. Based on the content analysis it can be argued that there is still a lot of scope for inclusion and integration of the environmental contents. The analysis showed that in some chapters of the NCERT science textbooks the environmental issues and concerns were

discussed very meaningfully but the activities and exercises related to the environmental issues were found mostly from the knowledge, comprehension and application domains. Both the textbooks contain such contents which could help the students in applying their understanding of the environment in real-life situations. They also have activities through which the students can be encouraged for scientific inquiry and experimentations for sustainability of the environment. As we know that environmental issues and concerns require that the individuals should be prepared to take action in future and question the changes around them. Mere understanding of the related concepts or their application may not empower them to become responsible citizens that are able to think critically and creatively. Thus, although some activities have been found in the analysis that provide opportunities to the learners for imagining and creating designs that are environment friendly but more such activities can be included. It is also suggested that some chapters in the textbook could be enriched with discussion and debate based activities with respect to the environmental issues. For example, the chapter 'Diversity in Living Organisms' of Class IX, could discuss the threats that the biodiversity is facing due to the habitat destruction caused by deforestation and other human activities. It could involve some case studies from specific regions that have proved that any interference in the natural environment disturbs the natural processes of a region thereby affecting the diversity. Hence, how 'no action' on the part of human proved to be the best action. Some evidences/instances and/or activities could be added through which the student gets sensitised about issues of the biodiversity getting threatened because of the human activities. Similarly, the chapter 'Sound' of Class IX could discuss the idea of sound pollution and the various causes of it in our environment. The chapter 'Why Do We Fall Ill' of Class IX could include the influence of environmental conditions on the human health. This should bring the case of those diseases that have emerged in the contemporary world due to the changes in the environmental conditions ranging from the use of various gases that add to the air around us, to the use of pesticides/insecticides that we are slowly consuming through our food to the use of other chemicals that we are using in our day-to-day lives. So, some more topics presenting the relation of health and environment could be included in this chapter which could also include some debates and discussions on the present environmental conditions and the frequent outbreak of some diseases. The chapter 'Matter in Our Surroundings' discusses concepts related to the three states of matter. This chapter could also have discussed about the water scarcity that we face today despite the fact that 70 per cent of the earth is covered with water. There could have been discussions related to the fact that most of the fresh water is frozen as ice at the polar areas and hence not available for use by the common people. If we discuss the Class X science textbook, the textbook included activities and exercises related to environmental issues and concerns from knowledge, understanding, application, evaluation and synthesis domains but it was noticed that some more chapters could have had some environment related topics. For example, in the chapter 'Metals and Non-metals' extraction, enrichment of ores , refining have been discussed and the contents could have been enriched if the fact that mining has a severe effect on the environment

in the areas where mining is done and subsequently on the health of the resident people, would have been discussed. A whole chapter named "Our Environment" has been included in this, which although includes several topics related to the environmental concerns but some more discussion and debate based activities and questions could have included in this which could have debates and discussions on the current affairs like the ongoing global summits, etc., included in it. Inclusion of some stories from the tribal communities or the rural areas where people depend on the environment and directly use the natural resources will enhance the understanding of the students. It would also help them to understand that environmental concerns could not be addressed from outside but a close association with one's immediate environment while being a part of it goes a long way in sustaining the environment. The chapter 'Management of Natural Resources' included some relevant topics on environmental issues and sustainable development and has enriched content from various domains. The chapter 'Sources of Energy' should definitely include issues related to use of certain fuels and the possibilities of using alternative fuels. While studying the various opportunities that secondary science textbooks offer to learners for developing their thinking about environment and environmental issues, it was observed that the content related to environmental issues should include more activities, cases/instances from the past, contemporary ongoing concerns that would provide the learners to opportunities to think analytically, critically and creatively.

The Class IX textbook could include many activities and exercises related to environment which could help nurturing the curiosity and creativity of the children towards it. It could contain activities or exercises for the students to discuss environmental issues in groups. Although, the textbook has given opportunities for personal experimentation and observation, some more activities related to promoting the students to explore more about the present environmental conditions and enhance their understanding about the same through internet search or discussions could prove to be beneficial for the students. The Class X textbook represents environmental issues in more effective way than the Class IX textbook; still there is need for some more activities and exercise to be included in it. But to some extent both the textbooks contain such contents which could help the students in applying their understanding of the environment in their real life situations. The curriculum also needs to include such topics which could give the students the understanding about how science can play a role in defining the environmental issues and how they both are related. Only some of the popular environmental issues and concerns such as air pollution, water pollution, etc., are frequently discussed whereas some of the global environmental concerns such as nuclear accidents, biotechnology risks, and significance of biodiversity conservation are discussed only to a certain extent. Inclusion of some more local as well as global issues would bring the secondary science textbooks at par with the criteria prescribed by the *NCF-2005*.

References

Amer, A. 2006. Reflections on Bloom's Revised Taxonomy. *Electronic Journal of Research in Educational Psychology*. ISSN. 1696–2095. Vol. 4 (1), No. 8. 2006. pp. 213–230.

Bogdan, R.C., and S.K. Biklen, 1982. *Qualitative Research for Education: An Introduction to Theory and Methods (Third Edition)*. Allyn and Bacon, Boston.

Bybee, R.W. 1979. Science Education for an Ecological Society. *The American Biology Teacher*. Vol. 41, No. 3. New Dimensions in Biology Education (March, 1979). pp. 154–163.

———. 2008. Scientific Literacy, Environmental Issues, and PISA 2006: The 2008 Paul F-Brandwein Lecture. *Journal of Science Education and Technology*. Vol. 17, No. 6. (December 2008), pp. 566–585.

Chang S.N., Yueng Y.Y. and M.H. Cheng. 2009. Ninth Graders' Learning Interests, Life Experiences and Attitudes towards Science and Technology. *Journal of Science Education and Technology*. Vol. 18, No. 5. (October, 2009). pp. 447–457.

Donnelly, J. 2005. Reforming Science in the School Curriculum: A Critical Analysis. *Oxford Review of Education*. Vol. 31, No. 2. (June, 2005). pp. 293–309.

Dyke, M.L. 1997. Science Education for Environmental Education? Primary Teacher Perspectives and Practices. *British Educational Research Journal*. Vol. 23, No. 5. (December, 1997). pp. 641–659

Gay, L. R. 1987. *Educational Research: Competencies for Analysis and Application (3rd ed.)*. OH: Merrill, Columbus.

Iyengar, R. and M. Bajaj, 2011. After the Smoke Clears: Toward Education for Sustainable Development in Bhopal, India. *Comparative Education Review*. Vol. 55, No. 3. (1 August, 2011). pp. 424–456.

Ko A.C.C. and J.C.K. Lee 2003. Teachers' Perceptions of Teaching Environmental Issues within the Science Curriculum: A Hong Kong Perspective. *Journal of Science Education and Technology*. Vol. 12, No. 3. (September, 2003). pp. 187–204.

Krippendorff, K. 1980. Validity in Content Analysis. In E. Mochmann (Ed.), *Computerstrategien fÃ¼r die kommunikationsanalyse*. (pp. 69–112). Campus Frankfurt, Germany.

Kumar, D. and Berlin, D. 1998. A Study of STS Themes in State Science Curriculum Frameworks in the United States. *Journal of Science Education and Technology*. Vol. 7, No. 2. (June, 1998). pp. 191–197.

Liarakou, G., Gavrilakis, C. and Flouri, E. 2009. Secondary School Teachers' Knowledge and Attitudes towards Renewable Energy Sources. *Journal of Science Education and Technology*. Vol. 18, No. 2. (April, 2009). pp. 120–129.

Lumpe, A.T. and J. Beck, 1996. A Profile of High School Biology Textbooks Using Scientific Literacy Recommendations. *The American Biology Teacher*. Vol. 58, No. 3. (March, 1996). pp. 147–153.

McComas, W. F. 2002. The Ideal Environmental Science Curriculum: I. History, Rationales, Misconceptions and Standards. *The American Biology Teacher*. Vol. 64, No. 9. (November–December, 2002). pp. 665–672.

———. 2003. The Nature of the Ideal Environmental Science Curriculum: Advocates, Textbooks, and Conclusions (Part II of II). *The American Biology Teacher*. Vol. 65, No. 3. (March, 2003). pp. 171–178.

Moseley, C. 2000. Teaching for Environmental Literacy. *The Clearing House*. Vol. 74, No. 1. (September - October, 2000). pp. 23–24.

Munn T., Whyte A. and Timmerman P. 1999. Emerging Environmental Issues: *A Global Perspective of Scope*. Ambio. Vol. 28, No. 6. (September, 1999). pp. 464–471.

NCERT. *Science* Textbook for Class IX, National Council of Educational Research and Training, New Delhi.

———. *Science* Textbook for Class X, National Council of Educational Research and Training, New Delhi.

———. 1988. National Curriculum for Elementary and Secondary Education. National Council of Educational Research and Training, New Delhi.

———. 2005. *National Curriculum Framework*. 2005, National Council of Educational Research and Training, New Delhi.

———. 2006. National Focus Group Position Paper on Science Teaching, National Council of Educational Research and Training, New Delhi.

Smith, F.B. 1997. *Selbyana*, Vol. 18, No. 2. ORCHIDS (1997), pp. 167–171. Marie Selby Botanical Gardens Inc.

Stapp, W. B. 1969. *The Journal of Environmental Education.* Vol. 1, No. 1. pp. 30–31.

Stemler, Steve. 2001. An Overview of Content Analysis. *Practical Assessment*, *Research and Evaluation*. Vol. 7, No. 17.

Swan, J. 1969. The Challenge of Environmental Education. *The Phi Delta Kappan*. Vol. 51, No. 1. (September, 1969), pp. 26–28.

Wals, A.E.J., Brody, M., Dillon, J. and Stevenson, R.B. 2014. Convergence Between Science and Environmental Education. *Science.* 9 May, 2014. Vol. 344, No. 6184. pp. 583–584.

PROBLEM BASED LEARNING IN BASIC PHYSICS – XII

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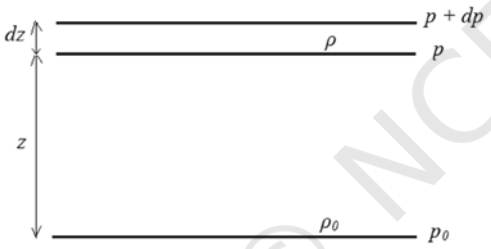
In this article, twelfth in the series, we present two interesting problems for a problem based learning course— one on modelling earth's atmosphere and second-on modelling of Sun based on basic physics. We present the learning objectives in this area of basic physics and what each problem tries to achieve with its solution. Methodology and philosophy of selecting these problems are already discussed.

Understanding the Earth's Atmosphere



1. Consider an isothermal model of the atmosphere, i.e., there is no change in atmospheric temperature with height.

Let ground values of pressure and density be p_0 and ρ_0 respectively.

Show that pressure of the earth's atmosphere varies as, where atmospheric pressure is p, and atmospheric density is ρ at a height z. Here, $z_0 = \frac{p_0 g}{\rho_0}$ is called scale height.

Taking $p_0 = 1.013 \times 10^5$ N/m^2 and $\rho_0 = 1.29$ kg/m^3, estimate the scale height value. Assuming $e^{-5} \approx 0$, estimate thickness of earth's atmosphere for such an isothermal model. Also estimate the pressure at the top of Mt. Everest which has a peak at about 8 km.

2. The following table shows temperature v/s altitude data that was displayed in an Air India flight from Mumbai to New Delhi on 10th August 2014 at around 6:30 pm recorded before landing at New Delhi.

Height in Metre	Temp in Celsius
300	30
800	27
900	26
1200	24
2100	20
3700	11
5900	–4
6300	–6
6900	–10
7500	–13
8100	–17
8800	–22
9300	–25

10100	–30
11300	–42

Clearly this shows that earth's atmospheric temperature does change with height. Check if this change is significant at a magnitude of scale height.

3. Actually air is a bad conductor of heat (to our advantage) and an envelope of air rising does not exchange heat with the surrounding but cools due to adiabatic expansion as a result of drop in the pressure. Refer to the graph in Problem 2 above.

We need to find an expression for p as a function of altitude z from the fact that experimentally we get T = - 0.0062 z + 305.582 (in Kelvin).

Solution

1. Starting with ground values of pressure and density be p_0 and ρ_0 respectively, at a further height pressure will change (decrease) by $dp = -\rho g dz$ at a further height dz.

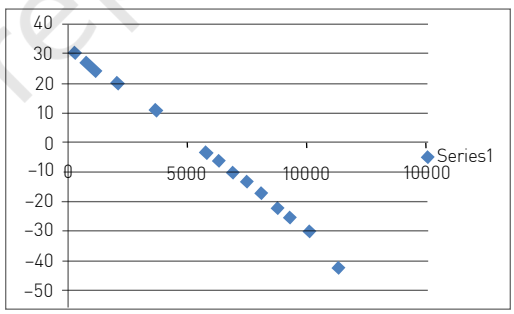
In such an isothermal atmosphere, $p \propto \rho$ and hence we can write $\frac{p}{p_0} = \frac{\rho}{\rho_0}$.

This leads to $dp = -\frac{\rho_0}{p_0} g dz$, integration of which yields, $p = p_0 \exp(-z/z_0)$ where $z_0 = \frac{p_0 g}{\rho_0}$ is called isothermal scale height of the atmosphere.

At sea level T = 300 K, ρ = 1.29 kg/m^3, assuming g = 9.81 m/s^2 (constant) and universal gas constant R = 8.314 J/mole/K we get z_0 = 8.58 km.

According to isothermal condition, atmospheric pressure decreases exponentially with increasing height. Since the temperature is assumed to be constant, and $\rho \propto \frac{p}{T}$, it follows that the density also decreases exponentially with the same scale-height as the pressure. According to the equation above, the pressure, or density, decreases by a factor 10 every 19.8 kilometre, as we move vertically upwards. This indicates that the effective height of the atmosphere is very small compared to the earth's radius, which is about 6400 kilometre. This means that the atmosphere constitutes a very thin layer covering around the surface of the earth. This also justifies our neglect of the decrease of g with increasing altitude.

2. Plot the graph of temperature v/s altitude and find the equation that represents the variation. You may easily do this in MS-EXCEL. The graph below shows plot of the given data with height above earth's surface on x-axis and corresponding temperature on y-axis.



[We get the equation T = –0.0062 z + 32.582, where z is in metres.].

3. Result of problem 2, clearly shows that over distance (scale height) z_0 (which we found to be 8.85 km), atmospheric temperature does not remain constant and our assumption of isothermal condition is not correct.

We have $\frac{dp}{dz}=-\rho g$ and $pV=nRT$, and $\rho=\frac{nM_A}{V}$ where M_A is the molecular weight of the air, we get $\rho=\frac{pM_A}{RT}$. With $T = T_0 - \alpha z$, we get $\frac{dp}{dz}=-\frac{pM_A g}{R(T_0-\alpha z)}$

Integration yields, $p=p_0\left(1-\frac{\alpha}{T_0}z\right)^{M_A g/RT}=p_0\left(1-\frac{\alpha}{T_0}z\right)^{5.425}$ and we have $\frac{\alpha}{T_0}=2.029\times10^{-5}$. With this pressure drops by factor of 10 every 32.2 km.

In adiabatic approximation,

$p^{1-\gamma}T^{\gamma}$=constant

giving $\frac{dp}{p}=\frac{\gamma}{1-\gamma}\frac{dT}{T}$

Combining the above relation with the equation of hydrostatic equilibrium, we obtain

$$\frac{\gamma}{\gamma-1}\frac{dT}{T}=-\frac{\mu g}{RT}dz\ ,$$

or

$$\frac{dT}{dz}=-\frac{\gamma-1}{\gamma}\frac{\mu}{RT}$$

Since $\rho T \alpha p$, according to the ideal gas law, then

$$(\rho T)_{packet}=(\rho T)_{atmosphere}$$

This yields $T=T_0\left(1-\frac{\gamma-1}{\gamma}\frac{z}{z_0}\right)$,

and $p=p_0\left(1-\frac{\gamma-1}{\gamma}\frac{z}{z_0}\right)^{\gamma/\gamma-1}$,where $z_0=\frac{RT_0}{\mu g}$

The expression obtained above in the limit of $\gamma\rightarrow1$ will get $p=p_0\exp\left(-\frac{z}{z_0}\right)$.

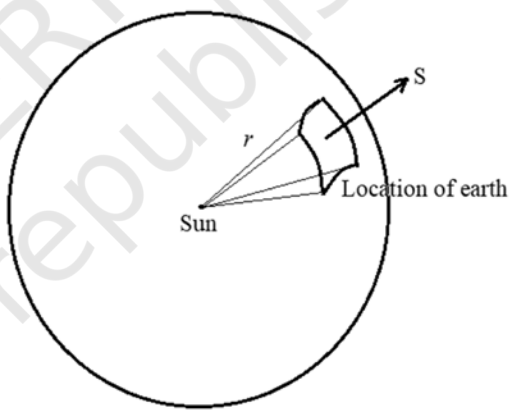
This, not surprisingly, is the predicted pressure variation in an isothermal atmosphere. In reality, the ratio of specific heats of the atmosphere is not unity, it is about 1.4 (i.e., the ratio for diatomic gases), which implies that in the real atmosphere

$$p=p_0\left(1-\frac{z}{3.5z_0}\right)^{3.5}$$

Model of Sun

In this problem we shall learn to estimate solar luminosity, surface temperature, core temperature, possible mechanism of energy generation inside sun (or stars) and criteria for an astronomical object to become a star.

Energy for survival of life comes from our sun. At the location of earth, we receive S = 1400 W/m^2 (called solar constant). If we use this fact and the fact that average distance between earth and sun is 1 astronomical unit (1 AU = 1.5×10^{11}m), then referring to the figure below, energy radiated by sun must be L_S=4πr^2 S=3.96×10^{26} W. This quantity is called as **solar luminosity**.



Surface Temperature of Sun

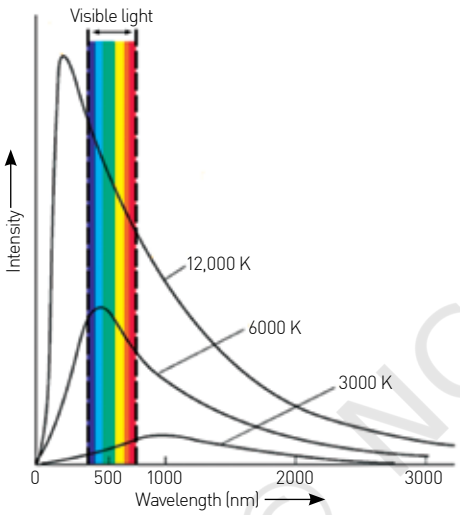
According to Stefan's Law power radiated by a black body per unit surface area having surface temperature T_S is given by $P=\sigma T_S^4$, where σ=5.67×10^{-8} W/m^2. If radius of sun is R_S , then this gives us $L_s=4\pi R_S^2\sigma T_S^4$ which gives

$$T_s=\left[\frac{L_S}{4\pi R_S^2\sigma}\right]^{1/4}=5781\ K$$

as the surface temperature of the sun. Where we have used radius of the sun as R_S=7×10^{8}m. Many times this is also referred to as black

body temperature of solar surface as we have approximated sun's surface here as a black body.

Another way of estimating surface temperature of the sun is using Wien's Law. The energy radiated by black body is radiated at different wavelengths at different temperatures is given by graphs shown in the following figure.



According to Wien's Law, if a black body radiates maximum energy at wavelength λ_m, then it has surface temperature T_S, given by

$$T_s = \left[\frac{0.29 cmK}{\lambda_m}\right].$$

Sun radiates maximum energy in the visible region of spectrum, estimated to be 500 nm. This gives us its surface temperature as 5800 K. This is almost same as our previous estimate.

The Process of Energy Generation Inside the Sun

The energy radiated from the surface must come from its interior which must be hotter than the surface. What must be the mechanism for generation of this amount of energy?

Three possibilities are:

(i) Gravitational potential energy

(ii) Chemical energy due to chemical reactions in the interior

(iii) Nuclear energy due to nuclear processes

Let us examine the consequence of each possiblility:

Gravitational Potential Energy

Sun may have been a big gas cloud which due to gravitational force has shrunk to its present size.

Gravitational potential energy of a spherical object of mass M and radius R is

$$U_G = -\frac{3}{5}\frac{GM^2}{R}$$

This energy is zero as $R \to \infty$ but for present radius is

$U_G = -2.286 \times 10^{41} J$.

This means that sun became hot as it contracted and heat energy came from gravitational potential energy.

With this energy and current luminosity, sun can continue shining for time of

$$\Delta t = \frac{U_G}{L_S} = 5.7 \times 10^{14} S = 1.8 \times 10^{7} \text{ years}$$

From radioactive dating, earth's present age is estimated to be 5×10^9 years. Clearly, gravitational energy could not be the source of sun's luminosity.

Chemical Energy

Typical energy released during a chemical reaction is of the order of an electron volt.

If all of sun is H-atoms, then number of H-atoms : $n = \frac{M_S}{m_H} = 1.2\times10^{57}$

If two ^1H combine to form H_2, the number of reactions $= \frac{n}{2} = 6\times10^{56}$

This can produce total energy

$U_{chemical} = 6\times10^{56}\times1eV = 9.6\times10^{37} J$

$\Delta t = \frac{U_{chemical}}{L_S} = 2.4\times10^{11} S = 7674$ years

This is too small. Thus, chemical reactions cannot be source of Solar Energy.

Nuclear Energy

There are two competing processes by which $4^1H \rightarrow {}^4He$ releasing 26.7 MeV

For This 3×10^{56} reactions would produce 1.28×1045 *J*

$\Delta t = \frac{U_{nuclear}}{L_S} = 3.24\times10^{18} S = 10\times10^{10}$ years

This appears to be the main source of Solar Energy.

How hot should the core be to initiate nuclear fusion reaction?

To trigger nuclear reaction : to fuse two protons, we need to overcome electrostatic repulsion between two protons.

This will be possible only if the gas is vey HOT. If we assume that initially when the cloud collapsed, its gravitational energy will get converted to thermal energy then gas gets heated up.

If $\Delta U_{Gravity} = \frac{3}{2} n k_B T_c$ then we get

$$T_c = \frac{\Delta U_{Gravity}}{\frac{3}{2} n k_B} = \frac{2.286\times10^{41}}{\frac{3}{2}\times1.2\times10^{57}\times1.38\times10^{-23}} = 9.2\times10^{6} K$$

Will this temperature be sufficient to ignite nuclear reaction?

If at the time when gas cloud contracted, if all of it is H-atoms, then what will happen?

H-atom has BE of 13.6 eV. If this energy is of the order of k_BT, then equivalent temperature is of the order of 10^5 K. Which means at the temperature which star reached due to gravitational collapse, we will have ionized gas, i.e., we will have protons and electrons separated.

A classical requirement of the temperature at the center of the stars

Assume that the gas that forms the star is pure ionized hydrogen (electrons and protons in equal amounts), and that it behaves like an ideal gas. From the classical point of view, to fuse two protons, they need to get as close as 10^{-15} m for the short range strong nuclear force, which is attractive, to become dominant. However, to bring them together they have to overcome first the repulsive action of Coulomb's force. Assume classically that the two protons (taken to be point sources) are moving in an antiparallel way, each with velocity v_{rms}, the root-mean-square (rms) velocity of the protons, in a one-dimensional frontal collision.

What has to be the temperature of the gas, T_c, so that the distance of closest approach of the protons, d_c, equals 10^{-15} m?

We equate the initial kinetic energy of the two protons to the electric potential energy at the distance of closest approach:

$$2\left(\frac{1}{2} m_p v_{rms}^2\right) = \frac{q^2}{4\pi\varepsilon_0 d_c}$$

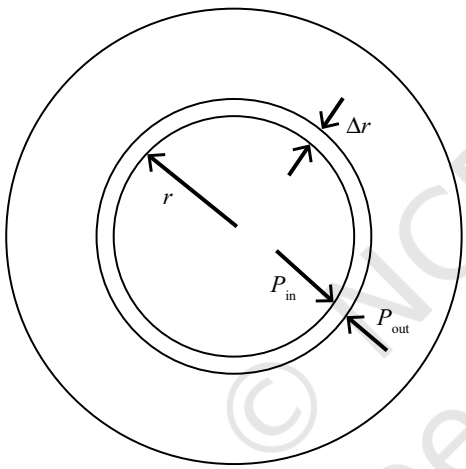
And since $\frac{3}{2} k_B T_C = \frac{1}{2} m_p v p_{rms}^2$

This means we require $T_C = \frac{q^2}{12\pi\varepsilon_0 d_c k_B} = 5.5\times10^9 K$

Two temperatures do not match, then how is nuclear reaction triggered?

To check if the previous temperature estimate is reasonable, one needs an independent way of estimating the central temperature of a star.

The structure of the stars is very complicated, but we can gain significant understanding making some assumptions. Stars are in equilibrium, that is, they do not expand or contract because the inward force of gravity is balanced by the outward force of pressure .



$\Delta P = P_{in} - P_{out}$

Fig.1. The stars are in hydrostatic equilibrium, with the pressure difference balancing gravity.

Refer to the the figure shown. For a slab of gas the equation of hydrostatic equilibrium at a given distance r from the center of the star, is given by

$$\frac{\Delta P}{\Delta r} = -\frac{GM_r \rho r}{r^2}$$

where P is the pressure of the gas, G the gravitational constant, M_r the mass of the star within a sphere of radius r, and ρ_r is the density of the gas in the slab.

An order of magnitude estimate of the central temperature of the star can be obtained with values of the parameters at the center and at the surface of the star, making the following approximations:

$$\Delta P \approx P_0 - P_C,$$

where P_C and P_0 are the pressures at the center and surface of the star, respectively.

Since $P_C >> P_0$, we can assume that $\Delta P = -P_C$

Within the same approximation, we can write $\Delta r \approx R$,

where R is the total radius of the star, and $M_r \approx M_R = M$, with M the total mass of the star.

The density may be approximated by its value at the center, $\rho_r \approx \rho_c$.

We can assume that the pressure is that of an ideal gas.

Thus, to find an equation for the temperature at the center of the star, Tc , in terms of the radius and mass of the star and of physical constants only:

Since we have that $\frac{\Delta P}{\Delta r} = -\frac{GM_r \rho_r}{r^2}$,

making the assumptions given above, we obtain that: $P_C = \frac{GM\rho c}{R}$,

Now, the pressure of an ideal gas is

$$P_C = \frac{2\rho_c k_B T_c}{mp},$$

where k_B is Boltzmann´s constant, T_c is the central temperature of the star, and m_p is the proton mass. The factor of 2 in the previous equation appears because we have two particles (one proton and one electron) per

proton mass and that both contribute equally to the pressure.

Equating the two previous equations, we finally obtain that: $T_C = \frac{GMm_p}{2k_B R}$

For the Sun we have that:

$\frac{M_S}{R_S} = 2.9\times10^{21}\text{kg/m}$

$\therefore T_C = \frac{GM_S m_p}{2k_B R_S} = 11.5\times10^6\text{K}$

which seems to be close to the temperature of gravitationally collapsed/contracted star.

Our simple estimate requires temperature of 5.5×10^9 K to initiate fusion reaction. This criterion we need to reconsider.

A quantum mechanical estimate of the temperature at the center of the stars

The large discrepancy found, suggests that the classical estimate for T_c obtained in is not correct. The solution to this discrepancy is found when we consider quantum mechanical effects, that tell us that the protons behave as waves and that a single proton is smeared on a size of the order of , the de Broglie wavelength. This implies that if d_c, the distance of closest approach of the protons is of the order of λ_p, the protons in a quantum mechanical sense overlap and can fuse.

Assuming that dc = $\lambda/2^{1/2}$ is the condition that allows fusion, for a proton with velocity v_{rms}, we have $\lambda_p = \frac{h}{m_p v_{rms}}$, $\frac{3}{2}k_B T_C = \frac{1}{2}m_p v_{rms}^2$ and $T_c = \frac{q^2}{2\pi\varepsilon_0 d_c k_B}$

We obtain $T_C = \frac{q^4 m_p}{24\pi^2\varepsilon_0^2 k_B h^2} = 9.7\times10^6\text{K}$

This gives $\frac{M}{R} = \frac{2k_B T_C}{Gm_p} = 2.4\times10^{21}\text{kg/m}$

While for the Sun we have that:

$\frac{M_S}{R_S} = 2.9\times10^{21}\text{kg/m}$

Thus quantum mechanically temperature required to initiate fusion reaction is same as the temperature available due to gravitational contraction and nuclear process for energy generation through fusion of hydrogen can start.

We now understand what makes Sun shine and generate this tremendous energy.

Considering Solar luminosity and energy per reaction, Sun requires $\frac{L_S}{E_{fusion}} = \frac{3.96\times10^{26}}{26.7\times1.6\times10^{-13}} = 9.27\times10^{37}$ reactions per second, which means 3.7×10^{38} atoms react per second. Sun at formation had $\frac{M_s}{m_p} = \frac{2\times10^{30}}{1.67\times10^{-27}} = 1.2\times10^{57}$ H-atoms (or proton). In case of Sun, once core mass of $0.1M_S$ of H is exhausted, there is no more energy production at the centre and it is unable to prevent a small collapse as radiation pressure drops. This heats up the core further and He burning begins. Before discussing He burning, let us estimate the time for core H-burning. Since there are 1.2×10^{56} protons at the core, if Sun continues to shine with same luminosity, it can continue to do so up to $\frac{1.2\times10^{56}}{3.7\times10^{38}}$

$=3.2\times10^{17}$ *sec* = 10×10^{19} *years* = 10 billion years. From earlier mentioned age of earth, it appears that Sun is mid way in its H-burning stage.

Fusing helium nuclei in older stars

As stars get older they will have fused most of the hydrogen in their cores into helium (He), so they are forced to start fusing helium into

heavier elements in order to continue shining. A helium nucleus has two protons and two neutrons, so it has twice the charge and approximately four times the mass of a proton. We saw before that $d_c = \lambda_p / \sqrt{2}$ is the condition for the protons to fuse.

Set the equivalent condition for helium nuclei and find v_{rms} (He) , the rms velocity of the helium nuclei and T (He) , the temperature needed for helium fusion.

For helium we have :

$$\frac{4q^2}{4\pi\varepsilon_0 m Hev^2_{rms}(He)} = \frac{h}{\sqrt{2} m Hev_{rms}(He)}$$

From where we get $v_{rms}(He) = \frac{\sqrt{2}q^2}{\pi\varepsilon_0 h} = 2.0\times10^6 m/s$

We now use: $T(He) = \frac{v^2_{rms}(He) m_{He}}{3k_B} = 6.5\times10^8 K$

These values are of the order of magnitude of the estimates of stellar models.

The mass to radius ratio of the stars

The previous agreement suggests that the quantum mechanical approach for estimating the temperature at the center of the Sun is correct.

We use the previous results to demonstrate that for any star fusing hydrogen, the ratio of mass M to radius R is the same and depends only on physical constants. Let us find the equation for the ratio M / R for stars fusing hydrogen.

Taking into account that $\frac{M}{R} = \frac{2k_B T_c}{G m_p}$ and that $T_c = \frac{q^4 m_p}{24\pi^2\varepsilon_0^2 k_B h^2}$,

We obtain $\frac{M}{R} = \frac{q^4}{12\pi^2\varepsilon_0^2 G h^2}$ the average electron number density inside the star $n_e = \frac{M}{(4/3)\pi R^3 m_p}$

the typical separation between electrons inside the star $d_e = n_e^{-1/3} = \left[\frac{M}{(4/3)\pi R^3 m_p}\right]^{-1/3}$

We assume that $d_e \geq \lambda_e / \sqrt{2}$ and since $\lambda_e = \frac{h}{m_e v_{rms}(electron)}$,

we get, $\frac{3}{2}k_B T_C = \frac{1}{2} m_e v^2_{rms}(electron)$

where $T_C = \frac{q^4 m_p}{24\pi^2\varepsilon_0^2 k_B h^2}$, $\frac{M}{R} = \frac{q^4}{12\pi^2\varepsilon_0^2 G h^2}$ and

$$d_e = \left[\frac{M}{(4/3)\pi R^3 m_p}\right]^{-1/3},$$

we get $R \geq \frac{\varepsilon_0^{1/2} h^2}{4^{1/4} q m_e^{3/4} m_p^{5/4} G^{1/2}} = 6.9\times10^7 m = 0.1R(Sun)$

Since $\frac{M}{R} = constant$, it also means

$M \leq M(Sun)$, for a gas cloud to shrink and initiate nuclear fusion to shine and become a star.

References

CARROL, B.W. AND D.A. OSTLIE, 2007. *An Introduction to Modern Astrophysics*. Pearson.

FRANK, H. SHU. 1982. *The Physical on Universe – An Introduction to Astronomy*. University Science Books, Sausalito, California.

FREEDMAN ROGER, WILLIAM J. KAUFMANN. 2007. *Universe*, 8th Edition, W. H. Freeman.

MODY, A. K. AND H. C. PRADHAN, 2011. *'Problem Based Learning in Basic Physics – I, School Science.* Vol. 49, No. 3. (September 2011). NCERT New Delhi

———.2014. 'Problem Based Learning in Basic Physics – VI. *School Science.* Vol. 52, No.4. (December 2014). NCERT New Delhi

NCERT. 2006. *Physics Textbook for Class XI Part-II*, NCERT, New Delhi.

PRADHAN, H.C. AND MODY, A. K. 2009. 'Constructivism Applied to Physics Teaching for Capacity Building of Undergraduate Students. *University News*. Vol. 47, No. 21. pp. 4–10.

RESNIK, HALLIDAY AND KRANE. 2007. *Physics*, Vol. I, 5th Edition, Wiley India.

PROTECTING THE PLANET: Role of the Youth

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Our main challenge is to develop economic, social and governance systems capable of protecting the planet, achieving sustainable levels of production and consumption while living in harmony with our natural environment. In our planet, access to clean air, water, and a liveable climate are inalienable human rights. We have only one planet and humankind must become accountable for the wanton destruction of our collective home. Protecting our future on this planet depends on the conscious evolution of the species and harmonious living with the planet at large.

India shares the concern of the international community about the need to protect the planet and the humanity from the impacts of climate change. Today, India faces the challenge of poverty eradication and sustainable development with sustaining its rapid economic growth while combating global threat of climate change. It may alter the distribution and quality of India's natural resources and adversely affect the livelihood of its people. Therefore, consider that while maintaining a high growth rate is essential for increasing living standards of our people, steps need to be taken to reduce their vulnerability to climate change.

A historic agreement to combat climate change and unleash actions encompassing mitigation, adaptation, finance, technology development and transfer, capacity building and transparency of action and support was agreed by the world community in Paris on 12 December 2015. The universal agreement's main aim is to keep a global temperature rise this century well below 2 degrees Celsius and to drive efforts to limit the temperature increase even further to 1.5 degrees Celsius above pre-industrial levels.

Youth represents the most dynamic segment of the population in any country and are the future of a nation. Young people's active and meaningful participation is indeed of crucial importance in all issues of concern. They are acting as the ambassadors of awareness campaign for educating the masses about our planet and its protection. They are encouraging the children to protect the bio-diversity on the planet.

Humanity's main challenge for the 21st century is to develop economic, social and governance systems capable of protecting the planet, achieving sustainable levels of production and consumption while living in harmony with our natural environment. The environment is one of the primary determinants of individual and community health, and exposure to physical, chemical and biological risk factors in the environment can harm human health in various ways. Compounded by climate change, the pressures on terrestrial and marine

ecosystems and resources are major threats to the earth's biological life support systems, human well-being and development.

The global climate is changing due to the emission of greenhouse gases (GHGs). The scientific consensus is that global climatic changes are largely the result of increased concentration of carbon dioxide, methane and other greenhouse gases in the atmosphere primarily caused by human activities, use of fossil fuel and industrial expansion. These changes are expected to result in higher average temperatures, changed rainfall patterns, and increased severity and frequency of floods, droughts and cyclones, which can severely impact livelihoods, especially of the poor in developing countries. The global-average surface temperature is now about 0.8°C above its level in 1750, with most of the increase having occurred in the 20th century and the most rapid rise since 1970. These developments have the potential to lead to large scale local or regional disruptions in ecosystems and adversely impact food security, fresh water resources and human health resulting in increased loss of planet.

International Efforts to Protect the Planet

In the present situation, protecting the planet is the most important challenge for us. Meeting this challenge is essential if the sustainable development goals that world have adopted are to be achieved. In the year 1972, the relationship between development and environmental degradation was first positioned on the international agenda. It was at the UN Conference on the Human Environment held in Stockholm in 1972. After this conference, the governments set up the United Nations Environment Programme (UNEP). The UNEP which nowadays continues to function as a global catalyst for action to protect the environment. However, little was done in the subsequent years to integrate concerns about environment into national economic planning and decision-making process.

In 1983, the UN established the World Commission on Environment and Development. The commission put forward

the concept of sustainable development as an alternative approach. It is simply based on economic growth — "which meets the needs of the present without compromising the ability of future generation".

After considering the 1987 Brundtland Report, the UN General Assembly called for the UN Conference on Environment and Development (UNCED). The goals of the summit were to come to an understanding of development that would support socio-economic development. It was also to prevent the continued deterioration of the environment of the world. It laid a foundation for a global partnership between the developing and the more industrialised countries. It was based on mutual needs and common interests. It would ensure a healthy future and protect the planet.

During the Earth Summit, 1992 held in Rio (Brazil), there were three major agreements to be adopted aimed at changing the traditional approach to development which are:

- Agenda 21 — programme of action for global action in all areas of sustainable development;
- The Rio Declaration on Environment and Development — principles defining the rights and responsibilities of States;
- The Statement of Forest Principles — principles to underlie the sustainable management of forests worldwide.

In addition, two legally binding conventions were taken at the summit for signature which aimed at preventing global climate change and the eradication of the diversity of biological species, which were giving high profile to following efforts:

- The United Nations Framework Convention on Climate Change, and
- The Convention on Biological Diversity.

United Nations Framework Convention on Climate Change (UNFCCC)

UNFCCC was one of the key outcomes of the Rio Earth Summit 1992, which is an international climate protection forum aiming to stabilise the concentration of heat-trapping Green House Gases (GHG). Stabilisation is at levels that will prevent dangerous interference with the climate system. In this direction the developed countries are to take significant measures in this area. They can help by reducing their emissions to 1990 levels by the year 2000. They should provide technology, finance and capacity building support to developing countries in this regard. In 1997, the convention was strengthened with a Kyoto Protocol, in which the developed countries took legally binding obligations. Their obligation was to cut their emissions by 5.2 per cent below 1990 levels by 2008–2012 in aggregate, as the first step towards much larger emission cuts in future. The developing countries, whose per capita emissions were just a fraction of developed countries, were not obliged to take binding emission reduction obligations. In 2007, the UNFCCC at its Thirteenth Conference of Parties (COP) adopted the Bali Road Map. The aim of this Conference was to push action on the shared vision, mitigation, adaptation, technology and financing. In 2009, the Copenhagen Accord was adopted by the parties to the Convention at the

fifteenth Conference of Parties (COP). It includes long-term goal of limiting average global temperature. It is to not more than 2 degree Celsius above of pre-industrial levels. This also attracted voluntary pledges for reduction of emission. In 2010, the Parties adopted Cancun Agreement. The agreement includes a comprehensive package to address the long-term challenge of climate change collectively by taking concrete action. In 2011, the meeting was held in Durban to draw up the blueprint for a fresh universal legal agreement. It was to deal with climate change beyond 2020. In 2012, the UN Climate Change Conference was held in Doha. In this conference, the governments consolidated the gains of the last three years of international climate change negotiations. The governments opened a gateway called Doha Climate Gateway for action on every levels for protection of environment.

In November 2013, the nineteenth session of the Conference of Parties was held in Warsaw. In this conference, a series of decisions were taken. The important decisions *inter-alia* were: (i) to evolve a draft text of the proposed new climate agreement, (ii) identification of information for Intended Nationally Determined Contributions, (iii) countries to close the pre 2020 ambition gap by intensifying their efforts, (iv) to establish Warsaw International Mechanism for Loss and Damage in order to provide most vulnerable population with better protection against the damage caused by extreme weather and rise of sea level, (v) to urge developed countries to provide more clarity on mobilising finance, (vi) establishment of Warsaw framework for Reducing Emissions from Deforestation and Forest Degradation in developing countries. In this conference, it was decided to invite all Parties to initiate domestic preparations for their intended nationally determined contributions. The same was without prejudice to the legal nature of the contributions. The other legal instrument with legal force was under the Convention applicable to all Parties towards achieving the objective of the Convention. It was also to communicate them well in advance of the COP-21.

During the period from 1–14 December 2014, the twentieth session of the Conference of the Parties (COP-20) of the United Nations Framework, Convention on Climate Change and Tenth Meeting of Parties to Kyoto Protocol took place in Lima, Peru. In this COP-20, it was decided that countries should not backslide from current pledges. This is relevant in view of the action of some countries which had gone back on their commitments of the Kyoto Protocol. The Lima (Peru) Conference urged that the contribution of countries has to be more than their present commitments. It was ensured that countries can include adaptation, finance, technology transfer, etc., also in their Intended Nationally Determined Contributions (INDCs) in addition to mitigation. During the period from 30 November to 12 December 2015, the 21st Conference of the Parties under United Nations Framework Convention on Climate Change was held in Paris. The Minister for Environment, Forests and Climate Change in India led a delegation and advocated ambitious action based on the principle of common but differentiated responsibility (CBDR) that stresses the need for equity and fairness.

Paris Agreement on Climate Change, 2015

On 12 December 2015 in Paris, a historic agreement to combat climate change and investment towards a low carbon, resilient and sustainable future was agreed by 195 nations. The Paris Agreement for the first time brought all nations for common cause. The universal agreement's key aim is to keep a global temperature rise this century well below 2 degrees Celsius. It is to initiate efforts to limit the temperature increase even further to 1.5 degrees Celsius above pre-industrial levels. The 1.5 degree Celsius limit is a significantly safer defense line against the worst impacts of a changing climate. Besides, the agreement aims to strengthen the ability to deal with the impacts. To achieve these goals, appropriate financial flows will be put in place. It makes stronger action by developing countries. To protect the planet, the future generations will mark the 12 December 2015 as a date when responsibility, a shared humanity and a care for world took centre stage.

Salient features of the Paris Agreement inter-alia are as follows:

- Aim is not only achieving the objective of UNFCCC but also enhancing the implementation.
- Ideas of Climate Justice, Sustainable Lifestyles and Right to Development, which were specifically raised by India were explicitly recognised in the preamble.
- "Common but Differentiated Responsibilities and Respective Capabilities" were said in the agreement, capturing the notion of historical responsibility of the developed countries.
- Differentiated obligations based on annexes were not reflected in the agreement. However, differentiation across all elements was maintained for developed and developing countries.
- Developed Country Parties will undertake absolute emission reduction targets while Developing Country Parties will continue to enhance their mitigation efforts.
- The agreement not only includes Nationally Determined Contributions on mitigation but also has elements of adaptation, finance, technology transfer and capacity building.
- Developed Country Parties shall provide financial resources to assist Developing Country Parties.
- India's proposal to link transparency with capacity building initiative was agreed to.
- Article 2(1) (c) of the agreement states to make finance flows consistent with a pathway towards low greenhouse gas emissions. This was included despite opposition from India and other developing countries.

The Challenge of Climate Change for the Youth

The United Nations system recognises the key role of the youth in protecting

environment. The youth play a noteworthy role and work closely with youth organisations around the world. This initiative is taken through the United Nations Joint Framework Initiative on Children, Youth and Climate Change (Joint Framework Initiative). From 2008 the Joint Framework Initiative is coordinating efforts of 16 intergovernmental entities. In these steps many youth organisations give power to youth to take adaptation and mitigation actions and enhance their successful participation relating to climate change policy and processes. In the present scenario the youth of every nation have a good social and environmental awareness. Youth knowledge and efforts are a key to lead countries towards a resilient future. It is the need of the hour to actively engage youth and youngsters at national and global levels. Youth of today can create awareness in societies, run education programmes towards conserving our environment and promote renewable energy and can work towards environment-friendly practices.

It is quite true that youngsters globally should have a say for their future because of their creativity and youthfulness. Youth involvement and determination can make a noteworthy difference in avoiding the worst scenarios of climate change effects which can make significant impact on the policies of world leaders and citizens globally. Access to clean air, water, and a liveable climate are inalienable human rights in the planet.

Today, India is facing the obstacle of sustaining its economic and commercial growth while simultaneously dealing with the problem of climate change. Climate change can have make massive impact the economic life and may adversely impact the livelihood and the way of living of its people. In this regard, India's development is solely based on the priority of economic and social development and initiatives towards poverty reduction of its rural and urban masses. In this direction, India is playing a major role towards evolving processes and policies which will effectively deal with climate change effects and poverty eradication and improving the living standard of its citizens.

Initiatives of Good Practices Developed by Young People

The youth represents the most dynamic segment of the population and are the future of a nation. The young people's active participation for the success of all initiatives is indeed of crucial importance. On this account, the climate change initiatives are no exception to this and the youth involvement in the negotiations as well as its implementation is important.

Climate change is a cross-cutting issue, affecting not only the environment, but society, food, security, livelihood, natural resource base and disaster management. With development efforts linked to climate

change and it being a significant barrier to sustainable development, youth and youth organisations have an important role to play in tackling the effects of climate change. In particular, young people can contribute to efforts aimed at ensuring that new mechanisms are put in place for providing access to green technologies. Youth can also play a role in monitoring the implementation of specific programmes.

At all levels, the dialogue between youth and the policy makers should be promoted. There should be proper mechanisms to permit youth the access to information and the opportunity to present their views. The youth education represents one of the most effective tools to combat the destructive potential of climate change. It may cultivate an international understanding among members of the next generation since it is a long-term process that will impact an infinite number of future generations. Workshops may be organised at all levels for the youth to enable them to acquire knowledge about the climate change and the means to prevent it. There is a need to sensitise our younger generation in this matter. The responsibility of protecting the planet from the effects of climate change is on all of us, but the future of our initiatives depends largely on how well we associate the youth.

Initiatives to Tackle Climate Change

In addressing climate change by highlighting various domestic initiatives being embarked upon by the current government which inter-alia include the following:

- The Prime Minister's Council on Climate Change has been reconstituted to evolve a coordinated response on climate change.
- The Government of India is taking pro-active steps on enhancing energy efficiency of renewable energy.
- New initiatives taken by the Government of India which include the ambitious target of generating 100,000 MW of solar energy, quadrupling of cess on coal for clean technologies, rapid afforestation through the Green India Mission and expansion in wind energy.
- A National Adaptation Fund for climate change has been established to finance concrete adaptation projects that are state driven and needs of the states.
- Our country has prepared a comprehensive National Action Plan on Climate Change (NAPCC). The aim of this is to achieve sustainable development. Also since the launch of the NAPCC, there have been efforts to merge national programmes of action to regional and local levels consistent with varying socio-economic and ecological conditions. The National Action Plan on Climate Change identifies measures that promote our development objectives and addresses climate change efficiently.

In India, there are eight national missions which form the core of the National Action

Plan on Climate Change. These missions focus on multi-pronged, long-term and integrated strategies for achieving key goals in the context of climate change. Most of these programmes are already part of our current actions. They may need a change in direction and accelerated implementation of time-bound plans.

1. **National Solar Mission** aims to establish our country as a global leader in solar energy. It aims to increase the share of solar energy in the total energy mix, recognising the need to expand the scope of other renewable and non-fossil options.
2. **National Mission for Enhanced Energy Efficiency** aims to strengthen markets for energy efficiency by creating conducive regulatory and policy regime to set specific energy targets.
3. **National Mission on Sustainable Habitat** aims to make habitats sustainable through improvements in energy efficiency in buildings and management of solid waste.
4. **National Water Mission** aims to ensure integrated water resource management helping to conserve water, minimize wastage and ensure more equitable distribution.
5. **National Mission for Sustaining the Himalayan Ecosystem** aims to safeguard the Himalayan glaciers and mountain ecosystem.
6. **Green India Mission** aims to respond to climate change by a combination of adaptation and mitigation measures, which would help enhance carbon sinks in sustainably managed forests and other ecosystems.
7. **National Mission for Sustainable Agriculture** aims to devise strategies to make Indian agriculture more resilient to climate change. It would develop new varieties of crops and especially thermal resistant crops and alternative cropping patterns. It would be capable of withstanding extremes of weather and variable moisture availability.
8. **National Mission on Strategic Knowledge for Climate Change** was launched with the objectives of mapping of the knowledge and data sources relevant to climate change. Also, it is positioned as a data sharing policy framework for building a strategic knowledge network among the various arms of the Government of India.

There is a project on Integrated Coastal Zone Management (ICZM), which is under implementation in three coastal states—Gujarat, West Bengal and Odisha. At the national level, activities like high tide line mapping; delineation of ecologically sensitive areas like mangroves, coral reefs; sandunes; mud flats; salt, marshes, etc., have been completed.

The Government of India has launched a major effort to create '100 smart cities' in our country. The core objective of this effort is to design more efficient and liveable cities. As it may be said that compact and well-connected cities are not only cleaner and safer but also more economically productive.

India has chalked out ambitious plans and policies to tackle climate change. In this direction, the environmental issues reflect

India's strong will to address this global public good. In our country, the scarcity of resources and meeting the demands is a challenge for all of us. Therefore, as mandated under the UNFCCC, domestic momentum for addressing climate change also critically depends on multilateral negotiations and actual disbursement of long term finance and technology transfer from developed to developing countries.

International negotiations cannot be credible without the backing of national legislations. In the context of climate change, if there is a need to change the existing laws such as the Air (Prevention and Control of Pollution) Act, 1981, the Environment (Protection) Act, 1986, the Water (Prevention and Control of Pollution) Act, 1974 and the Wildlife Protection Act of 1972, the Parliament of India is the competent authority to bring about such amendments in the existing laws.

In May 2014, the Ministry of Environment and Forests was renamed as the Ministry of Environment, Forests and Climate Change. It reflects the importance attached by the Government of India to meet the challenge of climate change of the country and everywhere. In his 2014 Independence Day speech, the Prime Minister called for manufacturing sector to try and make products which have 'zero effect' or no adverse impact on the environment. The Government of India is also laying high priority to cleaning of rivers of the country. Some of the recent climate initiatives of the Government of India include:

- Augmenting of renewable energy targets to 175 GW by 2022.
- Increase in statutory cess on coal, peat and lignite (from ₹50 per tonne to ₹200 per metric tonne) to augment the National Clean Energy Fund (NCEF) set-up in 2010 for supporting projects, programmes and policies that promote clean energy technologies.
- Movement from a carbon subsidisation regime to carbon taxation regime – carbon tax equivalent of US$ 60 per tonne of CO_2 in case of unbranded petrol and US$ 42 per tonne in case of unbranded diesel.
- Massive afforestation plans with investment to the tune of USD 6 billion.
- Setting up of a National Adaptation Fund for Climate Change with a funding of around US$ 18 million.
- Setting up of the National Institute on Climate Change.
- A sum of around US$ 90 million has been allocated for setting up of theUltra Mega Solar projects in five states.
- A sum of around US$ 18 million has been allocated for the Ultra Super Critical Coal based Thermal Power Technology.
- A sum of around US$ 72 million has been allocated for a new scheme aimed at solar power driven agricultural pump sets and water pumping stations.
- A sum of around US$ 18 million has been allocated to develop 1 MW Solar Parks on the banks of canals.
- Our country's Intended Nationally Determined Contribution (INDC) was announced on 2 October 2015. The main elements of India's INDC include:

- To reduce the emissions intensity of its GDP by 33–35 per cent by 2030.
- To achieve about 40 per cent cumulative electric power installed capacity from non-fossil fuel based energy resources by 2030 with the help of transfer of technology and low cost international finance including from Green Climate Fund.
- To create an additional carbon sink of 2.5 to 3 billion tonnes of CO_2 equivalent through additional forest and tree cover by 2030 in the country.

Conclusion

The issue of protection of planet needs to be addressed within the background of the sustainable development. There is need to ensure that development benefits reach to the poorest and most vulnerable section of our society. Millions of people are already being impacted by environmental degradation and climate change. The rise of sea levels in Small Island Developing States and agricultural stagnation is a serious concern for all. Its impacts are particularly acute for women, indigenous people and the elderly. Controlling greenhouse gas emissions and ecosystem resilience are fundamental for the growth of our future generations. We have only one planet and human kind must become accountable for the wanton destruction. Protecting our future on this planet also depends on harmonious living of our species.

References

Ackerman, Frank Kozul, Richard and Vos, Rob. (Eds.). 2012. *Climate Protection and Development*. Bloomsbury Publishing.

Ministry of Environment, Forests and Climate Change. 2014–2015. *Annual Report.* Government of India.

Dhawan, T.K. 2010. *Global Warming and Climate Change: International Legal Process*. Mohini Publishers and Distributors India.

Helm, Dieter and Cameron Hepburn, 2009. Eds. *The Economics and Politics of Climate Change*. OUP, Oxford.

Jayaram, Dhanasree. 2012. *Breaking Out of the Green House: Indian Leadership in Times of Environmental Change.* K.W. Publishers.

Sarkar, A.N. 2010. *Emissions Trading and Carbon Management*. Pentagon Press.

COMPUTATIONAL PHYSICS WITH SPREADSHEET – I

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Introduction

In classroom teaching, students are often shown graphs of relations derived which they themselves never generate using calculator as it becomes cumbersome and time consuming. This leaves a gap in their understanding of visualising mathematical dependence from the mathematical formula. The spreadsheet becomes an efficient means of generating data from the known mathematical relation. In this article we discuss three examples viz. δ v/s i curve for prism, trajectory of a projectile, exponential growth and decay and addition of simple harmonic oscillations.

Angle of Deviation in Prism

Consider the deviation of a ray through a prism as a function of the angle of incidence.

For prism of refracting angle we have following relations:

$$\mu = \frac{\text{Sin i}}{\text{Sin } r_1} = \frac{\text{Sin e}}{\text{Sin } r_2}$$

$\delta = i + e - A$ and $A = r_1 + r_2$

We may take independent variable i (angle of incidence) in column A and then calculate, r_1, r_2, e and δ in the columns from B to E.

A2 contains increment in angle i, B2 contains angle of prism A, C2 contains the refractive index of material of the prism.

So if the angle is in cell A5, the formulae for other angles become–

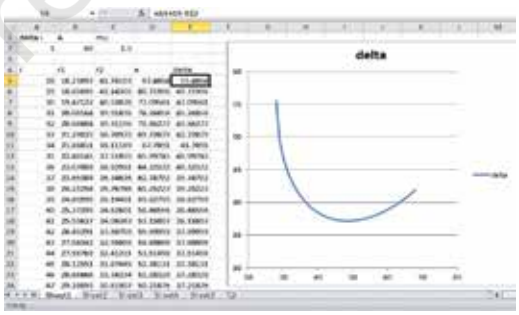
B5→=degrees (asin(sin (radians(a5))/C$2))

C5→=B$2-B5

D5→= degrees (asin(c$2 * sin (radians (C5))))

E5→=A5+D5-B$2

We get following calculations and plot for μ = 1.5 and A = 60°



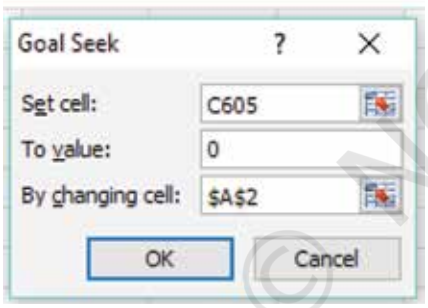
Projectile Motion

A body is projected with velocity u at an angle θ.

The equation for x displacement is
x = ucos(θ)t.

The equation for y displacement is $y = u\sin(\theta)t + \frac{1}{2} gt2$.

Since the excel calculations are done for a particular number of data points and graph plotted for the same, it becomes tricky to decide how many iterations to do for the projectile to land again on the ground. This can be found from trial and error. However there is a way to overcome this problem by using the 'goal seek' tool from what-if-analysis tool pack. Let us say we have used 600 data points for t. But it is not guaranteed that for the given value of u and theta, the projectile will ground again at 600th data point. So we click on Data → What-if-analysis → Goal Seek. A dialogue box opens:



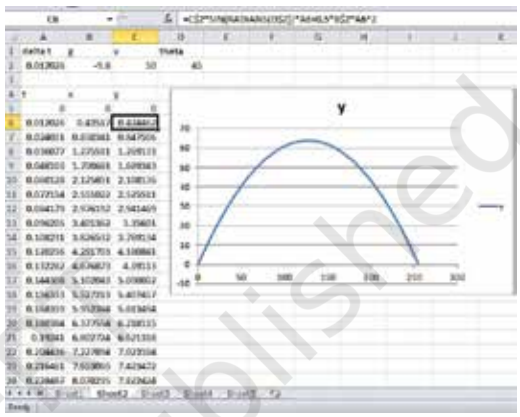
In 'Set cell': Type the address of the last cell of iteration for y value.

In 'To value': Type 0. (As the projectile grounds again, y coordinate is 0).

In 'By changing cell': Type the address of the delta t (incremental value of t). The address is provided by locking the cell. E.g., here it is A2, instead of just A2.

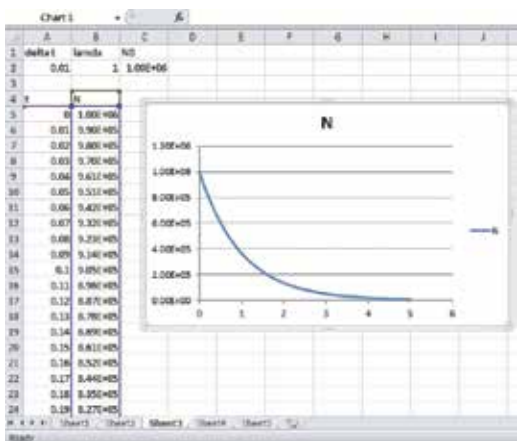
After putting the values, press the Ok button and the excel calculates what value of delta t will make the projectile land on ground in 600th t value. The corresponding value of x gives the range of the projectile.

As the speed and angle of projectile is changed, we have to do this process every time.



Radioactivity

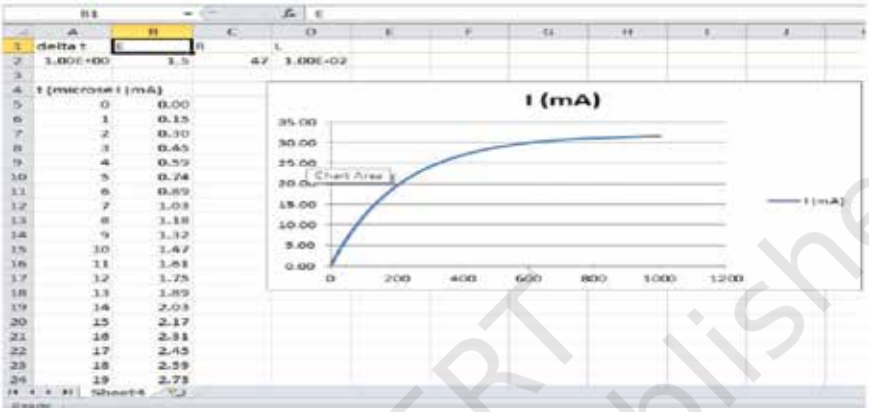
The number of radioactive atoms remained after time t is given by $N(t) = N_0 e^{-\lambda t}$. Where N0 is the number of atoms in the beginning and λ is the disintegration constant.



Growth of current in Inductor

The value of current in an LR circuit connected to a battery of E.M.F. E and resistor R is given by $i = \frac{E}{R}\left(1 - e^{\frac{-t}{(L/R)}}\right)$

We can observe by changing the value of L or R, how current grows faster or slower.



References

Bernard V. Liengme. 2009. *A Guide to Microsoft EXCEL 2007 for Scientist and Engineers 1st Ed.*, Academic Press.

Halliday, Resnick and Walker. 2005. Fundamentals of Physics 6th Ed., John Wiley & Sons.

Jain. M. K., S. R. K. Iyengar and R. K. Jain. 2010. *Numerical Methods for Scientific and Engineering Cλ*

SCIENCE NEWS

3-D X-ray Imaging Makes the Finest Details of a Computer Chip Visible

Researchers of the Paul Scherrer Institute (PSI) have made detailed 3-D images of a commercially available computer chip. This marks the first time a non-destructive method has visualised the paths of a chip's internal wiring (just 45 nanometres — 45 millionths of a millimetre — wide) and its 34-nanometre-high transistors clearly without distortions or deformations. It is a major challenge for manufacturers to determine if, in the end, the structure of their chips conforms to the specifications. Thus these results represent one important application of an X-ray tomography method that the PSI researchers have been developing for several years. In their experiment, the researchers examined a small piece that they had cut out of the chip beforehand. This sample remained undamaged throughout the measurement. The goal now is to extend the method in such a way that it can be used to examine complete chips. The researchers conducted the experiments at the Swiss Light Source (SLS) of the Paul Scherrer Institute. They report their results in the latest edition of the journal *Nature*.

The electrical wiring in many of the electronic chips in our computers and mobile phones are just 45 nanometres wide, the transistors 34 nanometres high. While it is standard practice today to produce structures this delicate, it remains a challenge to measure the exact structure of a finished chip in detail in order to check, for example, if it is built according to the specifications. Nowadays, for such examinations, manufacturers mainly use a method in which layer after layer of the chip is removed and then, after each step, the surface is examined with an electron microscope; this is known as FIB/SEM — focused ion beam or scanning electron microscope imaging.

Now researchers of the Paul Scherrer Institute have used X-rays to achieve non-destructive 3-D imaging of a chip, so that the paths of the conducting lines and the positions of the individual transistors and other circuit elements became clearly visible. "The image resolution we were able to produce is comparable to the conventional FIB/SEM examination method," explains Mirko Holler,

leader of the project. "But we were able to avoid two significant disadvantages: Firstly, the sample remained undamaged, and we have complete information about the three-dimensional structure. Secondly, we avoided distortions of the images that arise in FIB/SEM if the surface of the individual slice is not exactly planar."

Positioned with Nanometre Precision

For their study, the researchers used a special tomographic method (ptychotomography) that they have developed and enhanced over the course of recent years, and which today offers the worldwide best resolution of 15 nanometres (15 millionths of a millimetre) for examination of a comparably large volume. In the experiment the object to be studied is X-rayed at precisely determined places with light from the Swiss Light Source (SLS) of the Paul Scherrer Institute — for each illuminated spot a detector then measures the X-ray light pattern after its passage through the sample. The sample is then rotated in small steps and then X-rayed again step-wise after each turn. From the whole set of data obtained, the three-dimensional structure of the sample can be determined. "With these measurements, the position of the sample must be known to a precision of just a few nanometres — that was one of the particular challenges in setting up our experimental station," Holler says.

In their experiment the researchers examined small pieces of two chips — a detector chip developed at PSI and a commercially available computer chip. Each piece was about 10 micrometres (that is, 10 thousandths of a millimetre) in size. While the examination of an entire chip with the present measurement setup is not possible, the method's advantages are brought to bear even in this form, so that the first prospective users have already expressed an interest in conducting measurements at PSI.

The Goal: to Examine Entire Microchips

"We are currently starting to extend the method in such a way that it can be used to examine entire microchips within an acceptable measurement time. Then it will also be possible to study the same area of a chip multiple times, for example to observe how it changes under external influences," explains Gabriel Aeppli, head of the Synchrotron Radiation and Nanotechnology Division at the PSI.

A New Model for Capillary Rise in Nano-channels Offers Insights into Improved Hydraulic Fracturing (Fracking)

In the last decades, hydraulic fracturing or 'fracking,' a method of oil and gas extraction, has revolutionised the global energy industry. It involves fracturing rock with a pressurised liquid or 'fracking fluid' (water containing sand suspended with the aid of thickening agents) to draw out small oil and gas deposits trapped in stone formations.

After the water molecules of the fracking fluid are injected into these formations, they rise up the stone walls of the small channels where they have flowed. They can then undergo 'imbibition,' a type of diffusion that involves them being absorbed via nano-pores into the neighbouring pockets where the oil and gas reside. As the water molecules are absorbed, the oil and gas molecules are displaced and can then be pumped to the surface. This activity is driven by the capillary

force between the water and oil, which results from the tension generated at the interface or point where the two fluids meet.

Scientists have typically calculated the expected level of capillary rise in these conditions with the Lucas-Washburn equation, a mathematical model whose earliest parameters were first devised nearly a century ago. The challenge, however, is that that the equation has not been completely accurate in predicting the actual rise observed in nano-capillary laboratory experiments.

"The height of the capillary rise that was observed in these experiments was lower than what the Lucas-Washburn model would have predicted," explained Anqi Shen, a doctoral student at China's Northeast Petroleum University who works closely with Yikun Liu, a professor at the university. "Understanding what was causing this deviation became an important point of focus for my colleagues and me."

The researchers describe their findings this week in the journal *Applied Physics Letters,* from AIP Publishing.

"Many explanations have been offered for the lower-than-expected capillary rise. One area of discussion has focused on the viscosity of the fluid. Another has been the sticky layers of oil that form on the walls of the capillaries and narrow their diameter, which is an issue that we have also explored," Shen said, whose work is also funded by the Major Projects Program for the National Science and Technology of China.

"We looked at many factors and found that the surface roughness of the capillaries was the main reason for the lower-than-expected result. Specifically, we realised that the model could better determine the actual level of capillary rise if we adjusted the parameters to account for the frictional drag that is caused by the inherent roughness of the surface of the capillary walls. When we saw how this made the model more accurate, we knew that we could not ignore it," Shen said.

Moreover, the miniscule size of the capillaries means that even small increases in surface roughness can make a significant impact on calculations.

"Factors that might be ignored in normal conditions can have significant effects on a micro or nano level. For instance, a relative roughness of 5 per cent, in a tube with a radius of 100 cm where the obstacle height is 5 cm hardly affects the fluid flow in the tube. However, with a tube radius of 100 nm and obstacle height of 5 nm, it could significantly affect the fluid flow in the tube," Shen said.

Currently, there are only a few labs carrying out nano-capillary rise experiments. As a result, Shen and her colleagues could only work with the results from one laboratory in the Netherlands. Going forward, they intend to verify their mathematical formula by examining its effectiveness at simulating the results of other experiments.

Although Shen's research focuses on oil and gas development, she and her colleagues hope that their work can be of use to scientists working in other fields.

"Capillary rise is a basic, physical phenomenon that occurs in soil, paper, and other biologically relevant realms," Shen said. "Understanding how it is potentially affected at the nano-capillary level by frictional drag could shed light in a variety of scientific disciplines."

A New Theory to Describe Widely Used Material

LiU researcher Klas Tybrandt has put forward a theoretical model that explains the coupling between ions and electrons in the widely used conducting polymer PEDOT:PSS. The model has profound implications for applications in printed electronics, energy storage in paper, and bioelectronics.

One of the most commonly used materials in organic electronics is the conducting polymer PEDOT:PSS, and tens of thousands of scientific articles have been published referring to the material and its properties. One of the major advantages of PEDOT:PSS is that it conducts both ions and electrons, but a model that explains how this works has, until now, not been available. We know that the material has several useful properties, but we don't know why.

Klas Tybrandt, principal investigator in the Soft Electronics group at the Laboratory of Organic Electronics, Campus Norrköping, has developed a theoretical model for the interaction between ions and electrons that explains how ion transport and electron transport are related. The model has been published in the journal *Science Advances*.

"Classical electrochemical models have mainly been used in the past for this type of system, and this has led to a certain degree of confusion, since the models do not include the properties of semiconductors. We have used a purely physical description that clarifies the concepts," says Klas Tybrandt.

The material is a mixture of a semiconducting polymer and a polymer that conducts ions. The two phases are mixed down to the nanometer-scale, and even a thin film contains a huge number of interfaces. At the contact surface between the electronic and the ionic phases, what is known as an 'electrical double layer' forms, which means that a charge separation builds up here between ions and electrons.

"We have combined semiconductor physics with a theory for electrolytes and electrical double layers, and we have been able to describe the properties of the material on a theoretical basis. We have also experimental results showing that the model agrees with laboratory measurements," says Klas Tybrandt.

PEDOT:PSS is one of several polymeric materials that act in the same way. Increased understanding of the material and its unique properties is a major advance for researchers in several areas of organic electronics.

One such area is printed electronics, where it is now possible to calculate and optimise the performance of electrochromic displays and transistors.

Another area that benefits from the new model is bioelectronics. Here, materials that conduct both ions and electrons are particularly interesting, since they can couple the ion conducting systems of the body with the electronic circuits in, for example, sensors.

"We can optimise the applications in a completely new way, now that we understand how these materials work," says Klas Tybrandt.

A third area is the storage of energy in paper, a field in which LiU researchers are world-leaders.

"Understanding the complexity of these polymers allows us to develop and optimise the technology. This will be one of the areas for the newly opened Wallenberg Wood Science Center," says Klas Tybrandt.

Main funding for the project has been provided by the Swedish Research Council and the Swedish government's Strategic Research Area Initiative into Advanced Functional Materials at Linköping University.

The article 'Chemical potential-electric double layer coupling in conjugated polymer-polyelectrolyte blends', written by Klas Tybrandt, Igor V Zozoulenko and Magnus Berggren, Laboratory of Organic Electronics, Linköping University, has been published in *Science Advances*.

Big Data Approach to Predict Protein Structure

Nothing works without proteins in the body, they are the molecular all-rounders in our cells. If they do not work properly, severe diseases, such as Alzheimer's, may result. To develop methods to repair malfunctioning proteins, their structure has to be known. Using a big data approach, researchers of Karlsruhe Institute of Technology (KIT) have now developed a method to predict protein structures.

In the *Proceedings of the National Academy of Sciences (PNAS)* of the United States of America the researchers report that they succeeded in predicting even most complicated protein structures by statistical analyses irrespective of the experiment. Experimental determination of protein structures is quite cumbersome, success is not guaranteed. Proteins are the basis of life. As structural proteins, they are involved in the growth of tissue, such as nails or hairs. Other proteins work as muscles, control metabolism and immune response, or transport oxygen in the red blood cells.

The basic structure of proteins with certain functions is similar in different organisms. "No matter whether human being, mouse, whale or bacterium, nature does not constantly invent proteins for various living organisms anew, but varies them by evolutionary mutation and selection," Alexander Schug of the Steinbuch Centre for Computing (SCC) says. Such mutations can be identified easily when reading out the genetic information making up the proteins. If mutations occur in pairs, the protein sections involved mostly are located close to each other. With the help of a computer, the data of many spatially adjacent sections can be composed to an exact prediction of the three-dimensional structure similar to a big puzzle. "To understand the function of a protein in detail and to influence it, if possible, the place of every individual atom has to be known," Schug says.

For his work, the physicist uses an interdisciplinary approach based on methods and resources of computer science and biochemistry. Using supercomputers, he searched the freely available genetic information of thousands of organisms, ranging from bacteria to the human being, for correlated mutations. "By combining latest technology and a true treasure of datasets, we studied nearly two thousand different proteins. This is a completely new dimension compared to previous studies," Schug adds. He emphasises that this shows the high

performance of the method that promises to be of high potential for applications ranging from molecular biology to medicine. Although present work is fundamental research according to Schug, the results may well be incorporated in new treatment methods of diseases in the future.

Math Learned Best When Children Move

Children improve at math when instruction engages their own bodies. This is one of the findings from a recent study coming from the University of Copenhagen's Department of Nutrition, Exercise and Sports. The results also document that children require individualised learning strategies.

The project has investigated whether different types of mathematics learning strategies change the way children solve math problems.

Well-being and learning among school age children has a significant impact on how children fare later on in life. Therefore, frameworks for elementary school teaching and learning must be optimised. The 2014 Danish School Reform emphasised physical activity during the primary and lower secondary education years — as apart of academic instruction as well. Researchers from the Department of Nutrition, Exercise and Sports have investigated the effect of different types of primary school mathematics instruction.

It Helps to Use the Whole Body

Results from the study underscore that many children improve at math when their bodies are engaged during instruction, and that math instruction should be individualised.

"The children learn more if they move and use the whole body to learn," according to head researcher and Associate Professor Jacob Wienecke of the University of Copenhagen's Department of Nutrition, Exercise and Sports. "Compared to previous studies which demonstrated that intense physical activity could improve learning outcomes, we have been able to show that lower intensity activities are just as effective, or even more effective, as long as movement is integrated into the topic at hand."

After just six weeks of the study, all of the children improved their scores in a standardised fifty question national test. Children whose instruction included whole body activity performed best. Their performance improved by 7.6 per cent, with nearly four more correct responses than the baseline, and twice as much improvement as the sedentary fine motor skills group.

Differentiated Instruction is Crucial

When children were grouped according to pre study math performance, the results demonstrated that children with average and above average performance benefited most from using the entire body in learning. Children who weren't very good at math prior to the study received no particular benefit from the alternative instructional forms.

"We need to keep this in mind when developing new forms of instruction," according to Associate Professor Wienecke, who continues: "The new school reform focuses on, among other things, the incorporation of physical activity during the school day, with the aim of improving the motivation, well-being and learning of ALL children. However, individual understanding must be taken into account. Otherwise,

we risk an unfortunate combined outcome in which those who are already proficient advance, and those who have not yet mastered concepts cannot keep up."

The researchers are now investigating which areas of the brain are involved in these various learning strategies. At the same time, researchers will be testing the School Reform's positive effects on other academic skills, such as reading.

Results of the study have just been released in the article, Motor-enriched Learning Activities Can Improve Mathematical Performance in Preadolescent Children, published in the internationally renown scientific journal, *Frontiers in Human Neuroscience*.

About the Study

The University of Copenhagen's Department of Nutrition, Exercise and Sports studied the effect of various instructional types related to mathematics instruction for Danish primary school students. 165 Danish first grade students, divided among three schools in the Copenhagen area participated in a six-week study.

The children were divided into three groups:

- One group used the whole body during mathematics education. Teaching took place on the classroom floor, with tables and chairs set to the side. Students were included in problem solving by, for example, making a triangle or shaping numerals with their bodies, or using one another when being asked to add or subtract.
- Another group of students was sedentary and worked on math using fine motor skills. These children worked independently or in small groups using LEGO-bricks in a classroom setting. For example, they used bricks for arithmetic or to build models for solving geometry tasks.
- A control group engaged in regular mathematics instruction, using pencils, paper, rulers and the like.

Does the Universe Have a Rest Frame?

Physics is sometimes closer to philosophy when it comes to understanding the universe. Donald Chang from Hong Kong University of Science and Technology, China, attempts to elucidate whether the universe has a resting frame. The results have recently been published in *EPJ Plus*.

To answer this tricky question, he has developed an experiment to precisely evaluate particle mass. This is designed to test the special theory of relativity that assumes the absence of a rest frame, otherwise it would be possible to determine which inertial frame is stationary and which frame is moving. This assumption, however, appears to diverge from the standard model of cosmology, which assumes that what we see as a vacuum is not an empty space. The assumption is that the energy of our universe comes from the quantum fluctuation in the vacuum.

In a famous experiment conducted by Michelson and Morley in the late 19th century, the propagation of light was proved to be independent of the movement of the laboratory system. Einstein in his Special Theory of Relativity, inferred that the physical laws governing the propagation of light are equivalent in all inertial frames — this was

later extended to all physics laws not just optics.

In this study, the author set out to precisely measure the masses of two charged particles moving in opposite directions. The conventional thinking assumes that the inertial frame applies equally to both particles. If that is the case, no detectable mass difference between these two particles is likely to arise. However, if the contrary is true, and there is a rest frame in the universe, the author expects to see mass difference that is dependent on the orientation of the laboratory frame. This proposed experiment partially inspired by the Michelson and Morley experiments can be conducted using existing experimental techniques. For simplicity, an electron can be used as the charged particle in the experiment.

How Cheetahs Stay Fit and Healthy

Cheetahs are categorised as vulnerable species, partly because they have been considered to be prone to diseases due to their supposed weak immune system. However, they are hardly ever sick in the wild. A research team from the German Leibniz Institute for Zoo and Wildlife Research (IZW) recently discovered that cheetahs have developed a very efficient innate 'first line of defense' immunity to compensate potential deficiencies in other components of their immune system. The scientists have published their results in the open access journal *Scientific Reports* of the Nature Publishing Group.

Cheetahs have a relatively low genetic variability which means that, within a population, the individuals have a similar genetic makeup. This is also true for the major histocompatibility complex (MHC), a genome region that regulates the so-called 'adaptive' immune system and is typically highly variable in animal species. The adaptive immune system provides a rapid and specific defense against pathogens, if they have been encountered previously. A low MHC variability should, therefore, result in a weak adaptive immune system and, thus, a high vulnerability to diseases. This is often the case in species with low MHC variability, but there are some exceptions, the cheetah indeed being one of them. "During our long-term study that began in 2002, we investigated more than 300 free-ranging cheetahs that live on farmland in Namibia. We did not encounter any cheetah with symptoms of acute infections, nor did we detect lesions in the examined dead animals," explains Bettina Wachter, head of the cheetah research project.

How can cheetahs cope so well with pathogens despite their supposedly weak adaptive immunity? The immune system is divided into three components: (1) the constitutive innate immune system, which provides a rapid first line of defense against intruders, (2) the induced innate immune system such as the local and systemic inflammatory response, which enhances recovery and decreases pathogen growth, and (3) the adaptive immune system.

"We decided to investigate all three components simultaneously, an approach that is rarely done although it is very promising. For every animal, a well-functioning immune system is associated with certain energetic costs. However, this does not imply that all immune components are equally strongly developed. If a species is not vulnerable to

diseases, a good immune response must have evolved by strengthening other parts of the immune system," says Gábor Czirják, wildlife immunologist at the Leibniz-IZW.

To compare the results with another species, the scientists included leopards in the study. "Leopards live in the same habitat as cheetahs in Namibia, but they have a high variability in their MHC. Thus, leopards should have a strong adaptive immune system and might not invest that much energy in the other parts of the immune system," explains Wachter.

"We first needed to adapt six immunological tests from the toolbox of the wildlife immunology for the cheetah and leopard," explains Sonja Heinrich, first author of the study. "We conducted these tests at the laboratory of the Leibniz IZW, thus needed to transport the samples we collected in Namibia all the way to Germany, keeping the cooling chain uninterrupted from the captured animal in the field to the Leibniz IZW." The immunological tests confirmed that leopards have a stronger adaptive immune system than cheetahs, consistent with the differences in the MHC variability of both species. As expected, cheetahs had a stronger innate 'first line of defense' immune system than leopards, thereby probably compensating their weak adaptive immune system.

The induced innate immune system reacts to pathogen intruders as well as to temporary stress. Therefore, the scientists also determined the concentration of the hormone cortisol, which activates catabolic processes and is increasingly released during stress. Although both species were exposed to the same capture and handling procedures leopards had significantly higher cortisol concentration in their blood than cheetahs, indicating that leopards reacted stronger to the examination methods. Thus, short-term stress might have stimulated the induced innate immune system, making it difficult to assess whether this immune part also helps to compensate the weak adaptive immune system of cheetahs, if the stress effect is not considered.

This is the first study in mammals demonstrating that different species spend varying efforts in the development of the different immune components. Cheetahs have apparently developed a way to successfully fight against pathogens despite their low genetic variability in their MHC. However, the future of this vulnerable species is highly uncertain because most of their habitat occurs in unprotected areas and they frequently come into conflicts with humans. Only if these conflicts can be mitigated, the cheetahs have a good chance to persist in the wild in the future.

Research Leads to a Golden Discovery for Wearable Technology

Some day, your smartphone might completely conform to your wrist, and when it does, it might be covered in pure gold, thanks to researchers at Missouri University of Science and Technology.

Writing in the March 17 issue of the journal *Science*, the Missouri S&T researchers say they have developed a way to 'grow' thin layers of gold on single crystal wafers of silicon, remove the gold foils, and use them as substrates on which to grow other electronic materials.

The research team's discovery could revolutionise wearable or 'flexible' technology research, greatly improving the versatility of such electronics in the future.

According to lead researcher Dr Jay A. Switzer, the majority of research into wearable technology has been done using polymer substrates, or substrates made up of multiple crystals. "And then they put some typically organic semiconductor on there that ends up being flexible, but you lose the order that (silicon) has," says Switzer, Donald L. Castleman/FCR Endowed Professor of Discovery in Chemistry at S&T.

Because the polymer substrates are made up of multiple crystals, they have what are called grain boundaries, says Switzer. These grain boundaries can greatly limit the performance of an electronic device.

"Say you're making a solar cell or an LED," he says, "In a semiconductor, you have electrons and you have holes, which are the opposite of electrons. They can combine at grain boundaries and give off heat. And then you end up losing the light that you get out of an LED, or the current or voltage that you might get out of a solar cell."

"Most electronics on the market are made of silicon because it's relatively cheap, but also highly ordered," Switzer says.

"99.99 per cent of electronics are made out of silicon, and there's a reason – it works great," he says. "It's a single crystal, and the atoms are perfectly aligned. But, when you have a single crystal like that, typically, it's not flexible."

By starting with single crystal silicon and growing gold foils on it, Switzer is able to keep the high order of silicon on the foil. But because the foil is gold, it's also highly durable and flexible.

"We bent it 4,000 times, and basically the resistance didn't change," he says.

The gold foils are also essentially transparent because they are so thin. According to Switzer, his team has peeled foils as thin as seven nanometers.

Switzer says the challenge his research team faced was not in growing gold on the single crystal silicon, but getting it to peel off as such a thin layer of foil. Gold typically bonds very well to silicon.

"So we came up with this trick where we could photo-electrochemically oxidize the silicon," Switzer says. "And the gold just slides off."

Photoelectrochemical oxidation is the process by which light enables a semiconductor material, in this case silicon, to promote a catalytic oxidation reaction.

Switzer says thousands of gold foils—or foils of any number of other metals—can be made from a single crystal wafer of silicon.

The research team's discovery can be considered a 'happy accident.' Switzer says they were looking for a cheap way to make single crystals when they discovered this process.

"This is something that I think a lot of people who are interested in working with highly ordered materials like single crystals would appreciate making really easily," he says. "Besides making flexible devices, it's just going to open up a field for anybody who wants to work with single crystals."

Scientists Evade the Heisenberg Uncertainty Principle

State-of-the-art sensors, such as MRIs and atomic clocks, are capable of making measurements with exquisite precision. MRI is used to image tissues deep within the human body and tells us whether we might suffer from an illness, while atomic clocks are extremely precise timekeepers used for GPS, internet synchronisation, and long baseline interferometry in radio-astronomy. One might think these two instruments have nothing in common, but they do: both technologies are based on precise measurement of the spin of the atom, the gyroscope-like motion of the electrons and the nucleus. In MRI, for example, the pointing angle of the spin gives information about where in the body the atom is located, while the amount of spin (the amplitude) is used to distinguish different kinds of tissues. Combining these two pieces of information, the MRI can make a 3D map of the tissues in the body.

The sensitivity of this kind of measurement was long thought to be limited by Heisenberg's uncertainty principle, which states that accurately measuring one property of an atom puts a limit to the precision of measurement you can obtain on another property. For example, if we measure an electron's position with high precision, Heisenberg's principle limits the accuracy in the measurement of its momentum. Since most atomic instruments measure two properties (spin amplitude and angle), the principle seems to say that the readings will always contain some quantum uncertainty. This long-standing expectation has now been disproven, however, by ICFO researchers Dr Giorgio Colangelo, Ferran Martin Ciurana, Lorena C. Bianchet and Dr Robert J. Sewell, led by ICREA Professor at ICFO Morgan W. Mitchell. In their article 'Simultaneous tracking of spin angle and amplitude beyond classical limits,' published in *Nature*, they describe how a properly designed instrument can almost completely avoid quantum uncertainty.

The trick is to realise that the spin has not one but two pointing angles, one for the north-east-south-west direction, and the other for the elevation above the horizon. The ICFO team showed how to put nearly all of the uncertainty into the angle that is not measured by the instrument. In this way they still obeyed Heisenberg's requirement for uncertainty, but hid the uncertainty where it can do no harm. As a result, they were able to obtain an angle-amplitude measurement of unprecedented precision, unbothered by quantum uncertainty.

Professor Mitchell uses a solid analogy to state that "To scientists, the uncertainty principle is very frustrating—we'd like to know everything, but Heisenberg says we can't. In this case, though, we found a way to know everything that matters to us. It's like the Rolling Stones song: You can't always get what you want /But if you try sometimes you just might find /You get what you need."

In their study, the ICFO team cooled down a cloud of atoms to a few micro-degrees Kelvin, applied a magnetic field to produce spin motion as in MRI, and illuminated the cloud with a laser to measure the orientation of the atomic spins. They observed that both the spin angle and uncertainty can be continuously monitored with a sensitivity beyond the previously expected limits, although still obeying the Heisenberg principle.

As for the challenges faced during the experiment, Colangelo comments that "in the first place, we had to develop a theoretical model to see if what we wanted to do was really possible. Then, not all the technologies we used for the experiment existed when we started: among them, we had to design and develop a particular detector that was fast enough and with very low noise. We also had to improve a lot the way we were 'preparing' the atoms and find a way to efficiently use all the dynamic range we had in the detector. It was a battle against the Dark Side of Quantum, but we won it!"

The results of the study are of paramount importance since this new technique shows that it is possible to obtain even more accurate measurements of atomic spins, opening a new path to the development of far more sensitive instruments and enabling the detection of signals, such as gravitational waves or brain activity, with unprecedented accuracy.

Secrets of Ancient Egypt May Spark Better Fuel Cells for Tomorrow's Cars

To make modern-day fuel cells less expensive and more powerful, a team led by John Hopkins chemical engineers has drawn inspiration from the ancient Egyptian tradition of gilding.

Egyptians artists at the time of King Tutankhamun often covered cheaper metals (copper, for instance) with a thin layer of a gleaming precious metal such as gold to create extravagant masks and jewelry. In a modern-day twist, the Johns Hopkins-led researchers have applied a tiny coating of costly platinum just one nanometer thick—about 1/100,000th the diameter of a human hair—to a core of much cheaper cobalt. This microscopic marriage could become a crucial catalyst in new fuel cells that generate electric current for powering cars and other machines.

The new fuel cell design would save money because it would require far less platinum, a very rare and expensive metal that is commonly used as a catalyst in present-day fuel-cell electric cars. The researchers, who published their work earlier this year in *Nano Letters*, say that by making electric cars more affordable, this innovation could curb the emission of carbon dioxide and other pollutants from gasoline- or diesel-powered vehicles.

"This technique could accelerate our launch out of the fossil fuel era," said Chao Wang, a Johns Hopkins Assistant Professor of chemical and biomolecular engineering and senior author of the study. "It will not only reduce the cost of fuel cells. It will also improve the energy efficiency and power performance of clean electric vehicles powered by hydrogen."

In their article, the authors tipped their hats to the ancient Egyptian artisans who used a similar plating technique to give copper masks and other metallic works of art a lustrous final coat of silver or gold. "The idea," Wang said, "is to put a little bit of the precious treasure on top of the cheap stuff."

He pointed out that platinum, frequently used in jewelry, also is a critical material in modern industry. It catalyses essential reactions in activities ranging from petroleum processing and petrochemical synthesis to emission control in combustion vehicles,

as well as being used in fuel cells. But, he said, platinum's high cost and limited availability have made its use in clean energy technologies largely impractical— until now.

"There's a lot more cobalt out there than platinum," said lead author and Johns Hopkins post-doctoral fellow Lei Wang (not related to Chao Wang). "We've been able to significantly stretch the benefits of platinum by coating it over cobalt, and we even managed to enhance the activity of platinum at the same time."

Earlier attempts to plate precious metals on non-precious materials were largely stymied by galvanic replacement reactions—oxidation of the non-precious metal. In this study, the team successfully suppressed such reactions by introducing carbon monoxide, a gas molecule that strongly binds to cobalt, protecting it from oxidation.

Not only did the cobalt-platinum nanoparticles reduce the usage of platinum; they performed almost 10 times better than platinum alone. The researchers said this enhanced catalytic activity resulted from both the maximized exposure of platinum atoms on the surface and from interactions between the two metals. "The intimate contact between cobalt and platinum gives rise to compressive strain," Lei Wang said. "It shortens the distance between platinum atoms and makes the chemical reactions more feasible on the surface."

Because platinum and other rare metals play key roles in many industrial applications, the implications of this work extend beyond fuel cells. Currently, the team is working on adapting their technique to other precious metals and non-precious substrates. New developments will target further applications of such materials in chemical conversions of hydrocarbons.

"Many reactions that depends on precious metal catalysts could be rendered cheaper and more effective by taking advantage of our technology," Chao Wang said. "At a time when we are becoming painfully aware of the limits of our non-renewable sources of energy and materials, this technique points us in a very welcome new direction."

Single Atom Memory: The World's Smallest Storage Medium

One bit of digital information can now be successfully stored in an individual atom, according to a study just published in *Nature*. Current commercially-available magnetic memory devices require approximately one million atoms to do the same. Andreas Heinrich, newly appointed Director of the Center for Quantum Nanoscience, within the Institute of Basic Science (IBS, South Korea), led the research effort that made this discovery at IBM Almaden Research Center (USA). This result is a breakthrough in the miniaturisation of storage media and has the potential to serve as a basis for quantum computing.

Disks coated with a magnetised layer of metal allow our computers to store files in the form of bits, each with the value of either 1 or 0. A certain direction of magnetisation corresponds to the 0 bit, the other direction to the 1 bit. While at the moment small areas of the disk, of around a million atom, correspond to each digital bit of information, this research went way beyond this and utilised the smallest amount of matter usable for this purpose: one atom.

In this study, scientists worked with a tool, called Scanning Tunneling Microscope (STM), which has a special tip that enables the user to view and move individual atoms, as well as to apply a pulse of electrical current to them. They used this electric pulse to change the direction of magnetisation of individual holmium atoms. By doing that, the team could write a memory of either 1 or 0 in a single holmium atom as well as swap the two.

A quantum sensor, designed by Heinrich's team and currently unique worldwide, was used to read the memory stored in the holmium atom. It consists of an iron atom placed next to the holmium atom. Using this technique, as well as another one, called tunnel magnetoresistance, the researchers could observe that holmium maintains the same magnetic state stably over several hours.

Then, when Heinrich's team of researchers tried to use two holmium atoms instead of one, they made another surprising discovery. Placing holmium atoms even one nanometer apart did not impact their ability to store information individually. This came as a surprise, since it was expected that the magnetic field from one atom would impact its neighbour. To put this scale into perspective, if a nanometer were blown up to the diameter of a typical human hair, the hair would have a diameter equivalent to the length of a school bus in comparison.

In this way, the scientists could build a two bit device with four possible types of memory: 1-1, 0-0, 1-0 and 0-1 clearly distinguished by the iron sensor.

Moore's Law predicted that the amount of data that can be stored on a microchip would double every 18 months and indeed this happened for decades. The last model electronic devices are always smaller and more powerful than the previous one. However, as devices become smaller and smaller, since atoms are so close to each other, new interfering quantum properties begin to manifest and cause problems. The impossibility of keeping up with further miniaturisation, brought experts to talk about the death of Moore's Law.

Interestingly, holmium atoms seem to escape this fate, for still unknown reasons. "There are no quantum mechanical effects between atoms of holmium. Now we want to know why," points out Heinrich. Holmium atoms can be arranged very closely together, so the storage density using this single-atom technique could be very high. He continues: "We have opened up new possibilities for quantum nanoscience by controlling individual atoms precisely as we want. This research may spur innovation in commercial storage media that will expand the possibilities of miniaturising data storage."

Heinrich is one of the few in the world using this tool to measure and change the properties of individual atoms. He plans to significantly expand on this research at his newly created IBS research centre, located at Ewha Womans University in Seoul.

Stress May Protect, at Least in Bacteria

Antibiotics harm bacteria and stress them. Trimethoprim (TMP), an antibiotic, inhibits the growth of the bacterium Escherichia coli and induces a stress response. This response also protects the bacterium from subsequent deadly damage from acid. Antibiotics can

therefore increase the survival chances of bacteria under certain conditions. This is shown in a study by researchers at the Institute of Science and Technology Austria (IST Austria), carried out by Karin Mitosch, Georg Rieckh and Tobias Bollenbach, which was published in the journal *Cell Systems*.

Bacteria often encounter harsh environmental conditions: pathogens, for example, have to withstand acidity in the stomach. A specific stress response may help them to survive such stressful conditions. At the same time, the response to a specific stress factor may also protect the bacterium from another stress factor; this is known as cross-protection. In their study, first author and Ph.D student Karin Mitosch and colleagues investigate whether the stress response to antibiotics can also provide such cross-protection.

Antibiotics, i.e., drugs that kill bacteria or inhibit their growth, can also activate stress response genes. So far, it has been unclear whether this stress response may also protect bacteria against other environmental influences. To investigate this question, the researchers exposed the bacterium Escherichia coli to low concentrations of four different antibiotics. At the same time, they measured how transcription changes across the entire genome of the bacterium in response to the antibiotics. Transcription is the copying of DNA into mRNA, which in turn provides the instructions for protein production.

One of the antibiotics investigated, trimethoprim (TMP), induces a rapid acid stress response, which is very variable from one bacterial cell to another. Those bacterial cells with a strong stress response are better protected from a subsequent acid attack. When the researchers exposed bacterial populations to an extremely acidic hydrochloric acid solution, the bacteria died rapidly: their survival is measured as 'half-life'— similar to the decay of radioactive materials— and amounts to only about 30 minutes. When the researchers placed the bacterial populations into a solution containing low concentrations of TMP first, and only later into the hydrochloric acid solution, the half-life triples to over 100 minutes.

Mitosch and colleagues elucidated the biochemical mechanism on which this cross-protection is based. TMP leads to a depletion of adenine-nucleotides, an important building block of DNA and energy carrier in the cell. This depletion in turn induces the acid stress response. Karin Mitosch explains the importance of their findings: "We propose a way how to find cross-protection between antibiotics and other stress factors. This is important, as our study gives an example for how antibiotics can influence the survival chances of bacteria in different environmental conditions. If we understand which cross-protection exists, targeted strategies may be developed that enhance the effect of antibiotics in the treatment of diseases."

Tracking a Solvation Process Step by Step

Chemists of Ruhr-Universität Bochum tracked with unprecedented spatial resolution how individual water molecules attach to an organic molecule. They used low-temperature scanning tunneling microscopy to visualise the processes at a scale smaller than one nanometre. This allowed them to

investigate the phenomena of hydrophilicity and hydrophobicity at the molecular level, i.e., why certain parts of organic molecules attract or repel water.

"The results are an important step on the path to understanding solvation processes, that is, how substances dissolve in water," explains Karsten Lucht of the Bochum Chair of Physical Chemistry I. He reports the results with the team led by Professor Dr Karina Morgenstern and colleagues from the Chair of Organic Chemistry II in the journal *Angewandte Chemie*. The scientists cooperate in the excellence cluster Ruhr Explores Solvation, or Resolv for short.

The aim of the cluster is to understand how solvents affect the reactions in solution and the use of solvents to control reactions.

Tracking Water Accumulation Step by Step

As an organic molecule, the researchers used an azo dye that consists of two carbon rings with attached functional groups that are polar, i.e., slightly positively or negatively charged. They deposited the molecules on a gold single crystal and cooled the system to six Kelvin. Then they added individual water molecules step by step and observed where these attached to the dye.

The first water molecules preferred to attach themselves to the polar functional groups. When the researchers increased the amount of water, the newly added molecules attached themselves to the water molecules that were already bonded. "Our experiments show that hydrophilicity and hydrophobicity can be traced back to molecular level," says Karina Morgenstern. The water molecules avoided non-polar areas of the molecule, polar areas were preferred.

Three Complementary Procedures

The processes that were observed here with scanning tunneling microscopy are usually investigated spectroscopically or with molecular dynamic simulations. However, the first method does not provide spatial information, and the latter is based on assumptions due to the size of the system. "Every method has its value," explains Karsten Lucht. "The three approaches complement each other."

Where Does Laser Energy Go After Being Fired into Plasma?

An outstanding conundrum on what happens to the laser energy after beams are fired into plasma has been solved in newly-published research at the University of Strathclyde.

The study discovered that the same forces that produce a bubble in plasma in the laser-plasma wakefield accelerator produce two additional low-energy but high-charge electron beams simultaneously with a low charge high energy beam. These high charge beams can have a thousand times more charge than the high energy beam.

Plasma, the state in which nearly all of the universe exists, can support electric fields that are 1,000 to 10,000 times higher than in conventional accelerators, simply by separating the positive and negative charged particles that makes up the plasma medium, which is quasi-neutral.

This can easily be achieved using an intense laser pulse, the light pressure of which pushes electrons out of its way, leaving behind the much heavier ions which remain in place and exert an attractive force on the displaced electrons. The displaced electrons then

oscillate around the stationary ions resulting in a wake behind the laser pulse, in a similar manner to the wake behind a boat.

Because the laser pulse travels at a velocity close to that of light in vacuum, the wake can track and accelerate charged particles rapidly to very high energies, over extremely short lengths.

The research paper, entitled 'Three electron beams from a laser-plasma wakefield accelerator and the energy apportioning question,' has been published in *Scientific Reports.*

Professor Dino Jaroszynski, of Strathclyde's Department of Physics, led the study. He said: "The intense laser pulse we used, and the acceleration of the wake it creates, lead to a very compact laser wakefield accelerator, which is millimetres long, rather than tens of metres long, for an equivalent conventional accelerator. The plasma wake forms into something like a bubble-shaped, laser-powered miniature Van de Graaf accelerator, which travels at close to the speed of light.

"Some of the laser energy is converted to electrostatic energy of the plasma bubble, which has a diameter of several microns. Conventional accelerators store their microwave energy in copper or superconducting cavities, which have limited power-carrying capability.

"An interesting conundrum that has not been considered before is the question of where laser energy goes after being deposited in plasma. We know where some of this energy goes because of the presence of high-energy electrons emitted in a narrow, forward directed beam.

"One of these beams is emitted by a sling-shot action into a broad forward-directed cone, with several MeV (mega electron volt) energies and nanocoulomb-level charge. Paradoxically, another beam is emitted in the backward direction, which has similar charge but an energy of around 200 keV (kilo electron volt). These beams carry off a significant amount of energy from the plasma bubble.

"It is interesting to observe that answering a very basic question — where does the laser energy go? — yields surprising and paradoxical answers. Introducing a new technology, such as the laser-wakefield accelerator, can change the way we think about accelerators. The result is a very novel source of several charge particle beams emitted simultaneously.

"My research group has shown that the wakefield accelerator produces three beams, two of which are low energy and high charge, and the third, high energy and low charge."

Dr Enrico Brunetti, a Research Fellow in Strathclyde's Department of Physics and a member of the research group, said: "These beams can provide a useful high flux of electrons or bremsstrahlung photons over a large area, which can be used for imaging applications, or for investigating radiation damage in materials. If not properly dumped, they can, however, have undesirable side-effects, such as causing damage to equipment placed close to the accelerator.

"This is a particular concern for longer accelerators, which often use plasma wave guides based on capillaries to guide the laser beam over long distances. These low energy,

high charge beams also carry a large amount of energy away from the plasma, setting a limit to the efficiency of laser-wakefield accelerators.

"This is an issue which needs to be taken into account in the future design and construction of laser-wakefield accelerators."

Source : Compiled Science Daily

Website : www.sciencedaily.com

Mr. Ramanand Yadav,
Junior Project Fellow, DESM, NCERT

WEB WATCH

In this section, we present websites and a brief introduction about them. Inclusion of a site does not imply that *School Science* endorses the content of the site. Sites have been suggested on the basis of their possible utility to school systems.

- https://www.curiositymachine.org/

  This website has interactive science technology to cater curiosity and learning in students. It has a specific 'Family Challenge' which is a "free, hands-on AI education program that brings families, schools, communities, and technology know-it-alls together to give everyone the chance to learn, play and create with AI."

- https://evolution.berkeley.edu/evolibrary/home.php

  This website has in-depth course on the science of evolution, teaching materials, resource library. This site helps you understand what evolution is, how it works, how it factors into your life, how research in evolutionary biology is performed, and how ideas in this area have changed over time.

- https://www.educationworld.com/a_tech/tech/tech158.shtml

  The Web, of course, offers thousands of science sites on every imaginable scientific subject. A quick search will provide you with such excellent educational sites as Virtual Frog Dissection, The Atoms Family, Cells Alive, 4000 Years of Women in Science, and many, many more.

- https://animals.sandiegozoo.org/

  San Diego Zoo Animals has facts, articles, images, audios, videos, blogs and other sources about wildlife found at the San Diego Zoo and Safari Park. This site is great for natural science studies and helps the learners to know about various diversity of animals helping them to know about their unique features.

- https://www.mbgnet.net/

Missouri Botanical Garden features information on the biomes of the world and freshwater and marine ecosystems. There are diverse informative facts about ecosystem.

- https://www.ncei.noaa.gov/

  National Centers for Environmental Information (NCEI) of National Oceanic and Atmospheric Administration (NOAA) hosts and provides public access to one of the most significant archives for environmental data on earth. The website provides over 37 petabytes of comprehensive atmospheric, coastal, oceanic, and geophysical data.

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To Our Contributors

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