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The intertwined Hansas symbolise the integration of three aspects of the work of the National Council of Educational Research and Training (NCERT): (i) Research and Development, (ii) Training, and (iii) Extension. The design has been adapted from an Ashokan period relic of the third century B.C. found in excavations near Maske in the Raichur district of Karnataka.	The Weird World of Nanotechnology <i>P.K. Mukherjee</i>	34
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A Comparison of Primary Mathematics Curriculum of Bangladesh and West Bengal of India – Why?

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TO KNOW THYSELF compare thyself to others
Every individual is different from another. Similarly, nations too differ from each other. International comparison between educational systems generally has a long history, although it is only recently that it has been motivated by concern for others rather than national self-interest. Comparing, of course, is one of the most basic of conscious human activities; we necessarily and constantly compare in order to make choices and to judge where we stand in relation to others and to our own past. In the more specific context of education, it is important to distinguish the comparing, importing and exporting of ideas, which is an activity intrinsic to educational development, from the task of attempting to devise rules of and procedures for doing so in a systematic way (Alexander, 2000).

Education for international understanding and co-operation is a growing field in many countries; it is possible to find programmes of its nature in universities, in schools and in adult

education, but these programmes often need to be radically changed if they are to become meaningful. Today, mankind does not need verbal declarations on international understanding or vague intercultural exchanges. On the contrary, it needs concrete, scientific, technical, cultural and economic projects that reinforce the capacity for self development in countries. For this very reason, education for international co-operation has to be action-oriented, and fully aware of the concrete problems of national and international societies (Goedegebure, 1994).

Internationalism implies the awareness of all human beings as members of a single human society, irrespective of national boundaries and other differences. The modern period has seen a remarkable transformation in means of transport and communication, tremendous spread of education, and notable increase in the mutual contact between citizens of the world. As a consequence, the world has shrunk in size, thereby increasing interdependence even among people who are geographically far removed. United Nations Educational Scientific and Cultural Organisation (UNESCO), one specialised body of the UNO, is dedicated to the spread of international understanding through the medium of education in every part of the world (Sharma and Sharma, 2002).

Educational comparison is not merely incidental—a byproduct of idle human curiosity as it were. For those who have responsibility for the education of others, be they policymakers, administrators, researchers or teachers,

comparison is actually essential to educational progress (Alexander, 2000).

Comparative Perspective – Mathematics Education

Comparative studies in mathematics education have impact on several areas of education including debates about educational policy, instructional methods, and the effects of socio-cultural factors on education (Plomp and Loxley, 1993). There have been great changes in recent decades in mathematics curricula all over the world. Many countries have reformed their mathematics programmes to keep pace with the current developments in various fields of education and technology. Any attempt at reform would take into account local conditions which can vary from one country to another. Nevertheless, reform in all countries finds common difficulties which can be overcome by using the same methods (Aram, 1986).

Mathematics education reform movements have shown different practices in different countries. Some countries have tried to make use of other countries' experience, whereas some countries have tried to find solutions to their problems by seeking indigenous answers. It is, however, believed that the need for promoting international co-ordination and understanding was perhaps never as pressing as it is today (Aram, 1986). The universality of the teaching of mathematics is a recognised fact. Perhaps no other subject is taught so universally as mathematics and the syllabi, methods and objectives of teaching this subject are quite similar

in different countries of the world. The nature of the subject is such that it would easily lend itself to the promotion of inter-cultural understanding.

Place of Mathematics at Primary Level

Primary education is the foundation of any education system. Mathematics is one of the courses of basic education which is delivered mainly through primary education. In this age of science and technology, one cannot think of general education without sound background of knowledge of mathematics. As Roger Bacon rightly said, "Mathematics is the gate and key of science." Mathematics is as important as language. Primary mathematics curriculum should therefore be developed keeping in view, the needs of the learners and their society. Quality of mathematics education always depends on the curriculum and its implication in any country.

The aim of mathematics education cannot be confined only to knowledge and skill necessary for everyday life. Knowledge and skill of mathematics are pre-requisites for learning other important subjects (Sho, 1997). Developing logical thinking with interesting mathematical activities should be also one of the aims of primary mathematics education. By summing up these, one can say that the aim of mathematics education at primary level could be:

- (i) imparting knowledge and skill,
- (ii) developing logical and rational thinking,

(iii) application of mathematical knowledge in day-to-day life.

The extent to which these aims are imparted through curriculum in any country is a major question!. The detailed study of mathematics curriculum at primary level in any country would answer this question. Comparison of mathematics curriculum at primary level will enable the researcher to study the extent to which above aims are included in the primary the mathematics curriculum in Bangladesh and West Bengal of India and transmitted in schools at the primary level.

What is the Explanation of the related literature?

Related literature throws light on gaps existing in primary education and poor qualities of curriculum and its implication in Bangladesh. Standard of education depends on the standard and effort of the teachers and their performance depend on standard curriculum (Roy, 1986).

Bangladesh, like other nations, felt the need to modify the existing education system to improve the quality of education. With this felt need, different Educational Commissions and Committees were formed. Finally, competency based curriculum was introduced from 1992 (BNCTB, 1988) starting from grade I-V. Curriculum renewal and development is an ongoing process and no nation can afford to neglect this matter. The curriculum must meet the learner's needs, societal expectations, community aspirations and international comparisons. Bangladesh

Education Commission's report (1974) suggested continuous evaluation and research in the field of curriculum materials.

The Government of Bangladesh brought about a reform in the curriculum and syllabus of primary education through the BNCTB which has already been put into practice. But no systematic attempt has so far been made to bring qualitative improvement in primary education through curriculum research, specifically in the area of primary mathematics curriculum. Hossain and Jahan (2000) pointed out some of the major deficiencies in curriculum development in Bangladesh which include:

- (a) lack of professional expertise in the development of modern curriculum, both in the BNCTB and nationally;
- (b) lack of a solid research base, providing assessment information about the previous curriculum and the areas needing revision; and
- (c) insufficient curriculum emphasis on such competencies as understanding, comprehension and application.

In the absence of any empirical study on primary school curriculum in Bangladesh, it has also not yet been possible to evaluate the effectiveness of the existing mathematics curriculum as prescribed by the BNCTB. The facilities for implementing the mathematics curriculum in the primary schools of Bangladesh are not known due to lack of systematic research. Whereas various research studies in India have been

conducted and reported that learning achievement have primary school children in general and mathematics in particular is far from satisfactory (Das, 2000). In the age of science and technology, a strong base of mathematics is absolutely necessary for all. Therefore, developing the basic mathematical competencies among young children is a strong need felt by teachers, researchers and educators.

Why Comparison?

Periodical revision and reform of curriculum and syllabus must be carried out to make it need centred for the children of the country, to achieve the national goals and for the contemporary world, and at the same time all possible measures have also to be taken for its proper implementation. Implementation of curriculum at the primary schools in Bangladesh and West Bengal of India and its study is of vital importance in determining the effectiveness of the mathematics curriculum and the quality of primary education in these countries.

A thorough inquiry into the status of the mathematics curriculum for the primary schools is necessary to give a satisfactory answer to the questions relating to primary mathematics curriculum in Bangladesh and West Bengal of India. Some of these questions are: How far do the objectives of primary mathematics curriculum reflect in the prescribed curriculum? To what extent are the specified objectives of curriculum in consonance with the objectives of primary mathematics education set by experts from other parts of the world?

What are the contents needed for achieving such objectives? How far are these objectives reflected in the prescribed curriculum content and in the teaching-learning process? How far is the content able to bridge the gap between theory and practice? How is primary mathematics curriculum being implemented in the schools? What problems do teachers face in implementing them? How do teachers assess their pupils' achievement in the schools and in the classroom?

Documents of national policy of education and review of related literature tell that Bangladesh needs to improve the quality of education by modifying the curricula at all levels. For the sake of improvement in quality of education, Bangladesh cannot adopt ready-made ideal curriculum and education system from any other developed country because the differences of cultural and social aspects of both these countries would lead to failure of the system. If at all Bangladesh wants to follow or borrow something good as a sample of education system for the sake of better quality of education, she must look into similarities of culture, language and other aspects of that system from which educational ideas could be borrowed for better quality of education.

Comparison – Regional and International Organisations

By exchanging information and experience, pooling expertise, sharing facilities, and undertaking joint activities, several countries working together can increase their resource

base and lower costs to their mutual benefit. Such arrangements are often set up among neighbouring countries (sub-regional), among all countries in a major geo-cultural region, or among countries sharing a common language or having cultural and commercial relations. Regional and International organisations often play an important role in facilitating such co-operation between countries (WCEF A, 1990). However, of late there has been more attention to mathematics programmes which are based upon the needs and cultures of the ethnic mixes found in most countries. First looking at UNESCO, most of UNESCO's work is directly with the governments of its Member States, and the mathematics education programme is no exception. Upon request, the mathematics education specialist from UNESCO works with the ministry of education, advising and providing information. UNESCO's principal emphasis on mathematics education has been to promote the exchange of information, to work nationally, and to co-operate with regional and international groups (Jacobsen, 1996). This, in turn, will help the system to lift the quality of education.

Comparison between Bangladesh and West Bengal of India - Why?

Looking to the fact that the sharing of Bangla, by Bangladesh with parts of India - offer both possibilities and challenges for cooperation among people in education and culture - in the field of literacy as well as in substantive study of science, social science and humanities. It is necessary however to

assert that while neither education nor educational co-operation will alter the basic determinants which politically exist. For example, Bangladesh is known to use Bangla in its judicial and perhaps educational system to a much greater extent than in Indian West Bengal - and the latter is said to be studying the former (Bhattacharya, et al., 1993). The Dhaka declaration (December 1985), as it came to be called, underscored the historic significance of the first ever summit meeting of the South Asian Countries and described it as a tangible manifestation of their determination to cooperate regionally, to work together towards finding solutions to their common problems in a spirit of friendship, trust and mutual understanding and to the creation of an order based on mutual respect, equity and shared benefits (Bhattacharya, 1995). Bangladesh and West Bengal of India, share common historical, cultural, religious and linguistic heritage. Not only do India and Bangladesh have many agreements to their credit to foster all-round ties between the two countries but they also share democratic relations and share many common policies in world affairs. In this context, it is of great importance to study and compare mathematics curriculum at the primary level of both countries. This, in turn, will help spell out the positive points of curricula of both the countries.

Conclusion

Such research work will help to give answers to questions raised regarding the achievement of goals of primary

mathematics education in context of the present needs of the society, existing gaps of the education system of Bangladesh and West Bengal of India in terms of curriculum design and its implementation and suggestions to modify the primary mathematics curricula, if needed for better quality of education and to satisfy aims of primary education. Such comparative study will help identify strong positive and negative points existing in curricula of both the countries that will further enable to give suggestions for modification of primary

mathematics curricula of Bangladesh and West Bengal of India.

Therefore, a comparative study of the primary mathematics curriculum in Bangladesh and West Bengal of India would be of great value, because on the basis of such a study, an insight will be developed into the existing scenario and issues related to mathematics curriculum” which in turn would act as a guide for appropriate plan of action, which may be undertaken for the implementation of good quality primary mathematics education.

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Energy Security through Nuclear Energy in India*

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INDIAN ECONOMY has shown impressive growth in the recent past and it is expected that it will continue to do so for several decades to come. Growth in economy has to be accompanied by growth of primary energy and electricity consumption. Assuming i) India's Gross Domestic Product (GDP) growth rate remaining around 5 to 6 % for fifty years to come¹ and ii) applicable correlations between GDP growth rate and energy growth rate², as the GDP multiplies by nearly 15 times in the forthcoming fifty years, primary energy and electricity consumption would also go up. Estimates indicate that the domestic fossil resources would not be able to meet rising energy demands and one has to go in for a quantum increase and large imports of fossil fuels. Excessive dependence on imports can impact energy security in two ways, first due to price volatility in the international market and second due to disruption of fuel supplied in case of any regional disturbance. Moreover, excessive fossil fuel consumption using the present technologies impacts environment at local, regional and global level. This may

change as new technologies are developed. In the coming years, new emerging technologies like carbon capture and sequestration, renewables and various nuclear technologies will compete with each other for their share. Based on the energy growth scenario built by Department of Atomic Energy (DAE), it can be said that the cumulative primary energy requirement during the 50-year period between the years 2002 and 2052 would be about 2400 EJ. Domestic fossil fuel resources can provide only about half of it even when the total recoverable prognosticated hydrocarbon resources are taken into account. Hydro and non-conventional renewable sources can provide about 12%. The remaining energy has to be shared by nuclear and imported components. If DAE's vision of installing about 20 GWe of nuclear power capacity, consisting of Pressurised Heavy Water Reactors (PHWRs), Light Water Reactors (LWRs), and Fast Breeder Reactors (FBRs), by the year 2020 and then installing, as many as possible, metal based FBRs from the plutonium generated from all the thermal reactors materialise, it is possible that nuclear power contributes about a quarter of the total electrical power by the year 2052. In that case the cumulative nuclear energy will constitute about 10% of the total cumulative primary energy during the 50-year period and cumulative requirement of imported energy would be contained at 29%. The larger/ smaller the nuclear energy production achieved the corresponding energy import will be

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smaller/larger. The success of the nuclear energy programme thus has very crucial bearing on energy security of India. The present article briefly describes energy trends of the present century, expected nuclear renaissance in the world and brief details of energy scenario in India for the next 50 years.

Energy trends in 21st century

Nearly a quarter of the world population is not getting even minimal commercial energy due to lack of purchasing power. A large disparity in the living standard of various sections of the society is one of the main causes of social tensions and disturbances. It is expected that the deprived section of people will gradually get its energy needs in the present century so as to improve its living standard thereby lessening the economic disparity. Developing countries like China and India will need huge amount of energy as their population is very large and increasing, and they are way below the world average energy consumption. The energy supply sustainability thus becomes an important issue. Energy should preferably be produced and consumed without any negative side effects on environment and without risking its availability to future generations. All forms of commercial energy coal, oil, gas, hydro, nuclear, wind and solar etc. need to be exploited to their full potential. As mentioned earlier, there is a correlation between GDP-growth of a nation

and its energy growth and this correlation is very strong for the developing countries where per capita GDP is low (Fig. 1). Per capita income in India is many times below the world average. Energy requirements of India are likely to increase at a high rate on two counts, first the increase in population and second the rise in per capita income.

Preserving Earth's Climate

Carbon dioxide emission and its stabilisation

The atmospheric level of carbon dioxide in the pre-industrialisation era was at around 280 ppm, which has already increased to about 380 ppm. Presently about 7 billion tonnes of carbon is being emitted annually to our atmosphere and if this trend continues then it may reach to about 14 billion tonnes per year fifty years from now (BAU path Fig. 2) taking the quantity of carbon in the atmosphere

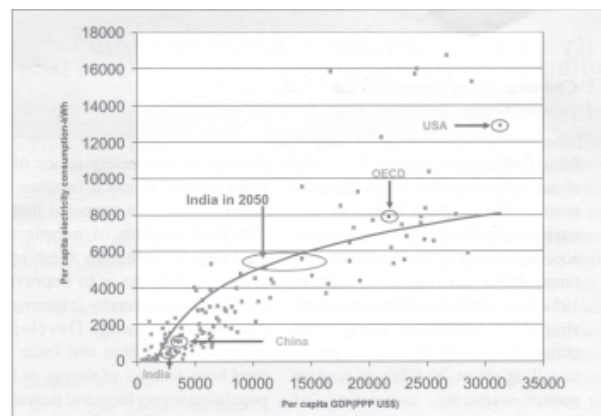


Fig. 1: Per capita electricity consumption Vs per capita GDP for various nations of the world

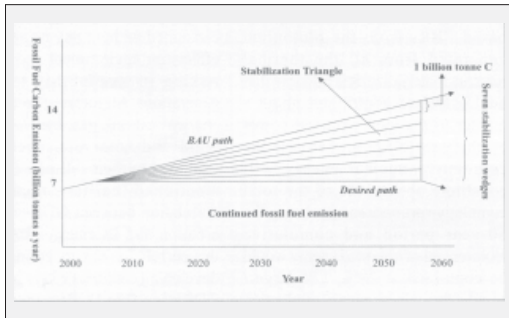


Fig. 2: Stabilisation Triangle
(Adapted from S. Pacala and R. Socolow, *Stabilisation wedges: Solving the Climate Problem for next 50 Years with Current Technologies*, in *Science*, Vol. 305, 13 August 2004)

to about 1200 billion tonnes which is double the figure of the pre-industrialisation era. The corresponding quantity of CO₂ in the atmosphere would be 560 ppm, the level at which catastrophic climate changes might be triggered. The cost of such climatic changes may be very high, several percentages of the world GDP. In order to avoid such a disastrous situation and to flatten the carbon emission curve (desired path) the world community has to immediately initiate development and deployment of suitable technologies. S. Pacala and R. Socolow have shown a way to solve this climate problem with current technologies³. They discuss fifteen such technologies or technology combinations, categorised as 'End user efficiency and conversion', 'Power generation', 'Carbon Capture and Storage', 'Alternative energy sources' and 'Agriculture and forestry' (Box-1).

Box 1

End-user Efficiency and Conservation

1. Increase fuel economy of two billion cars from 30 to 60 mpg
2. Drive two billion cars not 10,000 but 5,000 miles a year (at 30 mpg)
3. Cut electricity use in homes, offices and stores by 25%

Power Generation

4. Raise efficiency at 1,600 large coal-fired plants from 40 to 60%
5. Replace 1,400 large coal-fired plants with gas-fired plants

Carbon Capture and Storage (CCS)

6. Install CCS at 800 large coal fired power plants
7. Install CCS at coal plants that produce hydrogen for 1.5 billion vehicles
8. Install CCS at coal-to-syngas plants

Alternative Energy Sources

9. Add twice today's nuclear output to displace coal
10. Increase wind power 40-fold to displace coal
11. Increase solar power 700-fold to displace coal
12. Increase wind power 80-fold to make hydrogen for cars
13. Drive two billion cars on ethanol, using one sixth of world's cropland

Agriculture and Forestry

14. Stop all deforestation
15. Expand conservation tillage to 100 per cent of cropland

Each of the fifteen technologies shown in Box-1 is capable of avoiding 1 billion tonne a year of carbon emission to the atmosphere. Starting from now, the year 2006, if deployment of seven such technologies (Seven technology wedges Fig 2), taking care of any overlapping areas, is completed in fifty years then the annual carbon emission will stabilise at the present level itself (desired path Fig 2). Deployment of more such technologies will be required subsequently in 2056 to initiate further reduction in the annual carbon emission thus limiting the total cumulative quantity of carbon in atmosphere to well below the critical the of 1200 billion tonnes. Individual countries, depending on their economic, social and other conditions, may decide how to contribute towards accomplishing the above startling feat. Nuclear energy is one of the most potent technologies in the present context. If twice of today's nuclear output is added to displace coal then one 'technologywedge' is earned. There is adequate nuclear potential in the world to earn many such wedges. India also has a significant nuclear potential if a suitable fast breeder reactor route is developed and deployed. Moreover keeping the present domestic fuel resource base in mind, it is the only solution if India intends to limit the energy import dependence at the current level of about 29%.

Nuclear Energy

As of April 2006 about 440 reactors of 370 GWe-net installed capacity were under operation. India's share is less

than 1% of the total. However India's share, out of 20 GWe under construction reactors, is 3.6 GWe about 18% of the total. Growth of nuclear power around the world was very high during the two decades 1970-1990. Largest capacity addition was achieved in the year 1985 (Fig. 3 and 4). While there was a decline in new constructions subsequent to 1985, nuclear electricity generation has continued to grow due to better plant performances.

Worldwide opinion is again tilting in favour of nuclear energy. The low projection of IAEA, assuming that the reactors already under construction will be the only additions, is 416 GWe in 2020, a modest increase from the current 370 GWe, before its leveling off. The high projection incorporates the projects proposed beyond those already firmly committed. In that case the installed capacity would go up to 640 GWe, a substantial increase over the present capacity (Fig. 4). It is expected that this nuclear renaissance will be led by the developing countries, notably China and India, and the economies in transition (Russia and Eastern Europe) although quite a few reactors are expected in developed economies also⁴.

The reason of this nuclear renaissance is not far to seek. Environmental considerations, specially recently observed climatic irregularities that are perceived by many to be related to global warming, oil and gas price hikes and burgeoning energy demand from the developing world are the main driving forces behind this nuclear surge. Moreover vastly improved availability factors of nuclear plants and their

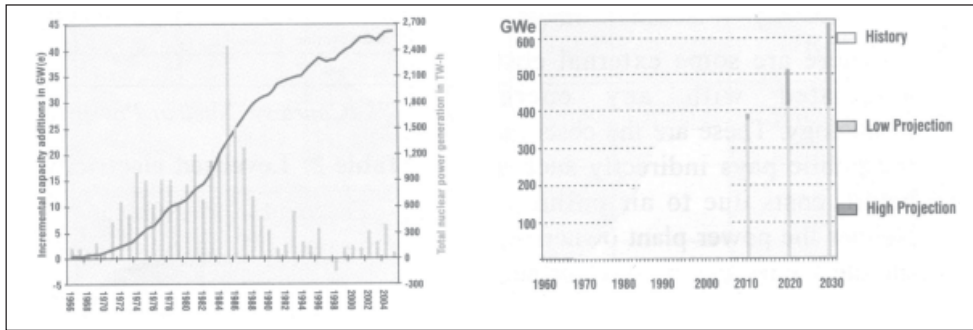


Fig. 3: Nuclear electricity generation and capacity addition

Fig. 4: Cumulative installed nuclear power capacity

(Courtesy: Nuclear Power and Sustainable Development, IAEA, April 2006, pg 2 and 3)

smoother and safer operations have also contributed to it (Fig 5, 6 and 7). Relative economy of various future power technologies will however be the most important factor deciding their share.

Table 1, Table 2 and Fig. 8 summarise new power plant construction cost estimates and levelised power production costs from numerous studies carried out recently in many parts of the

world. The estimates place the three alternatives, nuclear coal and gas on a level playing field.

According to the joint report of Nuclear Energy Agency (NEA), International Energy Agency and Organisation for Economic Cooperation and Development (OECD) titled 'Projected Costs of Generating Electricity: 2005 Update', in the study of which experts

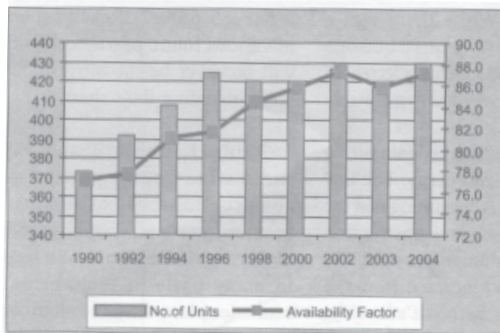


Fig. 5: Availability Factor Improvement
(Based on: Nucl. Eng. and Des. 236 (2006) 1460-1463)

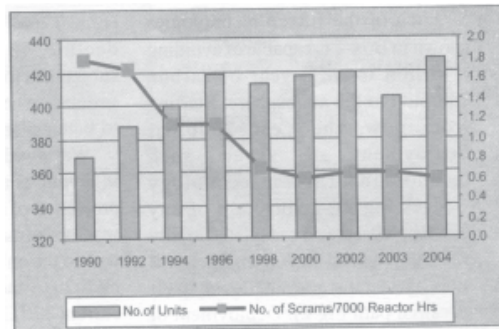


Fig. 6: Unplanned scrams/7000 hrs of Reactor Operation
(Based on: Nuclear Power and Sustainable Development, IAEA, April 2006, pg 16)

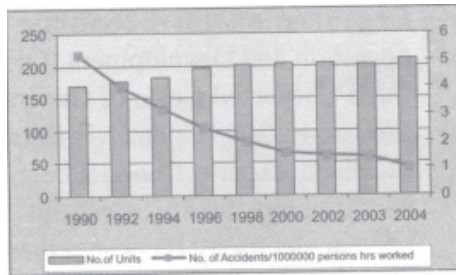


Fig. 7: Industrial accidents/Imillion man-hours (Based on: Nuclear Power and Sustainable Development, IAEA, April 2006, pg 17)

from 19 countries participated, at 5% discount rate, nuclear electricity is

cheaper than gas electricity in all the countries and also cheaper than coal electricity in all the countries except South Korea and the US. At 10 % discount rate, nuclear electricity is cheaper compared to gas electricity in all the countries except Japan and the US, and to coal electricity in all countries except Japan, the US and Germany⁵. According to Indian studies nuclear power is cheaper than coal power at 5% discount rate and at sites 800 km away from coal pitheads (Table-2). A relatively very less fuel price sensitivity of nuclear electricity also goes in its favour⁶. (Table 3).

Table 1: Comparative cost estimates of power

	MIT	University of Chicago	Royal Academy of Engineering	DGEMP France	MEI Japan	CERI Canada	OECD/NEA/IAEA
Levelised cost	US cents/kW.h	US cents/kW.h	US cents/kW.h	US cents/kW.h	US cents/kW.h	US cents/kW.h	US cents/kW.h
Nuclear	6.7	4.1-7.1	4.2	3.6	5.0	4.4-7.5	2.1-6.9
Coal	4.2	3.3-4.1	4.6-6.4	4.1-4.4	5.3	4.0-4.9	1.6-6.9
Natural gas	3.8 - 5.6	3.5-4.5	4.1-5.2	4.5	5.8	6.0-6.3	3.8-6.4
Oil					10.0		
Hydropower							4.0-24.2
Poultry litter			12.5				
Onshore wind			6.8-9.9				3.1-14.4
Offshore wind			10.1-13.3				5.2-12.3
Wave/marine			12.2				
Solar PV							12.1-187.6
Overnight cost	\$/kW(e)	\$/kW(e)	\$/kW(e)	\$/kW(e)	\$/kW(e)	\$/kW(e)	\$/kW(e)
Nuclear	2000	1200-1800	2119	1823	2614	1968-2491	1074-2510
Coal	1300	1182-1460	1345-1511	1290-1419	2548	1341	719-2347
Natural gas	500	500-700	553	652	1536	596	424-1292
Oil					2520		
Hydropower							1541-6985
Poultry litter			1390				
Onshore wind			1364				976-1634
Offshore wind			1695				1637-2622
Wave/marine			2580				
Solar PV							3363-10164

(Courtesy: Nuclear Power and Sustainable Development, IAEA) from Fig. 8.

This and many other advantages of nuclear energy such as much smaller, as compared to fossil energy, land requirement, waste generation and environmental pollution arise basically from the fact that nuclear energy is a very compact form of energy, a million times more compact than fossil fuel energy.

There are some external costs associated with any energy technology. These are the costs that the public pays indirectly such as health costs due to air pollution. Neither the power plant owners nor the electricity buyers pay for such costs. External costs for nuclear power are very much smaller as compared to fossil fuel based power technologies and are expected to remain so in the future also⁷.

Electrical Energy Growth in India: A scenario

Future electricity demand in India is going to be an order of magnitude larger in fifty years from now, A scenario has been developed in the DAE for growth of electricity generation based on a careful examination of all issues related to sustainability, particularly abundance of available

energy resources, diversity of sources of energy supply and technologies, security of supplies and self sufficiency. Present energy usage, domestic energy resources, future energy demands and the above scenario will now be briefly described.

Primary Energy and its components in the year 2002-03

Tables 4, and 5 show contributions of different fuels to commercial primary energy and electricity respectively in the year 2002-03 in India. Over all energy import content is about 29% of the total. More than 92% of the primary energy comes from fossil origin and the

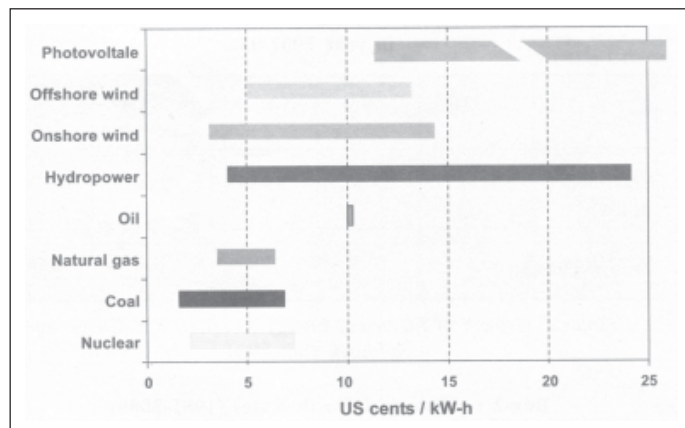


Table-2: Levelised electricity costs in India (at 2005-06 constant price)

Discount rate	Nuclear	Coal-fired (800 Tonn from pit head)	Gas-fired (LNG)
5%	152	164	182
10%	218	200	204

(Source: Cost Effectiveness of Electricity Generating Technologies, NPCIL, Sept. 2005)

Table 3: Electricity generation cost sensitivity on fuel price

<i>Fuel</i>	<i>Elect. Generation cost variation (%) (For 100% increase in fuel price)</i>
Nuclear	9
Coal	31
Gas	66

remaining is shared mainly by the hydro (6%) and nuclear (2%). Similarly fossil fuel provides 86% share in the total electricity generation while the hydro (10%) and nuclear (3%) contribute the remaining.

Past Trends and Future Projections of GDP Primary and Electrical Energy in India

During the twenty years period between 1980 and 2000 average growth rates of the GDP, primary energy and electricity in India have been 6%/y, 6%/y and 7.8%/y respectively. There has however been a gradual decrease in the energy and electricity intensities of GDP. Based on 1) India's 50 year GDP projections

referred to earlier⁹, 2) 1.2%/y fall of the primary energy intensity of GDP¹⁰ and 3) extrapolation of fall of the electricity intensity of GDP from the past data till 2025 and a constant fall of 1.2%/y thereafter one can estimate the future growth of the primary energy and electricity for the next fifty years which can broadly be represented in two periods, 2002-22 and 2022-2052, (See Box-2). Cumulative primary energy requirement turn out to be 2400 EJ during the projected fifty-year period which will be provided by a variety of domestic fuels: fossil, nuclear, hydro and non-conventional renewable and imports.

Domestic Energy Resource

Domestic primary energy and electricity resources, as estimated in the year 2002-03, are shown in Table 6. Fossil fuel resource consists of coal, and hydrocarbon (oil and natural gas). Economically mineable coal can give about 667 EJ. Proven hydrocarbon resource consisted of about 60 EJ only. Based on the total prognosticated hydrocarbon reserves of about 30 billion

Table 4: Contribution of different fuels to Primary Energy (EJ) in year 2002-03

	<i>Energy Resource Components</i>						<i>Total</i>
	<i>Coal</i>	<i>Crude</i>	<i>NG</i>	<i>Hydro</i>	<i>Nuclear</i>	<i>Nonconv Ren.</i>	
Contribution	6.40	4.83	1.18	0.79	0.23	0.08	13.46
%of total	47.53	35.97	8.97	5.85	1.72	0.19	100.00
Import	0.51	3.42	Neg	Neg	0.03	0.00	3.96
%of above	7.97	70.81	Neg	Neg	13.0	0.00	29.42

(Source: Growth of Electrical Energy in India, R.B Grover and Subhash Chandra)

Table 5: Contribution of different fuels to Electricity (TWh) in year 2002-03

	<i>Thermal</i>	<i>Hydro</i>	<i>Nuclear</i>	<i>Non-conv. Renewable</i>	<i>Total</i>
Contribution in TWh	550.82	65.66	19.24	2.66	638.38
% of Total	86.3	10.3	3.0	0.4	100

(Source: Growth of Electrical Energy in India, R.B Grover and Subhash Chandra)

**Box 2: Historic Growth Rates
(1981-2000)**

Historic Growth Rates (1981-2000)			
<ul style="list-style-type: none"> 6%/y for GDP, 7.8%/y for Electricity, 6%/y for Primary Energy 			
Assumptions for future projections			
<ul style="list-style-type: none"> Primary Energy Intensity fall 1.2%/y (World Energy Outlook, 2002) Extrapolation of electricity intensity fall from past data till 2025 and a constant fall of 1.2%/y thereafter 			
Computed Future Projected Growth Rates (2002-2052)			
Period (Year)	GDP	Electricity	Prim. Energy
2002-2022	5.8%/y	6.3%/y	4.6%/y
2022-2052	5.5%/y	4.5%/y	4.0%/y
<ul style="list-style-type: none"> Computed Cumulative Primary Energy Requirement during the period 2002-2052: 2400 EJ 			

tonnes in India, a recovery factor of 40% and the successful ongoing new exploration and licensing policy (NELP) of the Government of India the hydrocarbon resource has been assumed to be 12 billion tonnes equivalent to about 511 EJ. Full potential of hydro and non-conventional

renewable is limited to 6 EJ a year and 1.8 EJ a year respectively. The potential of nuclear energy comes from the modest amount of uranium and much larger amount of thorium. Domestic uranium can provide about 29 EJ from once through fuel cycle in PHWRs. The same uranium can however provide much larger energy, about 3700 EJ, through multiple cycle route in FBRs. Domestic thorium has still larger energy potential through breeder route. As thorium does not have any fissile component therefore the fissile seed in thorium-based reactors has to come from other reactors based on uranium. Stand-alone thorium systems coupled with neutron accelerators may also be possible in future. Nuclear energy thus has a very large potential and should find an important place in any balanced energy strategy.

The scenarios built by the Department of Atomic Energy is based on the following broad policies.

- Install about 20 GWe nuclear power capacity by the year 2020 (Box-3).
- Employ the most optimum combination of the FBR fuel and fuel cycle viz. metal-based Pu-U mix fuel and I-year out-of-pile fuel cycle for

Table 6: Primary Energy and Electricity Resource (Year 2002-03)

	Amount	Thermal Energy			Elec. Potential GWe- Yr.
		EJ	TWh	GWYr	
Fossil					
Coal	38-BT	667	185,279	21,151	7,614
Hydrocarbon	12-BT	511	141,946	16,204	5,833
Non-Fossil					
Nuclear					
Uranium - Met	61,000-T				
In PHWR		28.9	7,992	913	328
in Fast breeders		3,699	1,027,616	117,308	42,231
Thorium - Met	2,25,000-T				
In Breeders		13,622	3,783,886	431,950	155,502
Renewable					
Hydro	150-GWe	6.0	1,679	192	69
Non-conv. Ren.	100-GWe	1.8	487	56	20

(Source: DAE Document No.10, August 2004)

Box 3 : Indian Nuclear Power Programme 2020

Reactor type and capacities	Capacity (MWe)	Cumulative Capacity (MWe)
<ul style="list-style-type: none"> 16 reactors at 6 sites under operation Tarapur, Rawatbhata, Kalpakkam, Narora, Kakrapar and Kaiga 	3,900	3,900
<ul style="list-style-type: none"> 4 PHWRs under construction at Kaiga (2 × 220 MWe), RAPS-5 & 6 (2 × 220 MWe) 	880	4,780
<ul style="list-style-type: none"> 2 LWRs under construction at Kudankulam (2 × 1000 MWe) 	2,000	6,780
<ul style="list-style-type: none"> PFBR under construction at Kalpakkam (1 × 500 MWe) 	500	7,780
<ul style="list-style-type: none"> Projects planned till 2020 PHWRs (8 × 700 MWe), FBRs (4 × 500 MWe), LWRs (6 × 1000 MWe), AHvVR (1 × 300 MWe) 	13,900	21,180
<ul style="list-style-type: none"> TOTAL by 2020 		21,180 MWe

Table 7: Nuclear Power in the year 2052

<i>FBR</i>		<i>Breeding Properties</i>		<i>Nuclear Power Installed Capacity</i>		<i>Nuclear Electricity Generation</i>	
<i>Fuel</i>	<i>Fuel Cycle</i>	<i>System Doubling time (years)</i>	<i>Gr. Rate (%/y)</i>	<i>GWe</i>	<i>% of Total</i>	<i>TWh</i>	<i>% of Total</i>
Oxide	Two Year	25.8	2.7	67	5	498	6.3
	One Year	18.9	3.7	93	6.9	691	8.7
Carbide	Two Year	14.7	4.8	102	7.6	758	9.8
	One Year	11.0	6.5	195	14.5	1449	18.2
Metal	Two Year	12.3	5.8	127	9.5	944	11.8
	One Year	8.9	8.1	275	20.5	2044	25.7

Box 4 : Three Stage Nuclear Power Programme

<p>Stage - I PHWRs</p> <ul style="list-style-type: none"> • 14 - Operating • 4 - Under construction • Several others planned • Scaling to 700 MWe • Gestation period has been reduced • POWER POTENTIAL 10,000 MWe LWRs • 2 BWRs Operating • 2 WERs under construction 	<p>Stage - II Fast Breeder Reactors</p> <ul style="list-style-type: none"> • 40 MWth FBTR Operating since 1985 Technology Objectives realised • 500 MWe PFBR Under Construction • POWER POTENTIAL 530,000 MWe 	<p>Stage - III Thorium Based Reactors</p> <ul style="list-style-type: none"> • 30 kWth KAMINI-Operating • 300 MWe AHWR Under Development <p>POWER POTENTIAL IS VERY LARGE Availability of ADS can enable early introduction of Thorium on a large scale</p>

development of FBRs beyond the year 2020. Any other FBR-fuel, oxide or carbide, or a slower fuel cycle e.g. 2-year out-of-pile instead of 1-year out-of-pile would give much lower share of nuclear power (Table 7).

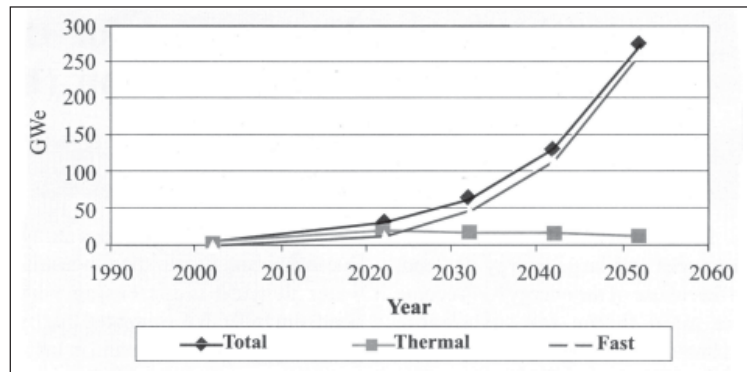


Fig. 8: Nuclear Power Installed Capacity-Type Mix

- Employ all the plutonium produced in nuclear reactors to build fast breeder reactors (Stage II of DAE's nuclear programme, Box 4) of the above type so as to give maximum possible nuclear capacity by 2052.

Salient features of the Scenario

Fuel-mix of the primary energy and electricity shows substantial changes from the present. The 92% contribution of fossil fuel in primary energy and 86% in electricity, in the year 2002-03, goes down to 76% and 63% respectively in 2052-53. This is mainly due to increased share of nuclear energy from 1.7% to 17% in primary energy and from 3% to 26% in electricity in the corresponding period. Out of the total cumulative primary energy requirement of 2385 EJ only 1688

EJ would be the domestic component leaving a shortage of 697 EJ (29% of the total), which needs to be necessarily imported. Thus the import dependence can be kept limited to the present level in principle by adopting the given strategy. Nuclear power reactor mix is shown in Fig. 8. Majority share is contributed by FBRs. This ambitious addition of FBRs is a theoretical limit of the present scenario; practically achievable addition would essentially depend on the successful and timely development and deployment of the required fuel (metal based Pu-U mix) and the corresponding fuel cycle (1-year out of pile). Technologies based on thorium, acceleration driven systems and fusion are also expected to play an important role.

END NOTES

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Two Foundation Stones of Radiation Medicine*

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MODERN PHYSICS may be said to date from 1895 when Roentgen discovered X-rays. Two other major discoveries followed in quick succession, namely, the discovery of radioactivity by Becquerel in 1896 and the discovery of radium by Madam Curie in 1898. These epoch making discoveries not only revolutionised physics but have proved to be of immense application in the medical field.

Madam Curie's birth centenary was recently celebrated in November 1967. This article gives an account of the discovery and applications of the two foundation stones of radiation medicine, namely X-rays and radium.

The first Nobel Prize for physics was awarded to Wilhelm Conrad Roentgen, Professor of Physics and Director of the Physical Institute of Wurzburg in Bavaria, for his epoch-making discovery of X-rays on 8 November 1895. He saw the bones of his living hand projected on a barium cyanide screen when he interposed it between the invisible beam of electromagnetic radiation, originating from the Hittorf Crookes tube, excited under the influence of high voltage from

an induction coil, and the detector plate. And this was the beginning of Radiation Medicine.

He made two important communications in this connection. The first was on 23 January 1896 in the auditorium of the Physical Institute. The title of his lecture was: "A New Kind of Ray (Ueber eine neue Art Von Strahlen)" in which he explained about his discovery of the penetrating rays. His lecture was accompanied by demonstrations. He took the X-ray photograph of the hand of Von Kolliker, the famous anatomist of the Wurzburg University and he showed it to the audience. In his second communication



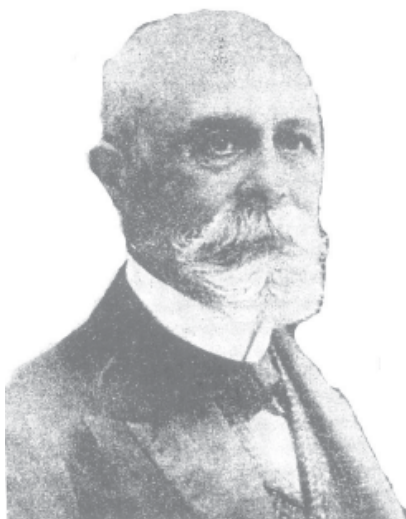
WILHELM CONRAD ROENTGEN
*Winner of first Nobel Prize for Physics, 1901,
(Courtesy: Dr. Lewis E. Etter and the Science
of Ionizing Radiation)*

*Reprinted from *School Science* Vol. 6 Nos 3 and 4, September and December 1968.

on 10 March 1896, he explained the various properties of this new kind of ray. This was entitled "Further observations on the properties of X-rays".

These two communications of far reaching importance were sufficient to stimulate, originate and develop a number of new ideas and researches. This physical discovery, in its further developments, led to an integral discipline of physics, general science, engineering, biology, medicine, chemistry, mathematics and so on; and it entered the field of almost any and every subject. It also helped to explain many phenomena hitherto regarded as an unsolved mysteries of nature.

Roentgen died of cancer of the intestine on 10 February 1923 at his Munich residence. He however impregnated his dynamic image over his time, which, like engravings on stone,



A.H. BECQUEREL
Winner of Nobel Prize for Physics 1903,
(Courtesy: Prof. A. Gandy, Foundation Curie, Paris)

can be seen in hospitals, research laboratories, biological laboratories and analytical institutions all over the world.

Within a matter of months, this discovery caught the imagination of scientists all over the world. Medical and commercial applications of X-rays followed with great rapidity. Speaking exactly, it was after one month and three days only of the discovery of X-ray that it was brought into use in Belgium hospitals. Roentgen Societies and Committees came into existence. Scientists and engineers put their heads together for the development of X-ray apparatus. Film manufacturers and dark room technicians made themselves busy after X-ray applications for the purposes of diagnosis. The subject of X-rays formed a strong nucleus round which many other branches of science began to revolve.

Before this discovery, hospitals were acquainted with the application of electromagnetic energy in the form of high frequency current, diathermy, etc. but it was for the first time that this energy (electromagnetic) entered the arena for the hospital in the form of penetrating radiation. Both civil and military uses of X-rays were quickly realised.

But not even six months had passed before reports of dermatitis on the hands of X-ray workers were received. These were similar to those which appeared before 1895, on the hands of discharge tube and vacuum tube workers, resembling sun-burn. This proved that X-rays could induce biological changes. And so, it was the starting point of radiation plus biology, that is radio-biology.

And now, with the help of X-rays, supported by special radiographic procedures, about two dozens of radiographies, covering from head to foot, are possible. Medical examinations of, say, neck section, chest, breast, cardiovascular system, genitourinary tract, skeleton, lymphatic system etc. can routinely be carried by means of X-radiation.

X-rays also began to be used for the treatment of tumours. In the field of kilovoltage and supervoltage therapy, 250 kv, 400 kv, million volt and two million volt X-ray machines are quite popular. Even in a linear accelerator or in a van de Graaf generator or in a betatron, high energy electron beams sometimes hurled against a target to produce highly penetrating X-rays, which in turn, are made useful, in the treatment of deep-seated tumours.

Thus, roentgenography and radiobiology have become established as recognised specialities in clinical medicine. This was the first foundation stone of radiation medicine.

The second important phase followed in quick succession. It happened thus. Aroused by this sensational discovery of X-ray, Antoine Henri Becquerel, the son of a professor of physics in Paris, began to look for a similar sort of penetrating ray from some other source. He thought about the phenomena of fluorescence which was seen to occur inside the Hittorf tube at the point where cathode rays struck the wall of the tube to originate X-radiation. The suggestion, therefore, was that there must be some sort of correlation between the fluorescence and the emission of X-ray.

It could be possible that the substance, capable of giving rise to fluorescence or phosphorescence could also be the emitter of this X-radiation. Driven by this belief he began to examine a number of such substances. In that pursuit he undertook the investigations of double sulphate of uranium and potassium. He also used photographic film as the detector of radiation. He found that the film, wrapped up with black paper, over which the crystal of uranium salt was kept in the drawer of his table, because of cloudy weather, for several days, showed the image of the substance on its developing. This photograph was similar to the one which he had obtained when the same arrangement of crystal and the photographic plate was kept in the sunshine. Rays, similar to X-ray, had



Prof. PIERRE CURIE and his wife
MARIE SKŁODOWSKA CURIE.
(Courtesy: Prof. A. Gandy, Foundation Curie, Paris)

thus been discovered by Becquerel. He found that, this emission was inherent in all the uranium compounds. Fluorescence had nothing to do with it. Becquerel communicated the result of his investigations to the Academy of Science, Paris, in the month of January 1896, that is only after three months of the discovery of X-rays. This was the beginning of natural radioactivity.

At this stage, Marie Sklodowska, a Polish girl, the daughter of physicist parents, holder of masters' degrees in physics and mathematics, a research scholar and the wife of a celebrated scientist Pierre Curie of Paris, was attracted by Becquerel's radiation. She began to investigate all the available substances for their emission of any penetrating radiation. In her case the detector was not a photographic film but a device based on the principle of ionisation. The ionisation chamber coupled with an electrometer, working on the principle of piezoelectric effect of quartz crystals, discovered by her husband, measured the intensity of radiation coming from the sample. Every time she found that the intensity was proportional to the amount of sample under investigation. A preparation of thorium salt also gave the same sort of result. But chalkolite, a uranium mineral, showed higher intensity than what was expected. She concluded that there must be a substance other than uranium, present in the sample, responsible for the higher emission. It really came out to be so when she started her historical work in collaboration with her husband, in the hutment of a school.

The hard work of days and nights consisted of pulverisation, precipitation and fractional crystallisation of pitchblende ore from the JOACHIMSTHAL uranium mine in Bohemia. The processing of each twenty-five pounds of ore gave an yield of a milligram of a white shining metal which was announced in December 1898 as radium. This new substance was two million times more active than uranium. The name radioactivity, that is, action at a distance, was given by Mme Curie to all those substances which emitted radiation. Thus, came into existence an element which is playing a vital role in clinics and in laboratories, even today.



MARIE CURIE
*Nobel Prize Winner for Physics 1903,
for Chemistry 1911*
(Courtesy: Prof A. Gandy, Foundation Curie, Paris)

In the year 1903, Mme Curie submitted her thesis for her degree of doctorate in which she described the various properties of radium.

She was the recipient of the Nobel Prize for physics jointly with A.H. Becquerel in 1903. She received the Nobel Prize for the second time in the year 1911, this time for chemistry.

Biological and medical implications of radium came accidentally when in 1901. Becquerel loaned some radium from the Curies for a demonstration to his students. A glass vial containing 200 milligram of radium remained in the pocket of his vest coat for six hours. This produced erythema that is reddening of his skin just beneath the vest coat pocket. Then appeared crackings of the skin at that site finally forming into an ulcer which was painful. Conventional treatment was able to bring a cure.

On receiving this report, Pierre Curie voluntarily exposed his arm to the rays from radium to verify the findings and he went through the same experience as substances like radium were also capable of producing biological changes just as X-ray did. The Curies and Becquerel started a lot of animal experimentation to study the physiological effects of radium rays. During years 1901-1906 radium was tried for its therapeutic effects on a number of ailments such as blindness, dermatological conditions, sciatic pain, female hemorrhages, cancer, etc.

Then in the year 1906, the Biological Laboratory of Radium (which later on became Foundation Curie) came into existence in Paris and it started clinical

works with radium. This was followed by radium institutes and radium departments in other countries also. Similar to X-rays, this discovery too spread far and wide and secured its position in the clinics.

Mme Curie, a lady of great eminence, the symbol of scientific faith and missionary zeal, a deep devotee at the temple of learning, did phenomenal work during her life time. Perhaps nature itself became jealous of her achievements, honours and awards. She became a widow when her illustrious husband Pierre Curie was run over by a truck on 19 April 1906. Soon after this tragic event however, she was again deeply engrossed in her work. As a result of prolonged exposure to anaemia she died of it on 4 July 1934. Radium which had bestowed such incalculable gifts in the alleviation of disease, took its toll from its discoverer. Mme Curie left behind her, an ideal and a strong scientific legacy in the persons of her daughter, Irene Curie



Prof. FREDERIC JOLIOT CURIE and his wife
Mme IRENE CURIE (daughter of Mme Curie)
Centre of the photograph.
Winners of Nobel Prize for Chemistry, 1935,
(Courtesy: Prof A. Gandy, Foundation Curie, Paris)

and her son-in law, Prof. Frederic Joliot Curie, again both of them Nobel laureates.

Rapid research and development followed and radium was found to be best suited for cancer treatment. Interstitial, intracavitary and surface applicators of radium in the form of moulds, plaques, etc came into use for the treatment of cancer of the various regions of the body such as skin, hand, nose, ear, eye, tongue, oral cavity, vocal cord, breast, uterus, rectum, etc. Permanent implants of radon seeds (bits of thin gold tubing containing radon gas) at certain delicate sites like tongue, tonsil intestine, etc. proved to be very effective. Combined

therapy of surgery and radium, backed up by roentgenography gave excellent results. Radium packings on curie level, gave high intensity beams of gamma radiation suitable for the treatment of deep-seated tumours. Solid radium salt filled in platinum containers in the shape of needles and shells began to pour into hospitals. In our country, this costly substance (about Rs. one lakh for a gram) came for the first time in Ranchi, Bihar, around the year 1920.

Thus, the two great discoveries of X-ray and radium plus the pioneering work of Roentgen, Becquerel and Mme Curie laid the foundation stones of Radiation Medicine.

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DNA Replication – A Unique Orchestration of Actions of Proteins

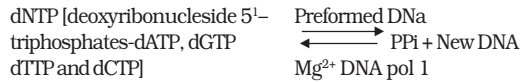
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WATSON AND Crick's landmark discovery of DNA structure in April 1953 suggested how DNA might be replicated and preserved for hundreds of generations. The self-complementarity of two polynucleotide strands of a DNA double helix discarded the idea that protein template might play a role in DNA replication. The semi-conservative fashion of DNA replication was distinctively demonstrated by Matthew Meselson and Franklin Stahl in 1958. This clearly states that when one DNA molecule duplicates to produce two identical new DNA molecules, each of the new molecules is comprised of one polynucleotide strand from the original DNA molecule bonded to one newly synthesised polynucleotide strand. Replication begins either at a single point or multiple points on gene in procaryotes and eucaryotes respectively. This point of origin on the gene signifies a specific sequence of bases especially A-T rich bases rather than G-C based due to presence of fewer (two) hydrogen bonds in A-T base pair than G-C base pair. DNA synthesis occurs at the replication fork which appears like 'Y' denoting the site

at which the DNA molecule is unwound into an open box and new strands are synthesised. The number of replication forks varies among the living organisms from 1 in *E. coli* circular chromosome to many in human linear chromosome.

Molecular Mechanism of DNA Replication

DNA replication involves a careful orchestration of the actions of different enzymes, DNA polymerase I and polymerase III and more than 30 proteins which act in concert to unwind the two polynucleotide strands of the DNA molecule, copy its template and produce two complete daughter DNA molecules. The initiation at an origin starts only after binding of specific major initiator protein dna A protein to the origin and thus, converts closed origin site of the double helix into open double helix. The other protein molecules like dna B, i.e. DNA helicase and dna C (helicase loader) join dna A to open the DNA double helix. Another protein, topoisomerase II or DNA gyrase hydrolyzes ATP, and help in unwinding of double helix by removing supertwists at origin site. Once the strands are separated, the unwound portion of DNA is then stabilised by single strand binding protein (SSB), which binds cooperatively to exposed single stranded DNA. The first nucleotide polymerising enzyme, DNA polymerase I was discovered by Arthur Kornberg and his colleagues in 1958 from *E. coli*. This enzyme requires all four deoxyribonucleoside 5' - triphosphates – dATP, dGTP, dTTP and dCTP and Mg^{2+} to synthesise DNA. DNA pol-I catalyses



step by step addition of doxyri-bonucleotide units to the 3¹-OH end of a performed DNA chain or template DNA strand. Two more enzymes DNA Pol II and Pol III were discovered in 1969 by Paula DeLucia and John Cairns from *E.coli*, which could also analyse a template directed synthesis of DNA from precursors-deoxyribonucleoside 5¹-triphosphates like that of DNA polymerase I. Now these enzymes have been shown to have clearly defined roles. A multisubunit assembly of 10 kinds of polypeptide chains called DNA polymerase III holoenzyme synthesises most new DNA, whereas DNA polymerase I remove the RNA primer and fills the gaps. DNA polymerase II participates in DNA repair, therefore, is not needed for DNA replication.

Events at Replication Fork: Leading versus Lagging Strand

At a replication fork, both strands of parental DNA serve as templates for the synthesis of both new daughter strands by an assembly complex that is the DNA

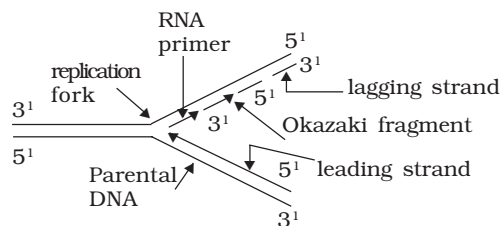


Fig. 1: Diagram of a replication fork and events on it

polymerase III. As DNA structure reveals that parental strands are antiparallel, the overall direction of DNA synthesis must be 5¹ → 3¹ for one daughter strand and 3¹ → 5¹ for the other. In 1960, it was resolved by Reiji Okazaki who found that newly synthesised DNA exists as small fragments containing 1000-2000 nucleotides in dividing bacteria whereas only 100-200 nucleotides in eucaryotes. These fragments are called Okazaki fragments (after the discoverer Reijokazaki and Tsuneko Okazaki), which are polymerised discontinuously only in the 5¹ → 3¹ direction. The strand formed from joining of Okazaki fragments by DNA ligase is called lagging strand whereas the DNA strand that is synthesised continuously without interruption is the leading strand. The synthesis of leading strand precedes the synthesis of lagging strand (Fig. 1). Both the Okazaki fragments and the leading strand are synthesised in the 5¹ → 3¹ direction, though the overall growth of lagging strand is opposite to leading strand, i.e. in the 3¹ → 5¹ direction.

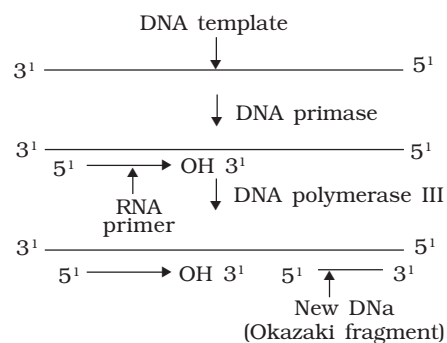


Fig. 2: DNA replication is primed by a short RNA primer

Initiation of DNA Synthesis

All DNA synthesis commences with the construction of RNA primer. In 1988, it was Kornberg who found that nascent DNA is covalently linked to a short stretch of RNA. A specialised enzyme called DNA primase or *dnaG* uses ribonucleoside triphosphates to synthesise short RNA primers on the lagging strand. In prokaryotes, DNA primase synthesises a short stretch of RNA primer about 5 ribonucleotides long and are made at intervals of 1000-2000 deoxyribonucleotides whereas in eucaryotes these primers are about 10 ribonucleotides long that are made at intervals of 100-200 deoxyribonucleotides on the lagging strand. For the leading strand, a special RNA primer is needed only at the start of replication. RNA primer, which is complementary to one of the template DNA strands, primes the synthesis of DNA. In *E.coli*, major initiator protein *dnaA* complexes with preprimosome containing seven proteins n^1 , n^{11} , *nj*, *i*, *dnaB* (DNA helicase and DNA unwinding enzyme), *dnaC* and *dnaG* (DNA primase) proteins to form a multisubunit assembly called primosome that enables synthesis of RNA primer and initiation of Okazaki fragments (Fig. 2). These protein components function in concert to ensure movement of primosome along the DNA strands, the displacement of SSBs, the recognition of appropriate start sites and the polymerisation of ribonucleotides into RNA primer.

Synthesis of leading and lagging strands: As the RNA primer contains a properly base paired nucleotide with a

3'-OH group at one end, it can be elongated by the DNA polymerase III holoenzyme at this end to being synthesis of an Okazaki fragment. The DNA polymerase III holoenzyme (DNA pol III) catalyses the formation of many thousands of phosphodiester bonds before releasing its template compared with only 20 phosphodiester bonds for DNA polymerase I (DNA pol I) thereby revealing capability of DNA pol III in DNA synthesis whereas the DNA pol I is associated with DNA repair. The synthesis of each Okazaki fragment is completed when DNA polymerase III holoenzyme runs into the RNA primer attached to the 5' end of the previous DNA fragment. The gaps between Okazaki fragments following removal of RNA primer are filled by polymerising action of DNA polymerase I. This enzyme uses its 5' → 3' exonuclease activity to remove RNA primer. RNA primer can also be erased by RNase H. A specialised enzyme called DNA ligase joins the 3' end of the new DNA fragment of 5' end of the previous one and thus produces a continuous DNA chain (lagging strand) from many Okazaki fragments. The continuous synthesis of leading strand using the RNA primer formed the DNA primase is another significant accomplishment of DNA polymerase III holoenzyme (Fig. 3).

The unwinding of the template DNA helix at a replication fork could in principle be catalysed by two types of DNA helicases acting in concert one running along the leading strand template and one along the lagging strand template. They continue to move along their strands thereby prying apart

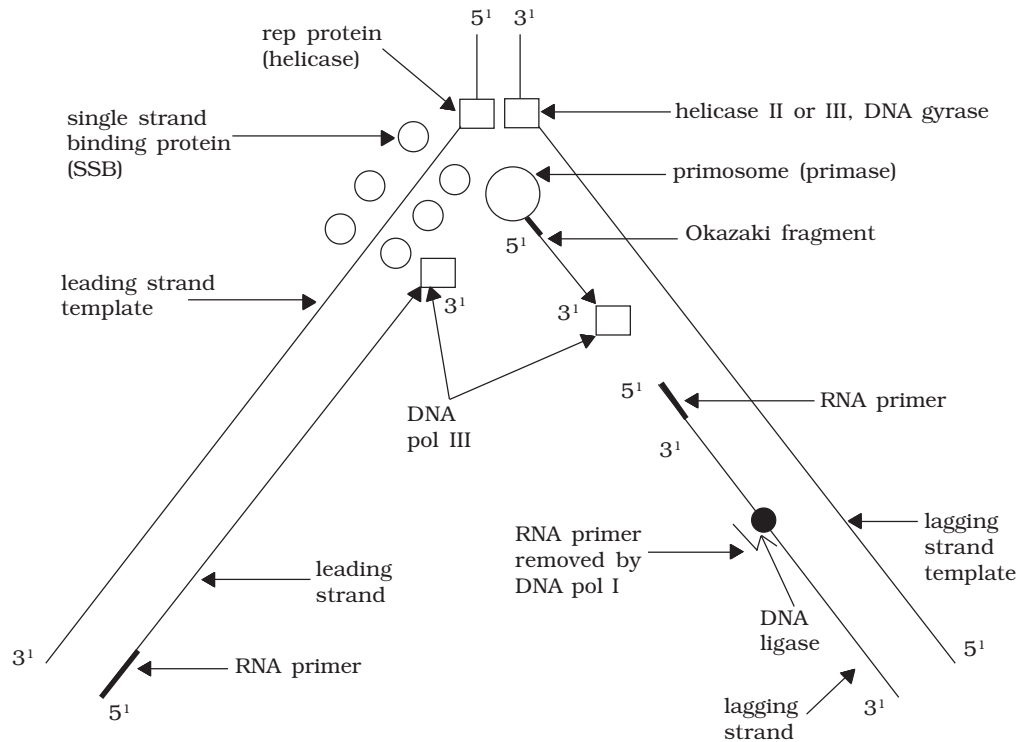


Fig. 3: Enzymatic events at the replication fork

the helix at rates upto 1000 nucleotide pairs per second. Single strand DNA binding proteins coat cooperatively the exposed single stranded DNA strands and straighten out the regions of single stranded DNA on the lagging and leading strand template. These proteins prevent formation of short hairpin helices in single stranded DNA thereby enhance the template capability of the single strand template DNA.

The fidelity of copying DNA during replication is such that only about one mistake is made for every 10^9 nucleotides copied. The high fidelity of DNA

replication depends not only on complementary base pairing but also on several proof-reading mechanisms like (i) $5' \rightarrow 3'$ polymerisation of DNA pol I and DNA pol III, (ii) $3' \rightarrow 5'$ exonucleolytic proof-reading of DNA pol I. Polymerases delete errors by acting much like correcting typewriters.

Despite its complexity and accuracy replication occurs very rapidly. In prokaryotes, replication rates approach 750 to 1000 base pairs per second per replication fork whereas 50 to 100 base pairs per second per fork in eucaryotic replication. In other words, DNA

synthesis is slower (about 1 μm of DNA per minute) in eucaryotes than in procaryotes (about 30 μm of DNA per minute) due to presence of nucleosomes in eucaryotic chromosomes.

DNA replication stops when the polymerase complex reaches a termination site on the DNA in *E.coli*. The 'Tus' protein binds to these 'Ter' sites and halts replication.

The Weird World of Nanotechnology

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IN THE ANNUAL meeting of the American Physical Society, held on 29 December 1959, the Nobel Laureate physicist Richard Feynman delivered a talk entitled “There’s Plenty of Room at the Bottom”. In this talk he said, “What I want to talk about is the problem of manipulating and controlling things on a small scale ... What I have demonstrated is that there is room – that you can decrease the size of things in a practical way. I now want to show that there is plenty of room ...”.

The essence of Feynman’s lecture was that there is a lot of scope for research on materials on a very small, i.e. nanometre scale. However, there may be new laws of physics governing the behaviour of matter at such (nano) scale. This may give rise to new kinds of forces and new kinds of effects. Anticipating this, Feynman said in his lecture, “At the above level, we have new kinds of forces and new kinds of possibilities, new kinds of effects. The problem of manufacture and reproduction of materials will be quite different”.

This historic lecture of Feynman, running to 7000 words, was published in the February, 1960 issue of *Engineering and Science*. However, the

person who was instrumental in popularising nanotechnology, the technology operating at the nano scale, was K. Eric Drexler. In 1986, he published his book entitled “*Engines of Creation: The Coming Era of Nanotechnology*”. He also founded an institute, the Foresight Institute, and became its Chairman.

What is ‘Nano’?

The word nano comes from the Greek word ‘nanos’ meaning dwarf. But, the prefix nano actually stands for a billionth (10^{-9}). Thus, one nanometre means one billionth of a metre ($1\text{ nm}=(10^{-9})$). To have a feel of how much one nanometre is, imagine ten hydrogen atoms being laid side by side. The combined width of all these atoms would equal one nanometre. Incidentally, one nanometre is also one thousandth the length of a typical bacterium or one millionth the size of a pinhead.

It may be noted that a nanometre is not the extreme in minisaturisation. One can scale down by one thousandth of a nanometre and get picometre ($1\text{ pm}=(10^{-12})$). Scaling down even further in steps of one thousand, one first encounters femtometre ($1\text{ fm}=(10^{-15})$) and finally one attometre ($1\text{ am}=(10^{-18})$).

Then, why are the scientists busy conceiving machines, implements and devices at a nanoscale? In fact, the properties and behaviour of materials undergo a sea change as we go from the macroworld (where the bulk properties of materials emerge from the collective behaviour of trillions of atoms) to the world of individual atoms and molecules. For instance, a 5-centimetre metal piece

would have similar properties as a 1-centimetre piece or even a 1-millimetre piece. However, a few isolated atoms of that metal are expected to show quite different properties. But, at what stage does this change of property begin to manifest itself? The transition from the atomic to the bulk properties occur at the nanometre scale, say scientists. At this scale, the atoms combine to form clusters. These clusters are variously called nonoparticles, quantum dots, Q-particles, artificial atoms, and so on. The diameter of a cluster usually ranges from 1 to 100 nanometres. These clusters are too large to be considered as molecules and too small to be treated as bulk material. Therefore, they give rise to an entirely new class of material called nanomaterial.

What are the laws that govern the behaviour of such material? At the atomic scale, the laws of quantum mechanics are applicable while the laws of classical physics govern the macroworld. However, the nanoworld can neither be described by the straightforward application of quantum mechanics or can it be described by the simple laws of classical physics. The nanoworld can, therefore, be described by an exotic combination of the laws of classical and quantum mechanics. These laws are not fully well-understood. However, the scientists have been busy unravelling these laws for almost past two decades now.

The New Laws of the Nanoworld

In 1987, Bart J. van Wees of the Delft University of Technology and Henk van

Houten of the Philips Research Laboratories were studying the flow of current resulting from the movement of electrons through narrow conducting paths within a semiconductor. By symmetrically varying the width of the conduction paths, the researchers measured the changes in the conductance values. They were indeed surprised to find a staircase pattern. Later, David Wharam and Michael Pepper of the University of Cambridge observed similar results.

The above studies clearly revealed that the electrical conductance is quantised. Later, Michael Houkes, Thomas Tighe and Keith Schwab discovered that thermal conductivity is also quantised.

Another phenomenon seems to manifest at the nano scale. In 1985, Konstantin Likharev, a young physics professor at Moscow State University, working with Alexander Zorin and Dmitri Averin, proposed that it would be possible to control the movement of single electrons on and off a special conductor, called Coulomb Island, that is weakly coupled to the rest of a nanocircuit. This phenomenon wherein the coulomb island allows conduction of only one electron at a time is called coulomb blockade. This could form the basis for an entirely new type of device, called a single-electron transistor. In 1987, thanks to the advances in nonofabrication, Theodore A. Fulton and Gerald J. Dolan of Bell Laboratories indeed succeeded in constructing the first single-electron transistor.

Thus, it is seen that on the nano scale the laws of electrical and thermal

conduction get quantised and the electrons while passing through a special conductor (called coulomb islands) become highly 'disciplined'; they pass one by one through the conductor.

Understanding the basic science of matter at the atomic level have helped scientists in fabricating structures at the nano scale. As a result, varied approaches to fabricating nanostructures have emerged in the nanoworld. The invention of scanning tunnelling microscope (STM) by Heinrich Rohrer and Gerd K. Binnig of the IBM Zurich Research Laboratory, for which they received the Nobel prize in physics in 1986, not only allowed scientists to observe the atomic world but also enabled them to create nanostructures. The success of the STM led to the development of another scanning probe device, called atomic force microscope (AFM). The pyramid-shaped tip on the AFM, which is about 2 to 30 nm wide, can be used to physically move the nanoparticles around the surfaces and to arrange them in patterns.

Indeed, the invention of the scanning probe devices (STM and AFM) has provided new innovative tools to the scientists for viewing, characterising and for manipulating the nanostructures. This will help them in creating implements that can be put to varied uses.

Lithograph techniques are used for fabricating electronic devices such as microchips. Besides conventional photo lithography scientists have also evolved soft lithograph and dip-pen lithograph

techniques; the latter uses atomic force microscope. However, all these lithograph techniques are called top-down methods because they begin with bulk structure and slowly reduce it to the nano scale for carving out nanostructures. Thus, nanoelectronic structures can be developed using top-down methods. However, scientists have found these methods neither very convenient nor cheap. So, researchers have shown growing interest in bottom-up methods which start with atoms or molecules and build up to nanostructures.

The bottom-up methods use a basic principle of nature, called self-organisation, discovered by J.M. Lehn for which he received the Nobel prize. Atoms, molecules, groups of molecules and even bigger units tend to structure by themselves towards well-ordered units. This self-assembling property of atoms and molecules can be used for making the smallest nanostructures, with dimensions between 2 and 10 nm, easily and inexpensively. Nanotubes, which are graphite cylinders with unusual electrical properties, and quantum dots – the semiconducting crystals containing a few hundred atoms – are examples of self-organising structures.

This knowledge about self-organising structures can be used for technological applications, i.e. in the production of new materials or in life sciences research. Materials ten times as hard as steel and considerably lighter at the same time and destruction of tumour are just two examples of nanotechnology in the fields of material and life sciences.

Teaching the Art of Mathematical Modelling

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WE ARE AWARE of the solution of word problems in arithmetic, algebra, trigonometry, calculus probability and linear programming. Sometimes students solve the problems without conceiving the physical picture of the situation presented by a given problem. Situational problems often need physical insight, that is, understanding of physical laws and some symbols to comprehend the mathematical results obtained with observed/practical values. We do not perform any practical activity, we do not approach the situation at all or we do not take any sample of blood to know human physiology, still our mathematics reveals the actual situation. So, to solve many problems pertaining to various fields including scientific research, there is an urgent need of developing the art of mathematical modelling right from the school stage.

Introduction

Right from the beginning, we have been engaging students in solving problems related to the real-world around us. For example, we have solved problems on simple interest using the formula for

finding it. The formula is a relation between the interest and the three other quantities that are related to it, that is the principal, the rate of interest and the period. This formula is a mathematical model for the above situation. Similarly, mathematical models for some other situations have also been evolved.

Science attempts to establish an understanding of all types of phenomenon. Many different explanations can sometimes be given that agree quantitatively with experiments or observations. However, when theory and an experiment quantitatively agree, then we can usually be more confident of the validity of the theory. Thus, a reliable mathematical model becomes an integral part of the scientific method.

One cannot underestimate the importance of experiments in developing mathematical models. However, mathematical models are important in their own right besides an attempt to mimic nature. This occurs because the real-world consists of many interacting processes. It may, therefore, be impossible in an experiment to entirely eliminate certain undesirable effects. Furthermore, one is never sure which effect(s) may have negligible impact on the outcome of an experiment. A mathematical model has the advantage that we consider only certain effects and do not take cognizance of others. The objective being to see which effects for given observations are valid and which one of them are immaterial. As new experiments or observations are made, the mathematical model is continuously

modified, revised and improved.

The process of conversion of a given physical situation into mathematics with some suitable conditions is known as mathematical modelling.

Some Expressive Relations of Mathematical Modelling

Application of mathematics to a given situation essentially involves two types of tasks, viz. mathematical modelling and application of mathematical techniques.

Applying Mathematics = Mathematical Modelling + Mathematical Techniques.

Mathematical Modelling = Art of applying + Insight into problem situations.

Here applying mathematics can be said to involve three steps:

- (i) The formulation of the problem, the approximations and assumptions based on experiments or observations that are necessary to develop, simplify and understand the mathematical model.
- (ii) Solution of realistic problems.
- (iii) The interpretation of mathematical results in the context of non-mathematical problem.

Applying mathematics along with mathematical modelling should provide one of the great motivating forces for learning mathematics. A practical problem should be posed, the need for mathematics for solving it should arise, the mathematical model should be developed and then used to solve not only the original problems, but also some other related problems of importance, in science and society.

Possible Courses in Mathematical Modelling

Some of the following topics that may be considered to develop art of mathematical modelling:

GROUP A: Application of Arithmetic, Algebra including abstract and linear algebra, Trigonometry, Differential Equations, Probability theory, Difference equations, Combinations, Computer simulation, Complex analysis, etc.

These topics should be taught in keeping with the mental maturity of a student at various stages of schooling.

GROUP B: Mathematical Models in Physical sciences, Engineering Sciences, Medical Sciences, Social Sciences, Business Management, etc.

Topics in group A are technique centred and illustrate the application of one technique to a wide variety of disciplines, while courses in group B are discipline centred and illustrate the use of mathematical techniques in a given discipline. Both types of courses illustrate the richness of mathematical modelling.

GROUP C: Mathematical models from Domestic problems, Energy utilisation, Resource utilisation, Pollution Control, Environmental control, etc.

Models of group C are problem centred and illustrate the use of wide variety of disciplines in tackling a central problem of importance to human societies. Few textbooks for courses of this type are available, but a course of this type will prepare our students to play their role in finding plausible solutions to some of

the larger problems of modern life, otherwise the role of mathematicians in the solution of these problems tends to be secondary.

GROUP D: Mathematical models in Linear Programming.

These can be included either in group A or B. This includes a wide variety of applications in almost all walks of life. It also emphasises the applications of a group of mathematical techniques of optimisation. Excellent books and courses are already available in this field.

GROUP E: Applications of mathematics for:

- (i) Secondary school mathematics students.
- (ii) Teachers of mathematics (pre-service or in-service).
- (iii) General users of mathematics.
- (iv) Non-mathematics majors.
- (v) Mathematics majors.

Here the courses are user-centred, several courses on “Mathematics across the curriculum giving applications of secondary school mathematics” either in everyday life or in other school subjects have been prepared in the United Kingdom and United States of America. UNESCO has undertaken to prepare books for teachers. Many social and biological scientists are interested in mathematical modelling courses to help them in making mathematical models and they need courses keeping their limited mathematical background in view and drawing illustrations from these fields. Finally, we need different courses

in mathematics for those who want to have insight into mathematical modelling.

GROUP F: Courses in mathematical modelling:

- (i) Idealised real-life problems in an academic settings.
- (ii) Real real-life problems taught in a real-world setting.
- (iii) Courses taught in coordination with industry.
- (iv) Courses taught jointly with other subjects/departments.

In (i), real-life problems are idealised and chosen according to the group of students. The students and teacher work as a team to solve these problems.

In (ii), students go to field or industry, then choose their problems and collect their data, make models, compare with observations and this is all done under the supervision of their teacher or qualified persons in industry or some other members of society. This sometimes takes the form of ‘sandwich’ courses in which students may spend their times in schools/colleges and in industry, acquiring academic knowledge and then looking at problems where they can use it.

In (iii), a course may be taught jointly by faculty members from schools/colleges and mathematicians in industry or some other members of the society, while in (iv), the courses are taught jointly by a mathematics teacher and teachers from some other subject.

Why is Mathematical Modelling Important?

Look the following situations:

An adult human body contains approximately 1,60,000 km of arteries and veins that carry blood.

The human heart pumps 5 to 6 litres of blood in the body every 60 seconds. The temperature at the surface of the Sun is about 6000°C.

Have you ever wondered how our scientists and mathematicians could possibly had estimated these results? Did they pull out the veins and arteries from some adult bodies and measured them? Have they taken out the blood to arrive at these results? Did they travel to the Sun with a thermometer to measure its temperature? Certainly not. Then how did they get these figures?

Well, the answer lies in mathematical modelling. Mathematical modelling is the process of creating a mathematical model of a problem, and using it to analyse and solve the problem.

So, in mathematical modelling, we take a real-world problem and convert it to an equivalent mathematical problem. We then solve the mathematical problem, and interpret its solution in the situation of the real-world problem. Then, it is important to see that the solution, we have obtained, 'makes sense' which is the stage of validating the model. Some examples, where mathematical modelling is of great importance, are:

- (i) Finding the width and depth of a river at an unreachable place.
- (ii) Estimating the mass of the Earth and other planets.

- (iii) Estimating the distance between the Earth and any other planet or a celestial body.
- (iv) Predicting the arrival of the monsoon.
- (v) Predicting the trend of the stock market.
- (vi) Estimating the volume of blood inside the body of a person.
- (vii) Predicting the population of a city after 10 years.
- (viii) Estimating the number of leaves in a tree.
- (ix) Estimating the ppm of different pollutants in the atmosphere.
- (x) Estimating the effect of pollutants on the environment.
- (xi) Estimating the temperature on the Sun's surface.

A point to remember is that here we aim to make the learner aware of an important way in which mathematics helps to solve real-world problems. However, a beginner needs to know some more mathematics to really appreciate the power of mathematical modelling. In higher classes some examples giving this flavour could be found.

Mathematical modelling is an interdisciplinary subject. Mathematicians and specialists in other fields share their knowledge and expertise to improve existing products, develop better ones, or predict the behaviour of certain products.

There are, of course, many specific reasons for the importance of modelling, but most are related in some ways to the following:

To gain understanding: If we have a mathematical model which reflects the essential behaviour of a real-world system of interest, we can understand that system better through an analysis of the model. Furthermore, in the process of building the model we find out which factors are most important in the system, and how the different aspects of the system are related.

To predict, or forecast, or simulate: Very often, we wish to know what a real-world system will do in the future, but it is expensive, impractical or impossible to experiment directly with the system. For example, in weather prediction, to study drug efficacy in humans, finding an optimum design of a nuclear reactor, and so on.

Forecasting is very important in many types of organisations, since predictions of future events have to be incorporated into the decision-making process. For example, in marketing departments, reliable forecasts of demand help in planning of the sale strategies. A school board needs to be able to forecast the increase in the number of school going children in various districts so as to decide where and when to start new schools.

Most often, forecasters use the past data to predict the future. They first analyse the data in order to identify a pattern that can describe it.

Then this data and pattern is extended into the future in order to prepare a forecast. This basic strategy is employed in most forecasting techniques, and is based on the assumption that the pattern that has

been identified will continue in the future also.

To estimate: Often, we need to estimate large values. For example, to estimate the number of fish in a lake, to estimate the number of trees in a forest etc. For another example, before elections, the contesting parties want to predict the probability of their party winning the elections. In particular, they want to estimate how many people in their constituency would vote for their party. Based on their predictions, they may want to decide on the campaign strategy. Exit polls have been used widely to predict the number of seats a party is expected to get in elections.

Stages in Mathematical Modelling

Step 1 : Understand the problem: Define the real problem, and if working in a team, discuss the issues that you wish to understand. Simplify by making assumptions and ignoring certain factors so that the problem is manageable.

For example, suppose our problem is to estimate the number of fish in a lake. It is not possible to capture each of these fish and count them. We could possibly capture a sample and from it try and estimate the total number of fish in the lake.

Step 2 : Mathematical Description and Formulation: Describe, in mathematical terms, the different aspects of the problem. Some ways to describe the features mathematically, include:

- define variables
- write equations or inequalities

- gather data and organise into tables
- make graphs
- calculate probabilities

For example, having taken a sample, as stated in Step 1, how do we estimate the entire population? We would have then to mark the sampled fish, allow them to mix with the remaining ones in the lake, again draw a sample from the lake, and see how many of the previously marked ones are present in the new sample. Then, using ratio and proportion, we can come up with an estimate of the total population. For instance, let us take a sample of 20 fish from the lake and mark them, and then release them in the same lake, so as to mix with the remaining fish. We then take another sample (say 50), from the mixed population and see how many are marked. So, we gather our data and analyse it.

One major assumption we are making is that the marked fish mix uniformly with the unmarked fish, and the sample we take is a good representative of the entire population.

Step 3: Solutions based on a Mathematical Model: The simplified mathematical problem developed in Step 2 is then solved using various mathematical techniques.

For instance, suppose in the second sample in the example in Step 2, 5 fish are marked. So, $\frac{5}{50}$, i.e., $\frac{1}{10}$ of the population is marked. If this is typical of the whole population, then $\frac{1}{10}$ th or the

population = 20.

So, the whole population = $20 \times 10 = 200$.

Step 4 : Interpreting the solution: The solution obtained in the previous step is now looked at, in the context of the real-life situation that we had started with Step 1.

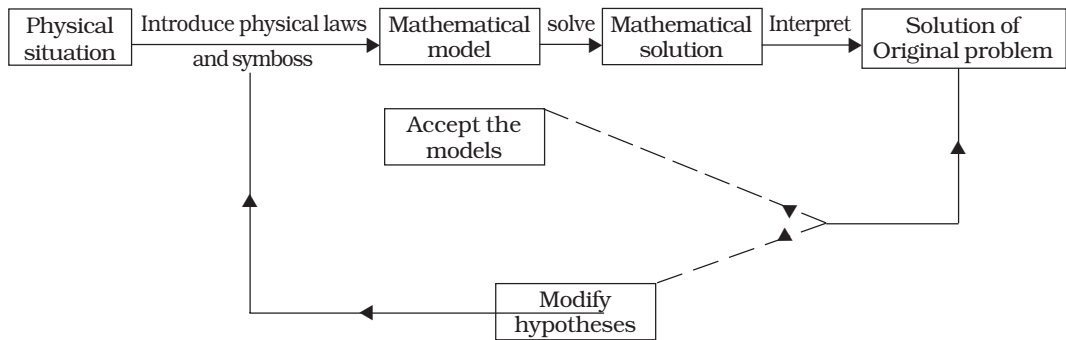
For instance, our solution to the problem in Step 3 gives us the population of fish as 200.

Step 5 : Validating the Model: We go back to the original situation and see if the results of the mathematical work makes sense. If so, we use the model until new information becomes available or assumptions change.

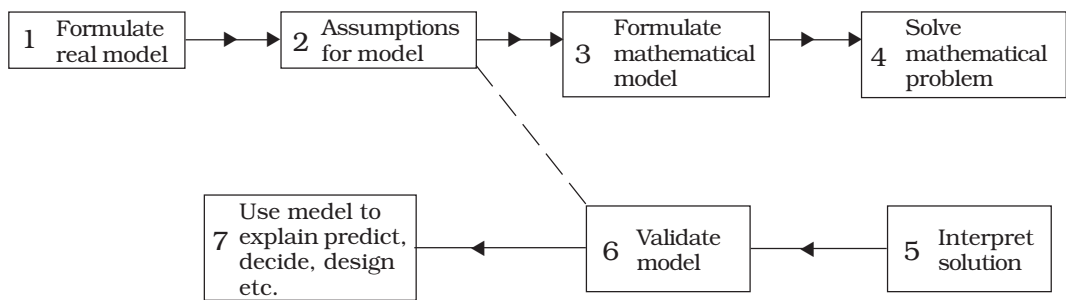
Sometimes, because of the simplification and/or assumptions we make, we may lose essential aspects of the real problem while giving its mathematical description. In such cases the solution could very often be *off* the mark, and not make sense in the real situation. If this happens, we reconsider the assumptions made in Step 1 and revise them to be more realistic, possibly by including some factors which were not considered earlier.

For instance, in Step 3 we had obtained an estimate of the entire population of the fish. It may not be the actual number of fish in the lake. We next see whether this is a good estimate of the population by repeating Step 2 and 3 a few times, and taking the mean of the results obtained. This would give a closer estimate of the population.

Another way of visualising the process of mathematical modelling is shown in the diagram at page 43.



The above diagram may be further explained as follows:



Some illustrations of Mathematical Modelling

Before going to the following example, you may need some background:

Not having the money you want when you need it, is a common experience for many people. Whether it is for buying essentials for daily living, or for buying comforts, we always require money. To enable the customers with limited funds to purchase goods like two wheelers, refrigerators, televisions, washing machines, cars, etc., a scheme known as an *instalment scheme (or plan)* is introduced by traders.

Sometimes a trader introduces an *instalment scheme* as a marketing strategy to allure customers to purchase these articles. Under the instalment scheme, the customer is not required to make full payment of the article at the time of buying it. He/she is allowed to pay a part of it at the time of purchase, and the rest can be paid in instalments, which could be monthly, quarterly, half-yearly, or even yearly. Of course, the buyer will have to pay more in the instalment plan, because the seller is going to charge some interest on account of the payment made at a later date (called *deferred payment*).

Before going to the actual problem, let us understand the most frequently used terms related to the concept.

The *cash price* of an article is the amount which a customer has to pay as full payment of the article at the time it is purchased. *Cash down payment* is the amount which a customer has to pay as part payment of the price of an article at the time of purchase.

If the instalment scheme is such that the remaining payment is completely made within one year of the purchase of the article, then simple interest is charged on the deferred payment.

Let us consider some examples of mathematical modelling:

Example 1: Romila wants to buy a bicycle. She goes to the market and finds that the bicycle she likes is available for Rs. 1,800. Romila has Rs. 600 with her. So, she tells the shopkeeper that she would not be able to buy it. The shopkeeper, after a bit of calculation, makes the following offer. He tells Romila that she could take the bicycle by making a payment of Rs. 600 cash down and the remaining money could be paid in two monthly instalments of Rs. 610 each. Romila has two options one is to go for instalment scheme the other is to make cash payment by taking a loan from a bank which is available at the rate of 10% per annum simple interest. Which option is more economical to her?

We solve this problem in various steps of mathematical modelling as follows:

Step 1 : Understanding the problem:

What Romila needs to determine is whether she should take the offer made by the shopkeeper or not.

For this, she should know the two rates of interest – one charged in the instalment scheme and the other charged by the bank (i.e., 10%).

Step 2 : Mathematical Description: In order to accept or reject the scheme, she needs to determine the interest that the shopkeeper is charging in comparison to the bank. Note that since the entire money shall be paid in less than a year, simple interest shall be charged.

We know that the cash price of the bicycle = Rs. 1800

Also, the cashdown payment under the instalment scheme = Rs. 600

So, the balance price that needs to be paid in the instalment scheme = Rs. (1800-600) = Rs. 1200

Let $r\%$ per annum be the rate of interest charged by the shopkeeper.

Amount of each instalment = Rs. 610

Amount paid in instalments = Rs. 610 + Rs. 610 = Rs. 1220. Interest paid in instalment scheme = Rs. 1220 – Rs. 1200 = Rs. 20. ... (1)

Since, Romila kept a sum of Rs. 1200 for one month, therefore, Principal for the first month = Rs. 1200.

Principal for the second month = Rs. (1200 - 610) = Rs. 590

Balance of the second principal Rs. 590 + interest charged (Rs. 20) = Monthly instalment (Rs. 610) = Second instalment

So, the total principal for one month = Rs. 1200 + 590 = Rs. 1790

Now,

interest = Rs. $\frac{1790}{100} \times \frac{r}{12}$... (2)

Step 3. Solving the problem: From (1) and (2), we have

$$\frac{1790}{100} \times \frac{r}{1} = 20$$

or $\frac{20}{1790} \times \frac{100}{1} = 13.14\%$

approximately.

Step 4. Interpreting the solution: The rate of interest charged in the instalment scheme = 13.14%.

So, she should prefer to borrow the money from the bank to buy the bicycle which is more economical.

Step 5. Validating the Model: This stage in the above case is not of much importance as the numbers are fixed. However, if the formalities for taking loan from the bank such as cost of stamp paper, etc., which make the effective interest rate more than what it is the instalment scheme, then she may change her opinion.

(Note: Interest rate modelling is still at its early stages and validation is still a problem of financial markets. In case, different rates are incorporated in fixing instalments, validation becomes an important problem.

Example 2: Suppose we have a room of length 6 metre and breadth 5 metre. We want to cover the floor of the room with square tiles of side 30 cm. How many tiles will we need? Solve this by constructing a mathematical model.

Step 1: Understanding the problem: What do we need to solve this problem? We have to consider the area of the room and the number of tiles required to cover that area.

Step 2: Mathematical. Description: The side of the tile is 30 cm, i.e., 0.3 m.

Since the length of the room is 6 m, we can fit in $\frac{6}{0.3} = 20$ tiles along the length of the room in one row. Also the breadth of the room is 5 metres, we have

$\frac{5}{0.3} = 16.67$. So, we can fit in 16 tiles in a column. Since $16 \times 0.3 = 4.8$, therefore, $5 - 4.8 = 0.2$ metres along the breadth will not be covered by the tiles. This part will have to be covered by cutting the other tiles. The breadth of the floor left uncovered, 0.2 metres, is more than the length of a tile, which is 0.3 m. So we cannot break a tile into two equal halves and use both the halves to cover the remaining portion.

Now, we have

Total number of tiles required = (Number of tiles along the length \times Number of tiles along the breadth) + Number of tiles along the uncovered area. ... (1)

Step 3 : Solving the problem: As we said above, the number of tiles along the length is 20 and the number of tiles along the breadth is 16. We need 20 more tiles for the last row. Substituting these values in (1), we get

$$(20 \times 16) + 20 = 320 + 20 = 340.$$

Step 4 : Interpreting the Solution: We need 340 tiles to cover the floor.

Step 5 : Validating the Model: In real-life, your mason may ask you to buy some extra tiles to replace those that get damaged while cutting them to size. This number will of course depend upon the

skill of your mason. But, we need not modify equation (1) for this purpose. This gives you a rough idea of the number of tiles required. So, we can stop our process here.

(Of course, it is possible that in some real-life situations, we do not need to validate our answer because the problem is simple and we get the correct solution right away.)

Example 4: Rolling of a pair of dice : Suppose your teacher challenges you to the following guessing game. She would throw a pair of dice. Before that you need to guess the sum of the numbers that show up on the dice. For every correct answer, you get two points and for every wrong guess you lose two points. What numbers would be the best guess?

Step 1: Understanding the problem: You need to know a few numbers which have higher chances of showing up.

Step 2 : Mathematical Description: In mathematical terms, the problem translates to finding out the probabilities of the various possible sums of numbers that the dice could show.

We can model the situation very simply by representing a roll of the dice as a random choice of one of the following thirty six pairs of numbers.

- (1, 1) (1, 2) (1, 3) (1, 4) (1, 5) (1, 6)
- (2, 1) (2, 2) (2, 3) (2, 4) (2, 5) (2, 6)
- (3, 1) (3, 2) (3, 3) (3, 4) (3, 5) (3, 6)
- (4, 1) (4, 2) (4, 3) (4, 4) (4, 5) (4, 6)

- (5, 1) (5, 2) (5, 3) (5, 4) (5, 5) (5, 6)
- (6, 1) (6, 2) (6, 3) (6, 4) (6, 5) (6, 6)

The first number in each pair represents the number showing on the first dice, and the second number is the number showing on the second dice.

Step 3: Solving the Mathematical Problem: Summing the numbers in each pair above, we find that possible sums are 2,3,4,5,6,7,8,9,10, 11 and 12. We have to find the probability for each of them, assuming all 36 pairs are equally likely.

We do this in the following table:

Observe that the chance of getting sum of a seven is 1/6, which is larger than the chances of getting other numbers as sums.

Step 4: Interpreting the solution: Since the probability of getting the sum 7 is the highest, you should repeatedly guess the number seven.

Step 5: Validating the model: Toss a pair of dice a large number of times and prepare a relative frequency table. Compare the relative frequencies with the corresponding probabilities. If these are not close, then possibly the dice are biased. Then, we could obtain data to evaluate the number towards which bias is.

Example 5: Profit of a company between cost price and selling price (the real-world problem): When a company produces a product it incurs

TABLE 1

Sum	2	3	4	5	6	7	8	9	10	11	12
Probability	$\frac{1}{36}$	$\frac{2}{36}$	$\frac{3}{36}$	$\frac{4}{36}$	$\frac{5}{36}$	$\frac{6}{36}$	$\frac{5}{36}$	$\frac{4}{36}$	$\frac{3}{36}$	$\frac{2}{36}$	$\frac{1}{36}$

costs. The company sells the product at a fixed price and is interested in examining its profitability.

Step 1: Understanding the problem:

You need to know the profitability of a company under some restrictions/constraints.

Step 2: Mathematical Description:

Here we suppose the costs are of two types: fixed and variable. The fixed costs are independent of number of units produced (e.g. rent and rates), while the variable costs increase with the number produced (e.g. materials).

Initially we assume that the variable costs are directly proportional to the number of units produced - this should simplify our model. The company has a certain amount of money coming in form of sales, and wants to ensure that is maximum. For convenience, we assume that all units produced and sold immediately.

Step 3: Solving the Mathematical problem: Let

- x be the number of units produced and sold,
- C be the total cost of production (in Rs.),
- I be the income from sales (in Rs.),
- P be the profit (in Rs.).

Our assumptions above state that C consists of two parts:

- fixed cost a (in Rs.)
- variable cost b (in Rs.),

Then $C = a + bx$... (1)

Also income I depends on selling prices s (Rs. per unit).

Thus $I = sx$... (2)

The profit P is then the difference between income and costs, i.e.,

$$P = I - C = sx - (a+bx) = (s - b)x - a \quad \dots (3)$$

We now have a mathematical model of the relationships (1) - (3) between the variables x , C , T , P , a , and s . These variables may be classified as

- Independent (or decision) x
- Dependent C , I and P
- Parameters a , b and s

Step 4: Solving the Mathematical problem:

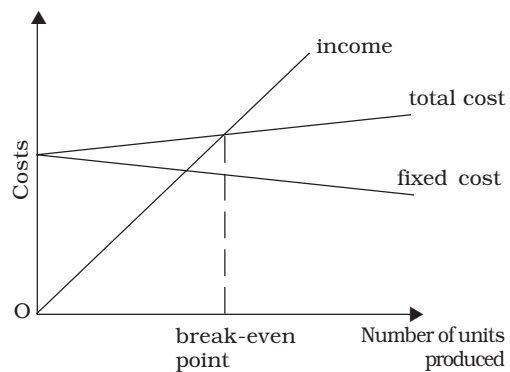
The manufacturer, knowing x , a , b and x can determine P . He/she can also see that to break even (i.e., No loss and no profit)

He/she must produce $\frac{a}{s - b}$ units (How?)

The model is best summarised as follows:

Step 5: Interpreting the solution:

The model agrees without intuition in that if fewer units are sold a loss will result but if lots of units are sold a profit will result. If the break-even point proves to be unrealistic, then a non-linear model could be tried or our simplifying



assumptions about cash flow(resources from earning and investment) amended.

Step 6: Validating the model: Taking the relationships (1) - (3) and data from various firms, the profit may be estimated and verified. You may wonder to what extent we should try to improve our model. Usually, to improve it, we need to take into account more factors. When we do this, we add more variables to our mathematical equations. We may then have a very complicated model that is difficult to use. A model must be simple to use. A good model balances two factors:

1. Accuracy, i.e., how close it is to reality.
2. Ease of use.

For example, Newton's laws of motion

are very simple, but powerful enough to model many physical situations.

So, is mathematical modelling the answer to all our problems? Not quite! It has its limitations.

Thus, we should keep in mind that a model is only a simplification of a real-world problem, and the two are not the same. It is something like the difference between a map that gives the physical features of a country, and the country itself. We can find the height of a place above the sea level from this map, but we can not find the characteristics of the people from it. So, we should use a model only for the purpose it is supposed to serve, remembering all the factors we have neglected while constructing it. We should apply the model only within the limits where it is applicable.

Concept of Force Across Different Levels

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EXPLORATION of misconcepts of physics among students at various levels has been of much interest during the last few decades {Saxena (1996), Saxena (1997), Hake (2001), Savinainen and Scott (2002), Jain et al (2003), Barak (2004), Sharma and Sharma (2003), Sharma and Sharma (2004), Jadhao and Parida (2005) and Sharma (2005)}. Prior knowledge of the misconcepts among students can be the basis for generating discussion and planning of strategy to help the students acquire the correct concepts and also make them think in a scientific way. Since pre-conceived concepts have been found to be resistant to change, it is all the more important that they are identified and suitable strategies are employed in the classroom situation to handle them effectively. There are a large number of misconceptions prevailing amongst physics students including the concept of force even after studying physics for a number of years. Examples of a few common misconceptions are given below: (i) force continues to be associated with the body till it remains in motion; (ii) velocity and acceleration are inseparable physical quantities and are in the same direction; (iii) force is in the direction of

velocity etc. It is, therefore, necessary to determine such alternative frameworks/ misconceptions before starting any teaching-learning process pertaining to conceptual dimensions of force. Concept of force is very fundamental in basic physics. Its effects are distinctly perceptible in every branch of physics/science.

A student of science begins formal learning about force from elementary level yet conceptual clarity eludes many for a quite long time. Force Concept Inventory (FCI) has been originally designed by Hestenes et. al (1992) to address conceptual dimensions of force and related kinematics. Hake (2001), Huffman and Heller (1995), Hestenes and Halloun (1995) and Savinainen and Scott (2002) have also carried out research investigations using FCI and highlighted its usefulness in evaluating students' understanding even before any formal teaching begins. FCI is an effective diagnostic tool to examine conceptual understanding of basic concepts of force. Keeping aforesaid in view, present study has been conducted on a group comprising students studying physics with a view to investigate their understanding the concept of force. For comparison, postgraduate teachers of physics were also involved in the study. The students associated with this study were drawn from those studying at the higher secondary level (popularly known as + level); Ist, IInd, IIIrd and final year students of B.Sc. Ed. course besides Ist and IInd year students of 2-year B.Ed. course (who were already graduates while some of them were post-graduates). It may be mentioned that four-year

B.Sc.Ed. course is an integrated course offered at Regional Institute of Education (RIE), Ajmer after completion of higher secondary.

Design of the Study (Tool, Sample and Process)

- A questionnaire in the form of Force Concept Inventory, developed by Hestenes et. al (1992) was used as standard tool for administering the test. It comprises 29 questions related to the basic conceptual dimensions of force viz. kinematics, Newton's first law, Newton's second law, Newton's third law, superposition principle and kinds of forces. All questions in it were multiple-choice type, each having five options, except for question number 16. Out of five options one is correct and remaining four are intended to assess suspected misconceptions.
- The tool comprising 29 items was administered on a heterogeneous and random group of students at different centers having well equipped facilities and well qualified and devoted teachers dealing with physics education. Students were instructed to give correct options for multiple-choice questions. There was no time limit fixed for responding to the questionnaire. However, 95 minutes duration was found enough to respond to all items. Details (type of sample, size of sample and level) of the sample are given in Table 1.
- At the next stage of the study six practical (laboratory) activities (I to VI) based on different conceptual dimensions of force were designed. Randomly selected groups of students from each level were asked to perform these activities and identify the specific concept involved in a particular activity. Activity I was related to Newton's first law of motion and students were expected to explain why only the coin at the bottom of a pile of 18 coins ejected out when it was hit by a single coin.

TABLE 1
Details of the Sample

S. No.	Type of Sample	Size of Sample	Level of Sample
1	Class XII students	63	+2
2	B.Sc. B.Ed. I year	15	U.G.
3	B.Sc. B.Ed. II year	25	U.G.
4	B.Sc. B. Ed. III year	23	U.G.
5	B.Sc. B.Ed. IV year	23	U.G.
6	B.Ed. I year	12	G
7	B. Ed. II year	11	G
8	P.G. Teachers	63	P.G.

Activity II was also related to Newton's first law of motion and students were expected to discover the importance of wearing a seat belt. Activity III was related to Newton's second law of motion and students were expected to investigate and formulate some ideas about the effect of moving steel ball on a stationary target steel ball (constant mass and changing force, constant force and changing mass and constant acceleration and changing mass). For performing this activity three rolling balls of different masses were given. Target steel ball had the same mass as one of rolling steel ball throughout the activity. Activity IV was related to Newton's third law of motion and students were expected to investigate the role of string in the activity. Also to understand that action acts on one object and the reaction is directed to the other. Activity V was also based on Newton's third law of motion. Here one fixed end of string was replaced with a another pulley. Activity VI was related to Newton's third law of motion. Here students were expected to guess if rotational motion needs something more than force alone i.e., existence of torque ($T = r \times F$).

- Randomly selected groups of students were interviewed individually by asking structured and cross-questions regarding aforesaid practical activities performed by them. Students were

also asked to write the reasons behind the identified specific concept involved in particular activity. The interview was conducted with the above students in a friendly atmosphere to supplement the written test and to reveal rationale behind giving particular answer to a question. However, interview sessions were not conducted for teachers. The proceedings were recorded audio and video graphically. The recorded versions of the interviews were transcribed for analysing their responses. Answers of the written test and interview were co-related to draw the inferences.

Analysis of the Responses and Results

Response to each question of questionnaire (FCI) was analysed and discussed in order to understand the reasons of options favoured by the students and teachers. Table 2 gives the analysis of responses related to basic conceptual dimensions of force in a particular question. During the analysis of responses no separate account was kept for male and female students/teachers. The following conclusions can be drawn:

- All the students and teachers responded to almost all the questions. However, 246 options were left unresponded out of total responses 6,830. In some cases there were very few correct responses e.g., question numbers 5,

9, 15, 16, 17, 19, 21, 22, 24 & 26 (Table 2). Out of total responses 2,178 were over all responded to correctly whereas number of overall wrong responses was 4,406.

- Overall percentage of unresponded, correctly responded and wrongly responded responses is 3.6, 31.9 and 64.5 respectively.
- The average correct response per student is 29.2% whereas for teacher it is 39.4%. There was only a one question, which was answered correctly by more than 95% of teachers (Table 2). About 40% teachers responded to twelve questions correctly.
- There are no significant differences amongst students' responses at different levels, which indicate that there is a difference and wide gap between the learning outcomes as expected from the curriculum given to the students and their real learning.
- In most of cases responses given by the teachers are not much different from the students' responses. This surprisingly and clearly point out that a fraction of teachers' also do carry misconceptions.
- Responses of students at all levels are varying from one option to other. They do not have concrete views regarding selection of a particular option. The same is the case with teachers.
- Responses to all questions of FCI clearly depict the existence of misconceptions regarding under-

standing the conceptual dimensions of force among students and teachers as well.

Misconceptions were identified on the basis of responses given by students and teachers. Analysis of the responses is discussed below:

Response to question 1 of questionnaire indicates that level of understanding of students at +2 level, I year B.Sc.B.Ed and II year B.Sc.B.Ed. is almost identical. Not a single student has left any option unresponded in this question. However, 3.2 % teachers did not respond to any of the options. It seems to us that teachers have got better understanding regarding this question as can be seen from their correct options. Teachers have opted options as 92 % (C), 3.2% (D) and 1.6% (E). Options (A) and (B) were not opted by any of the teacher. In this question concept of acceleration: mass/weight relation was studied. The correct option in this question is (C). It can, therefore, be concluded that students have moderate understanding regarding aforesaid concept.

Question 2 was related with the understanding of Newton's third law. Students at +2 level did not understand this question very well as no one has opted for the correct option (E). The understanding of this question is very poor amongst II and IV year B.Sc.B.Ed. and I and II years B.Ed students. As far as teachers are concerned only 52.4% have opted for the correct option (E). Surprisingly, students of I year B.Sc.B.Ed. have replied to this question correctly by opting for option E, which is nearly as high as the teachers, that is 53.3%.

TABLE 2
Analysis of responses related to different concepts of force

Concept	Q.N.	Unrespon- ded options			Correct options			Wrong options			% of wrong options		
		S	T	O.A.	S	T	O.A.	S	T	O.A.	S	T	O.A.
Acceleration: mass/weight relationship	1	-	2	2	97	58	155	75	03	78	43.6	4.7	33.2
Newton's third law	2	1	1	2	49	33	82	122	29	151	70.9	46.0	64.2
Acceleration; independent of mass/weight	3	1	7	8	31	30	61	140	26	166	81.3	41.3	70.6
Motion under no force	4	6	1	7	86	46	132	80	16	96	46.5	25.4	40.8
Role of force of gravity	5	1	-	1	26	15	41	145	48	193	84.3	76.2	82.1
Vector addition of displacement	6	4	2	6	55	36	91	113	25	138	65.6	39.6	58.7
Vector addition of velocities	7	6	4	10	44	34	78	122	25	147	70.9	39.6	62.5
Newton's first law with constant speed	8	9	2	11	45	24	69	118	37	155	68.6	58.7	65.9
Force due to action-reaction	9	4	8	12	31	08	39	137	47	184	79.6	74.6	78.2
Newton's first law with no force	10	2	4	6	74	34	108	96	30	126	55.8	40.6	53.6
Newton's third law	11	-	2	2	84	28	122	88	33	121	51.1	52.3	51.4
Balancing action- reaction forces	12	-	-	-	72	45	117	100	18	118	58.1	28.6	50.2
Newton's third law	13	3	5	8	51	10	61	118	48	166	68.6	76.2	70.6
Newton's third law	14	5	9	14	39	24	63	128	30	158	74.4	40.6	67.2
Impulsive action-reaction	15	1	2	3	44	17	61	127	44	171	73.8	69.8	72.7
Trajectory of a projectile	16	5	3	8	49	13	62	118	47	165	68.6	74.6	70.2
Gravitational force	17	-	2	2	49	20	69	123	41	164	71.5	65.0	69.7
Constant velocity- balancing upward and downward force of gravity	18	6	2	8	25	25	50	141	36	177	81.9	57.1	75.3

Superposition principle: vector sum	19	5	3	8	73	21	94	94	39	133	73.8	61.9	56.5
Speed (dx/dt) – rate of change of position	20	5	6	11	40	14	54	127	43	170	54.6	68.2	72.3
Acceleration (dv/dt)–rate of change of speed/velocity	21	5	4	9	47	15	62	120	44	164	69.7	69.8	69.7
Motion under gravitational force	22	3	4	7	26	13	39	143	46	189	83.1	73.0	80.4
Trajectory under superposition of two velocities	23	5	5	10	58	39	97	109	19	128	63.3	30.1	54.4
Constant acceleration with parabolic path	24	1	12	13	21	07	28	150	44	194	87.2	69.8	82.5
Constant acceleration	25	6	11	17	56	21	77	110	31	141	63.9	49.2	60.0
Newton's first law with no force	26	11	14	25	21	10	31	140	39	179	81.3	61.9	76.1
Newton's first law speed constant	27	2	8	10	62	27	89	108	28	136	62.7	44.4	57.8
Newton's first law with cancelling forces	28	6	10	16	46	22	68	120	31	151	69.7	49.2	64.2
Kinds of force-friction opposes motion	29	4	6	10	47	31	78	121	26	147	70.3	41.3	62.5

*S stands for students, T stands for Teachers and OA stands for overall

Concept of acceleration; independent of mass/weight, is hardly understood either by students or by teachers as can be seen from the correct options offered by them. Most of responses are other than from the correct option (C). It seems that the majority of the students barely understand the aforesaid concept. However, they have not left any option (except I year B.Ed. students) unresponded in contrast to teachers where 11.1% of them did not respond to any options in question 3.

The concept of motion under no force i.e., Newton's first law was tested in question 4. This concept is understood by most of the students and the teachers as is evident from their correct options. The correct option (B) was opted by 41.3% students at +2 level, 53.2% I year B.Sc.B.Ed., 56% II year B.Sc.B.Ed., 78% III year B.Sc.B.Ed., 56.5% IV year B.Sc.B.Ed., 58.3% I year B.Ed. and 73% teachers. However, none of the II year B.Ed. students has for opted the correct option.

Question 5 was related with the concept of gravitation. Only 23.8% teachers and less than 26.68% students opted for the the correct option (D). 8.3% I year B.Ed. students did not respond to this questions whereas rest of students and teachers choose one of the given options. Students' responses at any level were also not much different from the teachers. It seems that understanding of the students and teachers regarding the concept of gravity are not sound enough.

Concept of vector addition of displacement was investigated in question 6. More than 52.0% students of II and IV years B.Sc.B.Ed. as also the teachers have opted for the correct option (B). Whereas others have poor understanding of this concept. However, +2 level and I year B.Ed. students and teachers did not choose some of the given option (<8.3%).

Question 7 in which the concept of vector addition of velocities was examined, the correct option (E) was opted for the by 15.9% +2 students, 33.3% I year B.Sc.B.Ed. 52% II year B.Sc.B.Ed, 43.4% IV year B.Sc.B.Ed, 53.9% teachers and 52% I year B.Ed and 27.2% II year B.Ed. However, none of III year B.Sc.B.Ed. students have opted for the correct option. Unresponded responses were given by 7.9% +2 students, 9.1% II year B.Ed. students and 6.3% teachers in this question.

The concept related with Newton's first law: constant speed was investigated in question 8. This concept was poorly understood by +2, II year B.Sc.B.Ed, IV year B.Sc.B.Ed, I year B.Ed. and II year B.Ed. students. The correct

option (A) was opted for moderately by I year B.Sc.B.Ed. students 40% and teachers 38%. Here 3.2% each +2 students and teachers have left unresponded responses. It can be concluded from the responses given by the students and teachers as listed in Table-2 that their understanding regarding this concept is not concrete. Options selected by them indicated alternative views.

Responses to question 9 clearly indicated that the concept of force due to action-reaction is hardly understood either by the students or the teachers as correct option (D) was opted by +2 students 19%, I year B.Sc.B.Ed., 6.7%, III B.Sc.B.Ed. 8.7%, IV year B.Sc.B.Ed. 13%, I year B.Ed. 16.7% and II B.Ed. 36.4% and teachers 12.81%. This question also interpreted in terms of alternative views. II year B.Sc. B.Ed. students have not opted option (D) at all. Percentages of responses of students to this question are given below:

In regard to question 10, related with the understanding of Newton's first law of motion with no force, correct option (B) was opted for by more than 41.7% students except II year B.Sc.B.Ed. and teachers. Unresponded responses were less than 6.3% given by +2 students and teachers only. Other students have not left any option unresponded.

Question 11 was related to the understanding of Newton's third law of motion was moderately understood by the students and teachers as can be seen from their correct responses opted in this question.

It can be inferred from the responses given by the students and teachers that

Options → Students	A	B	C	D	E	UR
+2 level	14.3	23.8	22.2	19.0	17.5	3.2
I year B.Sc. B.Ed.	6.7	33.3	46.6	6.7	-	6.7
II year B.Sc. B.Ed	12.0	32.0	36.0	-	20.0	-
III year B.Sc. B.Ed	21.7	56.5	-	8.7	13.1	-
IV year B.Sc.B.Ed	-	39.2	39.2	13.0	4.3	4.3
I year B.Ed.	-	50.0	16.7	16.7	8.3	8.3
II year B.Ed.	9.1	-	54.5	36.4	-	-

understanding of Newton's third law of motion in different situations was poor in questions 12, 13 and 14.

Concept of action-reaction in the context of a given impulse was investigated in question 15. Responses given by the students and teachers have indicated that the concept involved in this question was barely understood.

The concept of trajectory of projectile was studied in question 16. It may be inferred from the responses given by teachers and students except II & IV years B.Sc.B.Ed. and II year B.Ed. that their understanding regarding trajectory of projectile is not up to the mark. The

correct option (B) was given by 20.4% teachers only. The percentages of responses given by the students at different levels are as follows:

Questions 17 and 18 was related to the concept of gravitational force. Responses given to this question have clearly indicated the lack of understanding the concept. The correct option (C) of question No. 17 was opted by 27% +2 students, 40% I year B.Sc.B.Ed, 24% II year B.Sc.B.Ed., 34.8% III year B.Sc.B.Ed., 34.8% IV year B.Sc.B.Ed., 16.7% I year B.Ed., 9.1% II year B.Ed. and 31.7% teachers. The percentage of correct options was even

Options → Students/teachers	A	B	C	D	E	UR
+ 2 level	1.6	27.0	57.1	8.0	-	6.3
I year B.Sc.B.Ed.	-	13.3	86.7	-	-	-
II year B.Sc.B.Ed.	52.0	48.0	-	-	-	-
III year B.Sc. B.Ed.	8.7	13.0	65.3	13.0	-	-
IV year B.Sc.B.Ed.	43.5	47.8	9.7	-	-	-
I year B.Ed.	-	-	50.0	41.7	-	8.3
II year B.Ed.	-	36.4	54.5	9.1	-	-
Teachers	11.1	20.4	39.7	23.8	-	4.8

poorer for question 18. Comparative understanding of this concept of students and teachers seems to be almost same.

Question 19 was related with the concept of superposition of vectors. In regard to this question students and teachers opted for the correct option (B) as 39.6% +2, 59.6% I year B.Sc.B.Ed., 48.0% II year B.Sc.B.Ed., 17.4% III year B.Sc.B.Ed., 56.5% IV year B.Sc.B.Ed., 25.0% I year B.Ed. and 63.7% II year B.Ed. students and 33.3% teachers. These responses indicated clearly the existence of alternative frameworks in the minds of students and teachers as well.

Concept of speed: (dx/dt) , rate of change of position, was studied in this question 20. Responses opted by the students and teachers are not much different from each other. The correct option (E) was opted by 15.9% +2 students, 33.9% I year B.Sc.B.Ed, 20% II year B.Sc.B.Ed, 13% III year B.Sc.B.Ed. and 18% II year B.Ed. students and 22.2% teachers. However, 65.3% IV year B.Sc.B.Ed. opted the correct option indicating the better understanding over others.

Responses in regard to question 21 have indicated existence of misconception among the students and teachers as can be seen from their responses (Table 2). In this question the concept of acceleration: (dv/dt) , rate of change of velocity, was investigated.

Concept of motion under gravitational force was examined in an question 22. Responses to this question

indicated that students and teachers have very poor understanding the concept (Table 3). Such poor understanding of the concept may be attributed either to ineffective instruction or lack of commitment to the subject. It has been pointed out that effective instruction requires more than dedication and knowledge of the subject. It requires technical knowledge about how students think and learn.

Question 23 was related to the concept of trajectory under superposition of two velocities. 61.9% teachers and 46.6% students have responded to this question correctly which indicates better understanding of teachers over students.

Concept of constant acceleration – parabolic path was investigated in question 24. It can be seen from Table 2 that aforesaid concept was hardly understood either by the students or the teachers.

The concept of constant acceleration was not understood satisfactorily either by students or teachers as is evident from the responses given by them in regard to question 25 (Table 2).

Question 26 was related to the application of Newton's First law of motion with no force. In this question the percentage of correct option (B) given by students and teachers is less than 26.7% in most of the cases. It is worthwhile to note from the following table that the responses given by the students and teachers are varying from one option to other. This indicates the existence of alternative views regarding the concept in their minds.

Options → Students/teachers	A	B	C	D	E	UR
+2 level	19.0	12.7	15.7	23.8	15.8	12.6
I year B.Sc.B.Ed.	6.7	6.7	40.0	26.7	20.0	-
II year B.Sc. B.Ed.	32.0	8.0	8.0	48.0	4.0	-
III year B.Sc. B.Ed.	17.4	17.4	47.8	4.4	3.0	-
IV year B.Sc. B.Ed.	4.3	21.8	34.8	26.1	13.0	-
I year B.Ed.	16.7	8.3	33.3	16.7	-	25
II year B.Ed.	27.3	-	18.2	45.5	9.0	-
Teachers	4.8	15.8	17.5	39.7	22.2	-

Understanding of students and teachers regarding Newton's first law of motion with constant speed was moderate as can be seen from the responses given by the students except for those of II year B.Sc.B.Ed. and teachers in regard to question 27 (Table 2).

From the analysis of the responses to question 28, it is evident that the level of understanding of students and teachers on this concept is at an average level. (Table 2). This question was related to Newton's first law of motion with involving forces that cancel each other.

Question 29 was related with the concept of kinds of forces: friction opposes the motion. Responses to this question have indicated better understanding of teachers over students as can be seen from percentage of following correct option (C) opted by students and teachers:

It is worthwhile to note from the above analysis of the students' and teachers' responses that there is a section of students and teachers who do carry misconceptions. This is despite the fact that all teachers are well-qualified. It can also be seen from the analysis of

Options → Students/teachers	A	B	C	D	E	UR
+2 level	19.2	26.9	33.3	9.5	11.1	-
I year B.Sc.B.Ed.	26.7	33.2	26.7	-	6.7	6.7
II year B.Sc.B.Ed.	12.0	60.0	24.0	4.0	-	-
III year B.Sc.B.Ed.	26.1	39.1	13.1	4.3	17.4	-
IV year B.Sc.B.Ed.	17.4	30.5	34.8	8.7	4.3	4.3
I year B.Ed.	33.3	33.3	16.7	-	-	16.7
II year B.Ed.	9.1	36.4	27.3	9.1	18.1	-
Teachers	7.9	22.2	49.2	11.1	-	9.5

the responses given by students that their views for opting for an option for a particular question are not concrete. Same is the case for teachers. This may be attributed to the existence of alternative frameworks in their minds. Similar results have also been reported by earlier studies regarding the existence of alternative frameworks associated with various concepts (Saxena (1996), Saxena (1997), Hake (2001) and Savinainen and Scott (2002)). The existence of misconceptions among the teachers has serious implications and likely to be passed on to their students (Sharma and Sharma (2003)). Teachers may, therefore, take this into account. They may try to identify alternative frameworks in the initial stage and to provide a curriculum that takes care of such types of frameworks of the students. This is especially important from the viewpoint of successful teaching and meaningful learning. For a prior knowledge of the misconcepts/ alternative frameworks among students can be the basis for generating discussion and planning of strategy to help the students in acquiring the correct concepts and also make them think in a scientific way.

Students' Frameworks

Analysis of responses obtained through interviews and written answers indicates following students' alternative frameworks regarding understanding the basic conceptual dimensions of force:

Students recognise

- Push or pull as force and

- Any thing, which can be changed or displaced.

Force causes

- Motion when it is applied in an unbalanced manner,
- Change in position, displacement, velocity,
- Change in motion, and direction and
- Change in state of body, distortion, configuration, affecting shape of the body.

Force is related with motion

- $F=ma$ (acceleration is produced by velocity or vice versa),
- More (larger) force means more (larger) velocity or vice versa.,
- Force is directly proportional to motion. Without force there is no motion and
- Force is a cause, which produces motion. Motion is an effect.

Motion means presence of force

- Any body undergoes displacement force is present there.
- No force, no motion.
- Force continues to be associated with the body till it remains in motion.

Constant force results in constant velocity.

Largest force determines motion.

Force acts on a body only in horizontal direction not in vertical direction.

If force is applied on different points, rotational motion is observed.

Greater mass having greater velocity and travelled greater distance.

Implications of the Study

Investigations into students' and teachers' ideas pertaining to the conceptual dimensions of force were conducted over groups comprising the following:

- Those who were studying the concepts this year (+2 level).
- Those who have passed +2 level last year and done related experiments this year.
- Those who have studied concepts beyond the ones being tested and are going to graduate.
- Those who are already graduates and post-graduates and have studied the concepts in theory as well as done related experiments during their courses studied earlier.
- Those who are already post graduates and are teaching the concept theoretically and practically for more than 12 years or so.

Responses were obtained using a questionnaire having multiple-choice questions, questions to be answered giving reasoning and asking the students to perform activities during which they were interviewed. Written responses as well as audio and video recorded versions were analysed after preparing their transcription. These responses indicate that there is a difference and a wide gap between the learning outcomes as expected from the curriculum given to the students and their real learning at all levels. It is also noted that there are no significant differences amongst students at different

levels. Surprisingly, teachers are also not exceptions to above inference in some of the conceptual dimensions of force. There can be a number of reasons for examples:

- Transactional strategies may not be effective.
- Concepts may not be internalised because of students' sticky nature and naïve behaviour.
- Students may not find content interesting enough and correlating concepts with practical experiences.
- Students may not be able to apply their knowledge in unfamiliar situations for finding solutions.

To bridge the gap between what we teach and what is learnt the following steps are suggested:

- Theory and practicals (laboratory experiments) must be integrated. Routine experiments have to be replaced with innovative experiments. Interaction with the students while performing experiments must be established and extended to real situations. For planning the teaching strategy, we must develop such situations where students encounter logically inconsistent situation.
- Students should be made familiar with common scientific processes viz. observation, identification, classification, discovering relationships, performing measurements, experimentation, establishing cause effect relationships, interpretation of results, inference, prediction and making hypothesis

- and testing the same. Special attention may be paid to processes of science during teaching and aim should be to make students keen observers with an eye for details, recognition of similarities and differences, inquisitiveness, develop understanding of concepts of force, processes involved and find applications of the same.
- Teachers may set the subject matter clearly and key features of conceptual dimensions of force must be identified before delivering to the students. It may also be ensured that students develop sufficient application skills and problem solving techniques through simple and exemplary questions/problems.
 - Teachers may identify alternative frames related to the concept of force in the initial stage and provide a curriculum that takes into account the existing alternative frames. Accordingly, their thought structures may be studied and modified.
 - Teachers may plan their lessons, activities, questions and other resources to focus on understanding and application of the basic concept of force. A feedback from the students at the end of the lecture may be taken to facilitate self-analysis of the lecture that may follow. Other fellow teachers may also critically analyse the feedback. Finally remedial measures may then be taken by teachers to rectify the misconcepts of the students.
 - Teaching-learning process should be made joyful by not limiting it to rote learning and also making it less stressful and burdensome. It may be related with life outside the school and beyond textbooks. It may also relate to the various scientific, environmental, technological aspects besides inculcating a scientific temper. Day-to-day experiences may be incorporated into the classroom activities.
 - Constructivist learning situation may be created during curriculum transaction (NCF-2005). Classroom experiences should be linked with experiences outside the classroom situations. Teachers should move beyond the position of having a general awareness that students are having difficulties with the concepts of force to being able to interpret the students' thinking more analytically so that they are in a better position to plan and to implement the next stage of teaching.
 - Active engagement of students in construction of knowledge through relevant activities has to be facilitated. Active engagement involves enquiry, exploration, questioning, debates, application and reflection, leading to theory building and the creation of ideas/positions. Schools must provide opportunities to question, enquire, debate, reflect, and arrive at concepts or create new ideas (NCF-2005).
 - The teacher's own role in student's

cognition has to be enhanced by allowing students to ask questions that require them to relate what they are learning in school to things happening outside, encouraging students to answer in their own words and from their own experiences, rather than simply memorising and getting answers right in just one way.

- 'Intelligent guessing' may be encouraged as a valid pedagogic tool. Quite often, students have an idea arising from their everyday experiences or because of their exposure to the media, but they are not quite ready to articulate it in ways that a teacher might appreciate. It is in this 'zone' between what you know and what you almost know that new knowledge often takes the form of skills, which are cultivated outside the school, at home or in the community. All such forms of knowledge and skills must be respected.
- Diagnosis and remedial teaching may be introduced. Physics teachers' education programmes may be revamped in such a way that teachers' must get an opportunity for removing their misconceptions and frequently updating themselves

with the new concepts of the subject.

It can be concluded from the examination of the students' and teachers' responses that there is a fraction of students and teachers who do carry misconceptions. This is despite the fact that all teachers are well qualified. The existence of misconceptions among the teachers has serious implications and likely to be passed on to their students. There is thus a very strong case for frequent in-service training/refresher courses of reasonably long duration for teachers in order to improve their efficacy. It is also suggested that teachers should try to identify alternative framework in the initial stage and to provide a curriculum that takes into account the existing alternative frameworks of the students. Students must be taught in such a way that classroom experiences should be linked with experiences of outside the classroom situations. Day-to-day experiences should be incorporated into classroom activities giving real feeling of oneness between the society and learning. The students should be encouraged to express their frank views and feelings about the teaching-learning process. Teachers must resort to remedial measures accordingly.

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Creating an Environment to Educate about the Environment

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THE NEW PARADIGM of education, embodying the spirit of science, of democracy, and of care for the environment, emphasises a number of key elements such as learning rather than teaching, building capacity for critical thinking and problem solving along with locale-specificity in the context of a global education (NCF 2005). In the march of science, anybody is welcome to challenge any assertion, whether it be of facts supposedly observed, or of models of how the system works. Along with rejection of all authority, science has also given up claims arriving at any absolute Truth. Science deals in knowledge that is always treated as provisional, that is, open to being supplanted by newer and more effective observations and theories. This open, democratic and participatory exercise of science has proved tremendously effective in rapidly increasing our knowledge of the natural world. Science should, therefore, be learnt as a dynamic experience rather than as a mechanical accumulation of facts.

The roots of the present status of EE (Environmental Education) in formal

education can be traced back to the Report of the Education Commission (1964-66) (Kothari Commission). This report also incorporated the best that basic education had to offer so as to relate it to the life, needs and aspirations of the students. The curriculum of general education for the upper primary and secondary stages, developed following the directives and guidelines provided in the National Curriculum Framework (NCF), has been quite wide-ranging on all aspects of the environment although EE was not perceived as a separate subject.

Educationists question, the utility of adding an additional subject to an already packed curriculum. The focus according to most environment experts is on the theoretical aspects of the natural life cycle rather than acquisition of practical skills and advice on how to regenerate human and natural environments. As far as the environmental textbooks brought out by various state governments are concerned it is a moot point whether their content will be utilitarian or useful because implementation of every environmental policy programme, project and plan comes down to the same common denominator-environmental education (EE). Effective, timely and targeted EE lies at the core of operationalising these paradigms, especially at the local level. There has been a changing vocabulary in local environment management - from 'simple' concepts such as community participation, to expanded issues such as capacity building, informed consent, public choice, decision-making, awareness building, governance,

decentralisation, local autonomy, information disclosure etc.

Despite widespread water scarcity, deforestation, chaotic cities, pollution and global warming having transformed into everyday realities, environment education in schools and colleges across the country is limited in its content and reach. The sudden information overload on environment conservation has left most well-intentioned school managements perplexed and confused. Though most urban schools have jumped on the green bandwagon, introducing environment education as an academic subject or an extra-curricular activity there is widespread dispute about its contours and content. It cannot be taught in isolation as a 'science' subject. Unfortunately awareness of environment as a holistic discipline is lacking in most curriculums. Environment education has become just another subject to be rote-learned for marks and results.

EE, therefore, is about understanding the causes and effects, of positive and negative aspects, of global and local issues, of immediate and long-term issues, and of direct and indirect impacts. Environment education should not be added as another subject to the already overburdened curriculum. Instead environment awareness should emerge from the subjects under study by infusion, not addition. For instance, in history one could talk about Emperor Akbar's environment policies and its impact on subsequent rulers. Most educationists and school principals are also averse to environment education

being added as a compulsory subject to curriculums. They prefer to introduce it as an extra-curricular activity, supervised by committed teachers and students resulting in the greening of all subjects.

Now consider the following facts

1. The threat to agricultural biodiversity comes mainly from the market advantage to be gained by switching over to modern agriculture and the High Response Varieties.
2. Brahmaputra carries one of the highest sediment loads in the world, about 332 million metric tonnes annually throughout its course due to soil erosion.
3. 50,000 species are becoming extinct each year. The fish supply in our oceans is being critically depleted by widespread uncaring practices. Many of the large fish species (marlin, cod, tuna) are depleted by as much as 80 per cent.
4. Toxic waste, routinely dumped at sites in the ocean, is creating "dead zones" where no life exists in the water from top to bottom for hundreds of kilometres.
5. The remaining rain forest along the Amazon is being cut down at the rate of 1500 sq. kilometers a year. Its importance in oxygen production, atmospheric cooling, and species habitat must be acknowledged and acted upon before it is gone.

6. Developing countries are still in the process of evolving appropriate solutions to handle their environmental problems.
7. Climate change is not just an environmental issue, as too many people still believe. It is an all-encompassing threat and it is a threat to health, since a warmer world is one in which infectious diseases such as malaria and yellow fever will spread further and faster, could imperil the world's food supply, as rising temperatures and prolonged drought render fertile areas unfit for grazing or crops. It could endanger the very ground on which nearly half the world's population lives – coastal cities, which face inundation from sea levels rising as a result of melting icecaps and glaciers. These are plausible scenarios, based on clear and rigorous scientific modelling. A few diehard skeptics continue to deny global warming is taking place and try to sow doubt. They should be seen for what they are: out of step, out of arguments and out of time. In fact, the scientific consensus is becoming not only more complete, but also more alarming. Many scientists long known for their caution are now saying that global warming trends are perilously close to a point of no return. Now, this is not science fiction. The good news is that there is much we can do in response. We have started using fossil fuels more cleanly and efficiently. Renewable energy is increasingly available at

competitive prices. With more research and development – current levels are woefully, dangerously low – we could be much farther along. India is in the grip of a multifaceted crises extenuated by the poor quality of governance and its inability to grapple with the challenges of population explosion, poverty and deprivation, social exclusion, rapid urbanisation, and environmental degradation caused by the very forces of development. Therefore, the above-stated facts amply illustrate that it is essential that a fuller understanding of various issues in the area of EE and particularly those that have bearings on school education and practice are explained and carried out. Thus, there is an urgent need to have a simplified overview of EE, objectives and principles of EE alongwith an understanding of the core issues of EE. This paper attempts to meet this need.

EE Framework

A useful framework for environmental education programmes and projects is the triple foci of education, research and practice. *Education* helps in building awareness among the target audience; primarily using knowledge and information as its resources. *Research* helps in assessment of the environment, using a number of problem issues as starting points. *Practice* helps in developing the appropriate action, using a number of *Skills and Expertise for the Purpose*.

EE Objectives

Participation- to provide individuals, groups and societies with opportunities to be actively involved in exercising their skills of environmental citizenship and be actively involved at all levels in working towards sustainable development.

Knowledge- to help individuals, groups and societies gain a variety of experiences in, and a basic understanding of, the knowledge and action competencies required for sustainable development

Values- to help individuals, groups and societies acquire feelings of concern for issues of sustainability as well as a set of values upon which they can make judgements about appropriate ways of acting individually and with others to promote sustainable development

Skills- to help individuals, groups and societies acquire the action competence or skills of environmental citizenship - in order to be able to identify and anticipate environmental problems and work with others to resolve, minimise and prevent them.

Awareness- to create an overall understanding of the impacts and effects of behaviours and lifestyles - on both the local and global environments, and on the short-term and long-term.

Principles of EE

1. EE should be a part of all education.
2. Environmental problems are interdisciplinary.
3. Direct experience in the natural

world is an essential part of EE. The way education happens is as important as its content.

Core Themes of EE

1. *Lifelong learning:* The potential for learning about sustainability throughout one's life exists both within formal and nonformal educational settings.
2. *Interdisciplinary approaches:* Education for sustainability provides a unique theme to integrate content and issues across disciplines and curricula.
3. *Systems thinking:* Learning about sustainability offers an opportunity to develop and exercise integrated systems approaches.
4. *Partnerships:* Partnerships forged between educational institutions and the broader community are key to advancing education for sustainability.
5. *Multicultural perspectives:* Achieving sustainability is dependent upon an understanding of diverse cultural perspectives and approaches to problem solving.
6. *Empowerment:* Lifelong learning, interdisciplinary approaches, systems thinking, partnerships, and multicultural perspectives empower individuals and institutions to contribute to sustainability.

Communities are increasingly bringing the old adage, "better safe than sorry," also known as the "precautionary

principle,” into practice. When there is reasonable concern that an activity or product raises threat to ecological or human health, the principle assertion is that precautionary measures should be taken, even without complete scientific data by employing the following diverse strategies to support environmental health:

- Identify and promote community actions and public policies to address key environmental health and justice issues in the most impacted communities.
- Support and strengthen multi-ethnic, community-led coalitions.

Provide grants, trainings, and technical assistance to help build the capacity of groups engaged in this work.

- Host educational events and briefings.
- Partner with nonprofits, grassroots groups, business and civic leaders, public health agencies, local governments, and regulatory agencies to develop a coordinated vision and effective strategies for fostering an environmentally healthy surroundings.
- Increase public awareness of and funding for environmental health and justice issues.

EE: Going Beyond the Blackboard

Despite steps undertaken to incorporate EE in formal education processes, there is still a clear need to ‘go beyond the black board’ to broaden and deepen the experience and involvement with the

environment. Some of the suggestions being made include:

- development of organisational frameworks for student mobility, including work-placement.
- structured exchange of students, teachers, trainers and administrators in various types of educational institutions.
- joint development of innovative curricula, teaching materials methods, and modules, including those that use new educational technologies.
- research internships at university, industry, laboratories, NGOs and community groups).
- intensive programmes such as workshops and training.
- other innovative approaches such as distance learning, computer-based education, etc.

Environmental action at the local level takes several different forms - such as those listed below. Each needs its own brand of EE. Think of what would be necessary for each action type?

Provide

Environmental activity essentially involves providing the necessary services, information, etc. in response to a demand or a need. It is primarily local in nature, in direct relation to the end user of the service. The activity comes at the end of the implementation cycle, but can also include provision of a policy framework, capacity building exercise, etc.

Control

Control involves the minimisation, curtailment or suppression of negative effects. Such negative effects can be at the local/individual level, for example affecting the health of a household, living/work conditions etc., or can be regional or transboundary in nature particularly in the case of pollution of air or water. Control of such negative activities takes the form of laws and legislation, enforcement of rules and regulations, education, public awareness etc. Implementation may also include citations, fines, court orders, etc.

Educate

A key common denominator that underpins all environmental action, education involves information dissemination and awareness-building, in order to bring about a change in attitudes and consumption patterns. It aims to influence overall resource utilisation. Education can be directed either at the individual/household or at the community/region as a whole. Education can be formal, university-based learning and training, but can also be non-formal on-the-job training, continuing education programmes, etc. It can be a continuous process, or a one-time process, providing quick summarised information or more comprehensive information.

Programme

Environmental programmes constitute an umbrella of broad approaches that

aim at preserving, implementing, educating, or controlling environmental effects, both negative and positive. Questions that needs to be asked include: what programmes are necessary? When should such programmes be implemented? Where and at what level should such programmes be developed (in terms of its formulation and implementation)? Who should implement the programmes, and who are the target beneficiaries? How should the programme be implemented?

Legislate

Certain environmental problems are best tackled through legislation - at the local, national and international levels. Legislative action can take various 'stick-and-carrot' forms, where positive action is rewarded and negative action is punished. Laws, rules, regulation, standards, acts etc. are common legislative forms of action. They may call for the setting up of institutions and regulatory bodies, procedures for action, fees, fines, taxes etc. to be paid. Legislation falls under, and is a part of, the broader umbrella of governance systems.

Finance

Most environmental activity, in one form or another, require financial resources to be allocated to operationalise a policy, programme or project. This may come from public funds, private investment, community contributions/donations, or other sources.

The Way Ahead for Environmental Education

EE is as complex and complicated as the term 'environment' itself. It cuts across many disciplines, sectors, realms, ecosystems and spheres. Because of this EE needs to be planned and implemented systematically for which some suggestions are given below:

Distill best practices and lessons: A large number of innovative practices and lessons already exist in the region. They need to be identified and replicated in other countries of the region.

Review and revise the existing curriculum: There is an urgency to review the existing curriculum in order to eliminate the dead woods and determine slots to incorporate environmental concerns.

Reorient the pedagogical approach: There is an urgency to reorient out existing teaching methods from 'chalk to talk' and lecture methods to problem-solving methods, from activity and issue-

based approach to field work and case studies, from 'didactic to advise-based approach, and from rote learning to attitudes and skills, development and learning through participation and educational training.

Encourage traditional non-media: Non-media (such as folklore, folk songs, story-telling, religious institutions, or traditional venue) should be involved to compliment the mass media to raise people's awareness about environment.

Synergise various efforts: Develop a synergy of formal education, media and NGO for promotional activities.

Establish resource centers: Resource centers need to be established to coordinate and support EE activities at various levels.

Develop national policies: Encourage and motivate national governments to prepare acts, policies and national strategies on EE.

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Two Typical Projectile Problems and their Solution

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IN THIS ARTICLE two problems on projectile motion have been set forth and solved with a view to help students and teachers involved in learning teaching of mathematics at higher secondary stage. Such types of problems are also relevant to physics students for entrance tests in professional courses.

Problem 1

A shell is fired from ground level so as to hit an enemy position, after passing over a hill, situated at the foot on its other side at same level. The shell passes just over the peak of the hill and strikes the target. The horizontal distances of the peak and the target are a and b respectively. If h be its height and g the acceleration due to gravity (Figure. 1), find the velocity and angle of projection of the shot. Also find how long the shell is over the hill after grazing its peak. Neglect the air resistance.

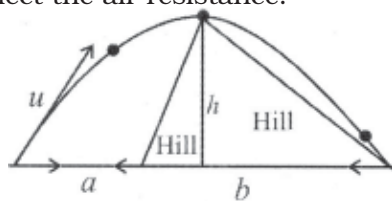


Fig. 1

Solution

Let the shell be fired with velocity u at an angle θ to the horizontal and t be the time taken by it to reach the peak of the hill.

Considering its vertical and horizontal motion,

$$h = (u \sin \theta) t - \frac{1}{2} g t^2 \quad (1)$$

$$a = u(\cos \theta) t \quad (2)$$

Eliminating t between Eqs. (1) and (2), one gets

$$h = a \tan \theta - \frac{1}{2} g \frac{a^2}{u^2 \cos^2 \theta} \quad (3)$$

Since to hit the enemy position at the foot of the hill at the same ground level, the horizontal range of the shell is:

$$b = \frac{u^2 \sin 2\theta}{g} \quad (4)$$

Eliminating u^2 between Eqs. (3) and (4)

$$h = a \tan \theta - \frac{a(b-a)}{b} \tan \theta$$

$$\text{or } \tan \theta = \frac{hb}{a(b-a)} \quad (5)$$

Using Eq. (5) in Eq. (4) we have the velocity of projection

$$u^2 = \frac{bg}{\sin 2\theta} = \frac{bg(1 + \tan^2 \theta)}{2 \tan \theta}$$

$$= \frac{g}{2h} \frac{a^2 (b-a)^2 + h^2 b^2}{(b-a)a} \quad (\text{for } b > a) \quad (6)$$

If $b = 2a$, h , that is, the height of hill top becomes equal to the greatest height attained by the shell. Then this problem reduced to a textbook problem¹

Combining Eqs. (5) and (4), we get

$$u^2 = g \frac{b^2}{8h} + 2h$$

$$u \sin \theta = \sqrt{\frac{bg}{2} \tan \alpha} + \sqrt{\frac{b^2 gh}{2a(b-a)}} \quad (7)$$

The time of travel T by the shot over the hill between the peak and the target is given by using Eqs. (1) and (7) $T =$ total time of flight – time to rise to the peak

$$\frac{2u \sin \theta}{g} - t$$

$$\frac{2u \sin \theta}{g} = \frac{1}{g} (u \sin \theta + \sqrt{u^2 \sin^2 \theta - 2gh})$$

$$\sqrt{\frac{hb^2}{2ga(b-a)}} \mp \sqrt{\frac{hb^2}{2ga(b-a)} - \frac{2h}{g}}$$

$$\sqrt{\frac{h}{2ga(b-a)}} b \mp \sqrt{b^2 - 4a(b-a)}$$

$$\sqrt{\frac{2ha}{g(b-a)}} \text{ or } \sqrt{\frac{2h(h-a)}{ga}}$$

according as $\frac{b}{2} > a$ or $b < a$ and $a = \frac{b}{2}$

If the $b = 2a$, $T = \frac{\sqrt{2h}}{g}$ as is in textbook¹.

Problem 2

A particle is projected from the foot of an inclined plane of length L and inclination θ to the horizontal. It grazes the top of the inclined plane at a subsequent time T and thereafter reaches the same horizontal level at the foot of the inclined plane. Find the velocity, angle of the inclined plane and its time of travel over the horizontal plane. Assume acceleration g due to gravity to be a constant and neglect the air resistance. (Figure 2). What can be maximum distance of the projectile from the inclined plane.

Solution

Let the particle be projected with a velocity u at an angle θ to the horizontal.

Considering its horizontal and vertical motion during time T of flight over the inclined plane.

$$L \cos \theta = u (\cos \theta) T \quad (1)$$

$$L \sin \theta = u (\sin \theta) T - \frac{1}{2} g T^2 \quad (2)$$

Eliminating L between Eqs. (1) and (2) or by formula for flight over the inclined plane we have

$$T = \frac{2u \sin \theta}{g \cos \theta} \quad (3)$$

Eliminating u between Eqs. (1) and (3)

$$\frac{\sin \theta}{\cos \theta} = \frac{g T^2}{2L}$$

$$\text{or } \tan \theta = \tan \theta \frac{g T^2}{2L \cos \theta} \quad (4)$$

In consequence of Eqs. (4), Eq. (1) gives the velocity of projection

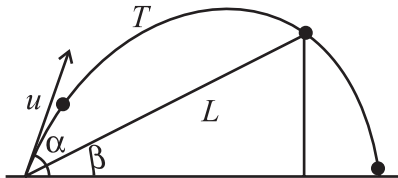


Fig. 2

$$u = \frac{L \cos \beta}{T} \sec \alpha = \frac{L \cos \beta}{T} \sqrt{1 + \tan^2 \alpha}$$

Substituting value of $\tan \alpha$ from Eq. (4)

$$\text{or } u = \frac{L}{T} \left[1 + \frac{gT^2 \sin^2 \beta}{L^2} \right]^{\frac{1}{2}} \quad (5)$$

If t be the time of its flight over the horizontal plane,

$t =$ total time of flight – time of flight over the inclined plane

$$\frac{2u \sin \alpha}{g} = \frac{2u \sin (\alpha - \beta)}{g \cos \beta} = \frac{2u \cos \alpha \sin \beta}{g \cos \beta}$$

Using Eq. (1), we get

$$t = \frac{2L \sin \beta}{gT} \quad (6)$$

The distance of the projectile from the inclined plane at time t is

$$y = u \sin (\alpha - \beta) t - \frac{1}{2} g t^2 \cos \beta \quad (7)$$

For maximum if $\frac{dy}{dt} = 0$ from Eg. (7)

gives because of Eg. (3)

$$t = t_{opt} = \frac{u \sin (\alpha - \beta)}{g \cos \beta} = \frac{T}{2} \quad (8)$$

$$y_{max} = \frac{1}{8} g (\cos \beta) T^2$$

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Early Adolescent's Conservation of Internal Volume

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PIAGET AND HIS collaborators had used conservation of volume to judge Genevan children's level of cognitive development. Their studies have demonstrated that conservation of volume is attained in three sequential phases of 8-years (internal volume); 9-years (liquid volume) and 11/12-years (occupied/displaced volume). Piagetians had fixed 75% level of performance as an index of conservation attainment by the target group. Researches conducted on early adolescents' (11/12-year) occupied/ displaced volume tasks show 25 to 48% level of performances (Beard; Elkind; Lovell; Uzgiris; Vernon; Vinh-Bang and Inhelder, all cited in Fogelman, 1970). Conservation of internal volume has been spurtly studied here as well as abroad. These facts had tempted, the author to investigate 'early adolescent's conservation of internal volume'. Specifically, the following hypothesis was examined through this study:

Sampled early adolescent's (i.e., 12/13-year) would be conserving internal volume to the extent of 75% of Piagetian criterion.

Sample: 80 Ss participated in this study. 20 Ss of either gender were randomly

selected from 2 boys/2 girls schools of Bhopal township. All of them were studying in Class VII and were between 12 and 13 years.

Data collection: Data were collected in small groups of 10Ss by the experimenter. Two towers made out of match-boxes of a brand were shown to the Ss ($2 \times 2 \times 6$). They were told that these towers were indetical in all respects and match boxes represented living spaces in them. The following three questions were then asked.

Identity phase: Do both the towers have equal spaces to live in them?

Judgement phase: One of the towers was changed into a $2 \times 3 \times 4$ configuration and the Ss had to judge, whether the two towers still had equal spaces to live in them. The Ss had to answer in yes or no.

Explanation phase: The Ss were requested to justify why they said yes or no to the judgement question.

Scoring: A non-conserver failed on all the three questions. A partial-conserver succeeded on anyone of the three questions only, while the conserver passed all the three questions.

Results:

Conservation of internal volume

	Conserver	Partial-conserver	Non-conserver
Boys	57.50	37.50	5.00
Girls	52.50	37.50	10.00

57.50% boys and 52.50% girls conserved this internal volume task. 37.50% of either gender category Ss were

partial conservers. 5% boys and 10% girls were non-conservers as well.

For a sample size of 80, at 5% level of confidence limit, the needed value of the Omega statistic (w) (percentage difference) is 0.22. Proposed hypothesis ascertained whether the sampled early adolescents' (12/13-year-olds) conserved internal volume to the extent of 75% level of performance or not. The attained level of performance had been 55% (boys/girls). 20% difference exceeds the tolerance limit of 17% in our case. Hence, the sampled Ss had performed significantly poorly against the 75% Piagetian criterion on the internal volume task. A delay of 2/3 year's, therefore, exists for these 12/13-year-old boys/girls of VII class on this task. It was also revealed by the data that gender difference was silent on this task like the earlier studies on different conservation tasks.

Discussion: It is difficult to understand, why/how 7.50% of the boys/girls denied/missed in variance of internal living spaces between the two identical towers ($2 \times 2 \times 6$) that were perceptually similar during the identity phase. In judgement phase, one of the towers was transformed into a $2 \times 3 \times 4$ configuration. In order to negotiate this created spatio-perceptual conflict, the respondent either equilibrated it through decentration of thought process or a non-decenter relied on the perceptually created information. All the partial-conservers were non-decenters of thought. For them perceptually transformed tower had changed in internal living spaces. This towed line of thinking duped them on

both the judgement/why (explanation) questions. The rest of the Ss (55%) were decenters of thought process and, therefore, succeeded in attaining conservation status. According to Piaget's theory of cognitive development, resolution of cognitive conflict on a conservation task is a process of reflective abstraction. It begins by operating on the stimulus materials and then interiorising the executed action of the experimenter. Creation of a logical link is necessary between the transformed and unchanged stimulus during the explanation phase.

Educational implications: According to Brunerian perspective on conservation of quantities, had the non-conservers and partial-conservers (45%) simply verbalised that the towers were identical and/or remained the same towers even then they would have been conservers. However, this creates two problems: How reliable is our faith that telling of imparted information is attended to properly and it is appropriately stored for future apt/quick retrieval? And, does conceptual/rational thinking come by listening to transmitted informations and/or by attending to empirico-inductive or perceptually produced information? Conservatism studies conducted on children, adolescents/adults across cultures support the view that rational thinking does not develop by listening to, reading about and remembering of scientific facts, etc. *Sciencing strategies* that bank on logico-mathematical schemes (concrete thinking) and hypothetico-deductive reasonings (formal thinking) form

necessary pre-requisites in the development of rational thinking of the individual. *Therefore, allow children to engage in exploratory activities that are related with change in configuration of things.* Let them also design measurement procedures to establish their invariant properties. Classroom discussion shall be useful in the creation/construction of logical linkages between the changed and unchanged things for why of their invariant properties. One shot exploration is a very poor pedagogic principle. Therefore, extend it to multiple contexts with a

variety of things available in the immediate environment of the learners. Existing lab facilities should be exploited maximally. This should be helpful in generating context-specific situations for ascertaining invariances of the quantities. On the learnt concepts, higher-order forms of invariances can be tried by the bright students either through hypothetico-deductive reasonings/mathematical interventions or by actually performing controlled experiments. All this, it is opined, should improve rational thinking process of the early adolescents.

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Concept Attainment in Geometry through CLD Model among Class V Students

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CONCEPT LEARNING has been an important component of the teaching-learning process. Concepts are products of reasoning and once developed play an important role in further thinking. Children at all levels of development constantly learn situations. Poor understanding of concepts can lead to dead ends while their proper understanding can advance one's comprehension of the subject.

Development of concepts in mathematics is most important for children to develop better understanding. Mathematics is a subject of significance by itself and also concomitant to other subject areas for which it is a compulsory subject at the school level. Geometry, a major part of mathematics is included from the primary level. Attainment of concepts in geometry facilitate learning in mathematics as well as is useful in day-to-day life.

For the development and attainment of concepts the guidelines provided by Klausmeier's "Conceptual Learning and Development Model" is popularly known as the CLD Model. This model postulates

four levels of concept attainment, i.e. (i) classificatory level; (ii) discrimination and naming the attributes level; (iii) inferring relevant and irrelevant attributes level; and (iv) the use of concept attained at classificatory and formal level which specifies the cognitive operations involved in the attainment of concepts.

The mental process of concrete level requires attention to the distinctive features of an object and forming a memory image which represents the objects as a unique bundle of features. Concepts attainment at the concrete level involves only the discrimination of an object from other objects, attainment of the identity level involves both discriminating various forms of the same object from other objects and also generalising the forms as equivalent. In classificatory level one can be able to correctly classify a large number of instances as examples and non-examples, but cannot accurately describe the basis for his grouping in terms of the defining attributes of the concepts. Hypothesising relevant attributes and rules, remembering and evaluating hypotheses using positive and negative instances are two important mental processes involved at this stage.

To find out the attainment of concepts in mathematics a number of studies have been reviewed which revealed the following: (i) There was no significant difference between boys and girls on the effect of graph comprehension (Curcio, 1987); (ii) There was no sex difference in logical reasoning

or use of geometry problem-solving performance (Battista, 1990); (iii) Males had higher scores in creativity and intelligence as compared to females (Agarwal et al. 1999); (iv) In the skill of planning science practical, the average score of boys was more than that of girls, but not found statistically significant. But in the skill of observation, girls performed better than boys though the difference was not statistically significant (Reeta Sharma, 2000).

In the entire chain of educational system elementary education system plays a very important role in the education of child. According to *National Curriculum Framework for School Education*, “mathematics has been an inseparable part of school curriculum ever since the beginning of formal education and it continues to be so.” The fundamental aspects of mathematics, i.e. geometry as well as arithmetic at primary level and upper primary level should be given proper importance. To meet the challenge of quality elementary education for all, our instructional process should be concept-based and activity-oriented.

By seeing the importance of concept-based education on mathematics at primary level, the investigator conducted the study to find “Concept attainment in geometry through CLD model among Class V Students”.

Objectives

In view of the above, the objectives of the present study were:

- (1) To examine the effect of Conceptual Learning and Development (CLD)

model of teaching on the attainment of geometrical concepts among Class V school children.

- (2) To find out the difference in the attainment of geometrical concepts at different levels among Class V school children of different gender.

Hypotheses

On the basis of above objectives, the following hypotheses were developed:

- (1) There is a significant difference in the mean gain score of concept attainment task in geometry at various levels of concept attainment during post-test over pre-test among the experimental and control group of children of Class V irrespective of sex.
- (2) There is a significant difference in the mean gain scores of concept attainment task at different levels in geometry during post-test over pre-test among Class V school children of different gender.

Design of the Study

The present study attempts to examine the effects of instruction based on Conceptual Learning and Development (CLD) model on the attainment of geometrical concepts among Class V children as a function of their sex. The experiment followed pre-test versus post-test control group design for evaluating different hypotheses.

Sample

Out of 95 students of Class V in Government Upper Primary school,

Gotamara, 60 students were selected randomly for investigation. The children were divided randomly into two groups, one formed the control group and the other the experimental group, each group had 30 students. Care was taken to select 15 boys and 15 girls in each group.

Procedure

The investigator selected 6 geometrical concepts from the syllabi of mathematics of Class V. The lesson plan for each concept was developed by the investigator on the basis of cognitive operations specified in CLD model. The children of experimental groups received the treatment by the investigator but the control groups received the instructions through traditional mode of teaching by their own teachers.

Concept Attainment (CA) task was developed by taking 6 geometrical concepts, i.e. angle; triangle; parallelogram; rhombus; rectangle and square. Four different sub-tests were

developed by the investigator carrying all the six geometrical concepts. The CA task was based on the objectives related to four different levels of CLD model of Klausmeier. Before treatment, the CAT was administered on both the experimental group and the control group and the scores were treated as the pre-test scores. After the treatment, the same sub-test was administered again to get post-test scores of every individual. From these scores true gain scores were calculated which were then subjected to statistical analysis like mean, standard deviation and t-test of significance.

Analysis

The present study was undertaken to try out the concept-based instructional treatment on the attainment of geometric concepts among Class V children of different sex. Accordingly, the study followed the pre-test versus post-test scored true gain scores were calculated.

Table 1: Mean and Standard Deviations on the Gain Scores of the Concept Attainment Test at four different levels of Concept Attainment during Pre-test and Post-test

<i>Levels</i>	<i>Sex</i>	<i>Experimental Mean</i>	<i>Group S.D.</i>	<i>Control Mean</i>	<i>Group S.D.</i>
1. Classificatory Level	B (M)	11.74	5.87	4.62	0.91
	G (F)	10.49	2.69	1.69	1.80
2. Discrimination and naming the attribute	B (M)	16.8	14.79	1.69	3.38
	G (F)	27.99	26.79	1.93	3.42
3. Inferring relevant and irrelevant attributes	B (M)	18.19	15.62	1.30	3.38
	G (F)	17.81	14.82	5.22	17.76
4. Use of concepts attained at classificatory and formal level	B (M)	7.06	6.16	-3.06	2.84
	G (F)	5.83	8.75	-3.06	3.91

Table 1 shows the mean and standard deviations of gain scores on concept attainment tests at four different levels during pre-test and post-test.

From this table, it was found that among Class V students, the experimental girls group scored highest mean gain score (27.99) at discrimination and naming the attributes level among all the groups from all levels of concept attainment. Again this group also shows highest standard deviation at this level from all four levels indicating more heterogeneous group. Similarly, the same experimental girls group scored lowest mean gain (5.83) among all experimental groups at the use of concepts attained at classificatory and formal level. At every level of concept attainment, in comparison to experimental groups the corresponding control groups scored lower mean gain and also lower standard deviations (except control girls group at inferring relevant and irrelevant attributes level).

The mean gain scores thus obtained, was subjected to the test of significant (t-test) at four different levels which is given in Table 2.

From this table, it is observed that all groups except control group children at classificatory level show no significant difference among boys and girls groups. Experimental boys and girls of Class V show no significant difference at all levels due to concept-based instruction which was given to them during treatment.

Thus, sex plays no significant role in concept attainment of experimental students as well as control groups students of Class V at four different levels of concept attainment.

Discussion

From the analysis of results, it was observed that the treatment was found effective equally among both boys and girls of Class V. When the raw scores of boys and girls were compared, it was

Table 2: Test of Significant (t-test) for the Main Effect of Sex on the Attainment of Geometric Concepts at four different Levels on Concept Attainment during Pre-test and Post-test

Levels	Groups	<i>t-Value</i> <i>Post-test Vs. Pre-Test</i>	<i>P</i>
1. Classificatory Level	VEB Vs. VEG	0.67	NS
	VCB Vs. VCG	5.57	0.01
2. Discrimination and naming the Attribute	VEB Vs. VEG	1.54	NS
	VCB Vs. VCG	0.20	NS
3. Inferring relevant and Irrelevant Attributes	VEB Vs. VEG	0.06	NS
	VCB Vs. VCG	0.86	NS
4. Use of concepts attained at Classificatory and formal level	VEB Vs. VEG	0.44	Ns
	VCB Vs. VCG	0.00	NS

found that boys of Class V performed better than girls at all the four levels. However, the difference in the gain scores of both boys and girls were found non-significant. This was possible due to the changes in outlook of the society for girls, as a result of which equal importance to both boys and girls was given. During instruction, it was observed that the children of both sexes of experimental group were able to transfer what they learned to attend. Thus, the results in every level reject the hypothesis that boys would perform significantly better on concept attainment tests at all levels. Same performance of both boys and girls in Class V is attributed to their ability to analyse and differentiate the defining and irrelevant attributes equally. The most important factor is the instruction during which the investigator tried to motivate the students and create an intention to learn various attributes. During teaching, the investigator also pointed out the relevant attributes of a concept and provided sufficient feedback and reinforcement to facilitate each individual to learn all relevant attributes. Further, specific care for girls inside and outside the school now-a-days enhances their mental ability, so that there is no significant difference in the mean gain score of concept attainment task at all levels among Class V students. This finding was also supported by the study conducted by Battista (1990) and by Sharma and Reeta (2000).

Major Findings

Thus, this study revealed the following results:

- (1) It is revealed that children belonging to experimental groups achieved significantly better than the corresponding control groups of children in the concept attainment test. Thus, the instructional strategy based on CLD model was effective among the children of both sexes belonging to Class V in the attainment of geometrical concepts at all the four levels.
- (2) Boys of Class V did not differ significantly from the girls in the attainment of geometrical concepts at all the four levels. Thus, sex did not influence significantly on the attainment of geometrical concepts due to instructional treatment.

Educational Implications

Concepts that students encounter in any given subject during an academic year are usually included in the instructional materials they use. Better performance of experimental students due to CLD-based instructional strategy implies that this new innovative instructional strategy should be incorporated in various components of school education such as curriculum, methods of teaching, textbooks, examination and also in advanced educational programmes.

Conclusion

Concept learning in the schools today need to be emphasised. With substantial research and individual efforts, the instructional materials based on concept attainment for school children are to be

developed in different subjects. This will enhance the competency and achievement of both boys and girls students. On the other hand, this better achievement will decrease the number of dropouts and thus fulfil the aim of "Education for All".

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Science News

The Nobel Awards - 2006

The Royal Swedish Academy of Sciences announced the Nobel prizes in Physics, Chemistry and Physiology or Medicine in the first week of October 2006. In all five scientists, two each for physics and physiology and one for chemistry have been nominated for the awards

Nobel Prize in Physics

The Nobel Prize in physics for the year 2006 has been jointly awarded to John C. Mather, NASA Goddard Space Flight Center, Greenbelt, MD, USA, and George F. Smoot, University of California, Berkeley, CA, USA, *“for their discovery of the blackbody form and anisotropy of the cosmic microwave background radiation”*. The work of the two physicists, based on measurements made with the help of the COBE satellite launched by NASA in 1989, provides the pictures of a newborn universe and attempts to gain some understanding of the origin of galaxies and stars.

The COBE results provided increased support for the Big Bang scenario for the origin of the Universe, as this is the only scenario that predicts the kind of cosmic microwave background radiation measured by COBE. These measurements also marked the inception of cosmology as a precise science. It was not long before it was followed up, for instance by the WMAP satellite, which yielded even clearer images of the

background radiation. Very soon the European Planck satellite will be launched in order to study the radiation in even greater detail.

The Big Bang scenario perceives the cosmic microwave background radiation as a relic of the earliest phase of the Universe. According to this scenario immediately after the big bang itself, the Universe can be compared to a glowing “body emitting radiation in which the distribution across different wavelengths depends solely on its temperature. The shape of the spectrum of this kind of radiation has a special form known as blackbody radiation. When it was emitted the temperature of the Universe was almost 3,000 degrees celcius. Since then, according to the Big Bang scenario, the radiation has gradually cooled as the Universe has expanded. The background radiation we can measure today corresponds to a temperature that is barely 2.7 degrees above absolute zero. The Laureates were able to calculate this temperature thanks to the blackbody spectrum revealed by the COBE measurements.

COBE also had the task of seeking small variations of temperature in different directions (which is what the term ‘anisotropy’ refers to). Extremely small differences of this kind in the temperature of the cosmic background radiation – in the range of a hundred-thousandth of a degree – offer an important clue to how the galaxies came into being. The variations in temperature show us how the matter in the Universe began to “aggregate”. This was necessary if the galaxies, stars and ultimately life like us were to be able to develop. Without

this mechanism matter would have taken a completely different form, spread evenly throughout the Universe.

COBE was launched using its own rocket on 18 November 1989. The first results were received after nine minutes of observations: COBE had registered a perfect blackbody spectrum. When the curve was later shown at an astronomy conference the results received a standing ovation.

The success of COBE was the outcome of prodigious team work involving more than 1,000 researchers, engineers and other participants. John Mather coordinated the entire process and also had primary responsibility for the experiment that revealed the blackbody form of the microwave background radiation measured by COBE. George Smoot had main responsibility for measuring the small variations in the temperature of the radiation.

Nobel Prize in Chemistry

Roger D. Kornberg, Stanford University, CA, USA, has been awarded Nobel Prize in chemistry for his studies of "*the molecular basis of eukaryotic transcription*". His work has been aptly summed up as 'A family story about life'.

In order for our bodies to make use of the information stored in the genes, a copy must first be made and transferred to the outer parts of the cells. There it is used as an instruction for protein production – it is the proteins that in their turn actually construct the organism and its function. The copying process is called transcription. Roger

Kornberg was the first to create an actual picture of how transcription works at a molecular level in the important group of organisms called eukaryotes (organisms whose cells have a well-defined nucleus). Mammals like us are included in this group, as is ordinary yeast.

Transcription is necessary for all life. This makes the detailed description of the mechanism that Roger Kornberg provides exactly the kind of "most important chemical discovery" referred to by Alfred Nobel in his will. If transcription stops, genetic information is no longer transferred into different parts of the body. Since these are then no longer renewed, the organism dies within a few days. This is what happens in cases of poisoning by certain toadstools, like the death cap, since the toxin stops the transcription process. Understanding of how transcription works also has a fundamental medical importance. Disturbances in the transcription process are involved in many human illnesses such as cancer, heart disease and various kinds of inflammation.

The capacity of stem cells to develop into different types of specific cells with well-defined functions in different organs, is also linked to how the transcription is regulated. Understanding more about the transcription process is therefore important for the development of different therapeutic applications of stem cells.

Forty-seven years ago, the then twelve-year-old Roger Kornberg came to Stockholm to see his father, Arthur Kornberg, receive the Nobel Prize in

Physiology or Medicine (1959) for his studies of how genetic information is transferred from one DNA-molecule to another. Kornberg senior had described how genetic information is transferred from a mother cell to its daughters. What Roger Kornberg himself has now done is to describe how the genetic information is copied from DNA into what is called messenger-RNA. The messenger-RNA carries the information out of the cell nucleus so that it can be used to construct the proteins.

Kornberg's contribution has culminated in his creation of detailed crystallographic pictures describing the transcription apparatus in full action in a eukaryotic cell. In his pictures (all of them created since 2000) we can see the new RNA-strand gradually developing, as well as the role of several other molecules necessary for the transcription process. The pictures are so detailed that separate atoms can be distinguished and this makes it possible to understand the mechanisms of transcription and how it is regulated.

Nobel Prize in Physiology or Medicine

The Nobel Prize in Physiology or Medicine for 2006 has been awarded jointly to two Americans Andrew Z. Fire and Craig C. Mello for their discovery of "*RNA interference – gene silencing by double-stranded RNA*". Andrew Z. Fire, born 1959, is a US citizen who acquired his Ph.D in Biology in 1983 from Massachusetts Institute of Technology, Cambridge, MA, USA. At present Andrew Z. Fire is a Professor of Pathology and

Genetics, Stanford University School of Medicine, Stanford, CA, USA. Craig C. Mello, born 1960, is also a US citizen, having done his Ph.D in Biology in 1990 from Harvard University, Boston, MA, USA. He is now a Professor of Molecular Medicine and Howard Hughes Medical Institute Investigator, Programme in Molecular Medicine, University of Massachusetts Medical School, Worcester, MA, USA.

The Nobel Laureates have discovered a fundamental mechanism for controlling the flow of genetic information. Our genome operates by sending instructions for the manufacture of proteins from DNA in the nucleus of the cell to the protein synthesising machinery in the cytoplasm. These instructions are conveyed by messenger RNA (mRNA). In 1998, the American scientists Andrew Fire and Craig Mello published their discovery of a mechanism that can degrade mRNA from a specific gene. This mechanism, RNA interference, is activated when RNA molecules occur as double-stranded pairs in the cell. Double-stranded RNA activates biochemical machinery which degrades those mRNA molecules that carry a genetic code identical to that of the double-stranded RNA. When such mRNA molecules disappear, the corresponding gene is silenced and no protein of the encoded type is made.

RNA interference occurs in plants, animals, and humans. It is of great importance for the regulation of gene expression, participates in defense against viral infections, and keeps jumping genes under control. RNA interference is already being widely used

in basic science as a method to study the function of genes and it may lead to novel therapies in the future.

A Black Hole Information Paradox

“Quantum information cannot be ‘hidden’ in conventional ways”, that is what Professor Sam Braunstein, Department of Computer Science, University of York, UK and Dr Arun Pati, of the Institute of Physics, Sainik School, Bhubaneswar, India, have established by deriving their ‘no hiding theorem’. Application of their result gives a surprising new twist to one of the great mysteries about black holes. According to Braunstein’s, quantum information can run but it can’t hide.

It need not be mentioned that conventional (classical) information can vanish in two ways, either by moving to another place (e.g. across the internet), or by “hiding”, such as in a coded message. There are enumerable examples of classical information being transcribed in coded form to make it accessible to a select few. The world of science too is not an exception to this. The famous Vernam cipher devised in 1917 or its relative the one-time pad cryptographic code are examples of such classical information hiding: In this case the information resides neither in the encoded message nor in the secret key pad used to decipher it - but in correlations between the two.

Until now physicists believed that above mentioned mechanisms of hiding classical information were applicable to quantum information as well. However,

Professor Braunstein and Dr Pati have demonstrated that if quantum information disappears from one place, it must have moved somewhere else. Braunstein and Pati after deriving their ‘no-hiding theorem’ applied it to study black holes which, in Einstein’s Theory of Relativity, are characterised as swallowing up anything that comes too close. In the mid 1970s, Stephen Hawking showed that black holes eventually evaporate away in a steady stream of featureless radiation containing no information. But if a black hole has completely evaporated, where has the information about it gone? This long standing question is known as the black hole information paradox.

Now, Professor Braunstein and Dr Pati have ruled out the possibility that information might escape from the black hole but be somehow hidden in correlations between the Hawking radiation and the black hole’s internal state. Braunstein and Pati’s result demonstrates that the black hole information paradox is even more severe than previously believed. According to Dr. Pati their result shows that either quantum mechanics or Hawking’s analysis must break down, but it does not choose between these two possibilities. The no-hiding theorem provides new insight into the different laws governing classical and quantum information. It shows that there’s got to be new physics out there stresses Professor Braunstein.

(Source: *Science Daily*)

A Salamander Robot May Unravel Evolutionary Ladder

Students of biology are aware that salamanders are tailed amphibians related to frogs and toads. Salamanders have weak limbs, which are not used for locomotion to a great extent. Their limbs are small and they can regenerate them. Salamanders vary in size from 15 cm to 1.5 m with some species being aquatic, mostly terrestrial and a few arboreal. They feed on insects and other invertebrates.

A group of European researchers has now developed a spinal cord model of the salamander and implemented it in a novel amphibious salamander-like robot. The robot changes its speed and gait in response to simple electrical signals, suggesting that the distributed neural system in the spinal cord holds the key to vertebrates' complex locomotor capabilities. This four-legged yellow creature reveals a great deal about the evolution of vertebrate locomotion. It's also a vivid demonstration that robots can be used to test and verify biological concepts, and that very often nature herself offers ideal solutions for robotics design.

In order to replicate the locomotion of salamander, the researchers first evolved a numerical model of its spinal cord by exploring three fundamental issues related to its vertebrate's movement. The questions addressed by them were: what were the changes in the spinal cord that made it possible to evolve from aquatic to terrestrial locomotion? How are the limb and axial movements coordinated? And how is a

simple electrical signal from the brain stem translated by the spinal cord into a change in gait?

The team developed their model once they were convinced that they had answers to these questions. The robotic model to simulate neural network in the spinal cord of primitive salamander essentially comprised — a system of coupled oscillators representing the neural networks. Simple electrical signals, like the signals sent from the upper brain to the spinal cord, were sent wirelessly from a laptop to the robot. These signals were enough to cause the robot to change its speed and direction and change from walking to swimming. The model therefore provides a potential explanation — relevant for all four-legged organisms — of how agile locomotion is controlled by distributed neural mechanisms located in the spinal cord.

This research may ultimately point to a way to gain better understanding of the more sophisticated circuits in the human spinal cord. If the control signals received by the spinal cord could be identified, perhaps it would be possible to re-initiate these by electrical stimulations in patients with spinal cord injuries. According to Professor Auke Ijspeert, *Ecole Polytechnique Fédérale de Lausann* (EPFL), the robot, in their study, has served as a useful tool for neurobiology. The robot has been used to show that our model actually reflects reality. The robot was very useful to validate that our model could effectively modulate speed, direction and gait — aspects that need a mechanical “body” to be properly evaluated — and also to

verify that the generated movements are close to those of a real salamander.

Ijspeert asserts that salamander robot developed by them vividly demonstrates that biology offers unique ideas for robotics design. According to him nature found a nice way of making a sophisticated circuit in the spinal cord and then controlling the muscles from there. It's a fantastic solution for coordinating multiple degrees of freedom in a simple distributed way. Robots that could change their speed, direction, and gait based on simple remote signals, like living organisms, would be extremely useful in search and rescue operations, for example.

(Source: *Science Daily*)

Researchers Learn What Sparks Plant Growth

Questions like 'how organisms decide when to grow and when to stop growing', often intrigue scientists and common man alike. A team of researchers at Howard Hughes Medical Institute have claimed to have discovered the secret long held by plants. The new discovery, which builds on more than a decade of painstaking surveillance of cellular communication between different types of plant tissues, shows clearly for the first time how plants "decide" to grow.

The research, conducted by Sigal Savaldi-Goldstein and Howard Hughes Medical Institute investigator Joanne Chory at The Salk Institute for Biological Studies, puts to rest a century-old debate over which tissue system in plants drives and restricts cell growth. According to Savaldi-Goldstein, a postdoctoral fellow

in Chory's lab, our work exposes the presence of cell-cell communication during growth, from the epidermis to the inner layers. Such a mode of communication is important for plants to maintain a coherent and coordinated growth of the shoot. Chory's research group has been interested in identifying the mechanisms by which plants alter their shape and size in response to changes in their environment. Chory studies *Arabidopsis*, a member of the mustard family that is to plant biologists what the mouse is to mammalian geneticists.

It took researchers 10 years to develop the tools to ask the question. How do organisms decide when to grow and when to stop growing? These questions are especially important in plants because they are rooted in the ground and must alter their shape and size in response to their local environment. Thus, it's a question of survival, asserts Chory. Roots and shoots are a plant's two major organ systems. For their study, scientists examined shoots and the three layers of tissues that make up the shoot system: the epidermis, which is the waxy, protective skin; the mesophyll tissue, which contains the plant's chloroplasts—cells that conduct photosynthesis; and the vascular tissue through which water and nutrients are transported.

During the last decade, Chory has made a number of significant discoveries involving a key family of plant hormones called brassinosteroids, as well as the receptors for the hormones and the genetic factors that regulate production and uptake of the hormone in the different layers of plant tissues.

According to Chory, brassinolide is a potent growth hormone involved in the plant's response to light. Such responses, which include adjusting plant growth to reach light or strengthening stems to support leaves, are central to plant survival. Brassinosteroid biosynthesis has become a critically important area of plant biology research with significant implications for commercial agriculture. According to Chory it has long been debated whether one of these tissue layers control plant growth or if all three layers have to work together. However, their finding shows very clearly that the epidermis is in control—in both driving and restricting growth. In addition, their studies show that the cells in the epidermis “talk” to the cells in the inner layers, communicating that they too should expand.

Savaldi-Goldstein made the discovery that the signal for growth originates in the epidermis by experimenting with dwarf Arabidopsis plants and the expression of brassinosteroids in the outer and inner layers of the shoot. When brassinosteroid hormone was expressed and taken up by receptors in the epidermis, dwarf plants grew to their full size. Savaldi-Goldstein and Chory also found that when a gene is expressed in the epidermis that inactivates brassinosteroid, the plant restricts growth. Thus, cell signalling began in the epidermis and followed into the inner layers of tissue, directing those cells to grow or to restrict growth. The outer epidermis, which helps plants retain water and regulate the exchange of gases, clearly plays the role of environmental sentinel, communicating

to plant tissues when conditions are right to seize the day for growth or hold back under less opportune conditions. More study is needed to determine all of the cues that spark the intimate dialogue between the cells of the epidermis and the inner cells of the shoot.

According to Chory, their study reveals that the major target tissue in the shoot for steroid hormones is the epidermis. The results also show that these hormones act locally. When similar studies are done for other plant hormones and in other organs, such as the root, then only the researchers would know the major sites of action of each plant hormone and perhaps be able to make models to predict how they work together to give rise to the tremendous diversity of shape and form found in the flowering plants.

(Source: *News release issued by Howard Hughes Medical Institute*)

Physicists Develop A Test For String Theory

One of the major criticisms against string theory has been that it does not make predictions by which it can be tested. A team of researchers at Carnegie Mellon University; the University of California, San Diego; and the University of Texas at Austin have now claimed to have developed a test of string theory. Their test involves measurements of how elusive high-energy particles scatter during particle collisions. Most physicists believe that collisions will be observable at the Large Hadron Collider (LHC), which is likely to be available towards the end of 2007 at the European

Laboratory for Particle Physics, commonly known as CERN.

According to Ira Rothstein, professor of physics at Carnegie Mellon and a member of the research team their work shows that, in principle, string theory can be tested in a nontrivial way. The other members of the team have been Jacques Distler, professor of physics at the University of Texas at Austin; Benjamin Grinstein, professor of physics at the University of California, San Diego; and Rafael Porto, a graduate student at Carnegie Mellon. The development of their test has been based on studies of how strongly W bosons scatter in high-energy particle collisions generated within a particle accelerator. W bosons are special because they carry a property called the weak force, which provides a fundamental way for particles to interact with one another.

Investigations on the scattering of W bosons, which has not been possible with other particle accelerators, would begin once the LHC facility becomes available sometimes later this year. Because the new test follows from a measurement of W boson scattering, it could eventually be performed at the LHC. According to Grinstein, the beauty of their test is the simplicity of its assumptions. The canonical forms of string theory include three mathematical assumptions — Lorentz invariance (the laws of physics are the same for all uniformly moving observers), analyticity (a smoothness criteria for the scattering of high-energy particles after a collision) and unitarity (all probabilities always add up to one). The test sets bounds on these assumptions.

Grinstein opined that if the test does not find what the theory predicts about W boson scattering, then it would be evidence that one of string theory's key mathematical assumptions is violated. In other words, string theory — as articulated in its current form — would be proven impossible. However, even if the bounds are satisfied, we would still not know that string theory is correct, according to Distler. But if the bounds are violated, we would know that string theory, as it is currently understood, could not be correct. At the very least, the theory would have to be reshaped in a highly nontrivial way.

It may be recalled that string theory attempts to unify nature's four fundamental forces — gravity, electromagnetism, and the strong and weak forces — by positing that everything at the most basic level consists of strands of energy that vibrate at various rates and in multiple, undiscovered dimensions. These "strings" produce all known forces and particles in the universe, thus reconciling Einstein's theory of general relativity (the large) with quantum mechanics (the small).

Proponents say that string theory is elegant and beautiful. Dissenters argue that it does not make predictions that can be tested experimentally, so the theory cannot be proven or falsified. And no particle accelerator yet exists that can attain the high energies needed to detect strings. Because of this technical limitation, tests of string theory have remained elusive until now.

(Source: Based on News release issued by Carnegie Mellon University)

**Controlling Ammonia Emissions
Could Reduce Harmful Atmospheric
Particles**

Concentration of tiny particles in atmospheric air can cause severe asthma in children, and lung cancer and heart attacks in some adults. One of the primary sources of such emissions is the cattle feed and the ammonia released during handling of animal refuse. A team of researchers believe that reducing barnyard emissions could be one way to help reduce the harmful effects of atmospheric particles. According to Peter J. Adams, an associate professor of civil and environmental engineering at Carnegie Mellon University, improved control of ammonia emissions from farm barnyards is more economical and efficient than trying to control the effects of sulphur dioxide and nitrogen oxide pollution from some industrial plants.

Carnegie Mellon research shows that in most farms, handling of animal manure is a major source of ammonia being released both to air and water. The study conducted by Adams shows that increased control of livestock feed, efficient use of nitrogen on farms, low-emission fertilizers and other improvements to manure handling on farms are cost-effective ways to reduce ammonia emissions and airborne particles. The research also reports that the potential savings from controlling ammonia manure emissions from farms is \$8,000 per ton in the winter, a cheaper and overlooked strategy for reducing airborne particle levels compared to controlling dangerous industrial

pollutants like sulphur dioxide and nitrogen oxides. In New York state, each 500-megawatt, gas-burning turbine produces as much as 61 tons per year of pollutants, such as sulphur dioxide and other dangerous airborne particulates, with remediation costs well into the millions, researchers said. Essentially, people can smell ammonia in concentrations over five parts per million (ppm). And it starts to burn the eyes at 20 ppm.

According to Adams while one can only smell the high ammonia concentrations on or near a farm, the more serious health threat occurs further away as a complex set of chemical reactions occur in the atmosphere that convert ammonia into microscopic, airborne particles of ammonium nitrate. Better farming practices could decrease ammonia emissions from farms and potentially save farmers money, asserts Adams.

In addition to monitoring ammonia emission on farms, Adams indicated that in urban areas vehicles equipped with catalytic converters emit significant amounts of ammonia as part of a trade-off in which nitrogen oxide pollution is reduced. While ammonia emissions from catalytic converters are potentially reducible, further research is needed to determine whether catalytic converters can effectively reduce both ammonia and nitrogen oxide pollution, according to researchers.

(Source: *Based on a news release issued by Carnegie Mellon University*)

Controlling Water Pollution By Isolating Urine

Although urine makes up only 1% of the total volume of wastewater, it accounts for 50–80% of the nutrient content. Nutrients have to be removed by resource-intensive processes at wastewater treatment plants. In the absence of these processes, nutrient discharges pose a risk of eutrophication – threatening in particular coastal waters and fish stocks. Many problematic substances, such as residues of medicines or endocrine disrupters, also enter wastewater via urine and may subsequently be released into the environment.

The Swiss Federal Institute of Aquatic Science and Technology (EAWAG) has now shown that separate collection and treatment of urine could make significant contributions to water pollution control and nutrient recycling worldwide. The “NoMix” technology thus represents a major opportunity for urban water management.

Novaquatis tested various methods of processing urine. Ideally, treatment should permit recycling of nutrients as fertilizers and, at the same time, removal of problematic micropollutants. For example, 98% of the phosphorus in urine can be recovered by precipitation with magnesium. The product – struvite – is an attractive fertilizer, free of pharmaceuticals and hormones. In Switzerland, nutrients from human urine could serve as substitutes for at least 37% of the nitrogen and 20% of the phosphorus demand that is currently met by imported artificial fertilizers.

(Source: *Based on news release by EAWAG*)

Green Comet

There’s a new comet visible in the southern hemisphere. The Comet has been named Lovejoy (C/2007 E2). It has been discovered on March 15, 2007 by an amateur astronomer Terry Lovejoy of Australia. Most surprising part of the discovery is the observation tool used by Terry Lovejoy. Believe it or not the observations leading to discovery of the comet were made not with a telescope but only an off-the-shelf digital camera. The green comet is too dim to be seen with the naked eye, but it is a nice target for backyard telescopes. After five days of monitoring, the comet’s orbit is now known with some accuracy and it is possible to make predictions about Comet Lovejoy’s future movements and brightness.

(Source: *NASA Science News*)

Two Poles of Sun – Poles Apart

Scientists who have been analysing data from the ESA-NASA Ulysses spacecraft have arrived at a surprising conclusion that one pole of the sun is cooler than the other. It may be recalled that uniquely-tilted orbit of Ulysses makes it the only spaceship capable of flying over the sun’s poles. Its ability to study the sun’s unexplored Polar Regions is considered to be a great asset by solar physicists.

According to George Gloeckler of the University of Maryland and a member of Ulysses science team, the spacecraft’s first polar flybys in 1994 and 1995 revealed the asymmetry in temperature at the two poles of the sun. The measurements by the spacecraft have

revealed a 7 to 8 per cent difference in temperature of the two poles. The measurement was both mysterious and a little hard to believe for the scientists. Since then they have been wondering as to what would make the sun lopsided in this way? There's still no definitive answer to that question, but now at least researchers know the effect is real. Observations made during Ulysses' recent visit to the sun's South Pole (in 2007) have shown that the average temperature there is virtually identical to what was observed nearly 12 years ago.

Gloeckler explained that taking the sun's temperature is tricky business because the spacecraft can not descend to the surface of the sun to measure temperature with a thermometer. Therefore, Ulysses analyses the samples of the solar wind at a safe distance of 300 million km. The researchers measure the abundance of two oxygen ions found in the solar wind. The ratio O^{6+}/O^{7+} tells us the temperature of the gas, according to Gloeckler who is the principal investigator of the instrument onboard Ulysses that facilitates this measurement and is called, the Solar Wind Ion Composition Spectrometer or "SWICS." According to SWICS, the average temperature of the sun's polar wind is about one million degrees C. But over one pole the wind is about 80,000 degrees cooler than over the other pole.

Researchers believe the solar wind at Ulysses is telling them something about polar conditions close to the surface of the sun. According to Arik Posner, Ulysses Program Scientist at

NASA headquarters, the solar wind comes from the poles. The sun's magnetic field opens up over the poles and allows some of the sun's atmosphere to escape. These openings are called "coronal holes," and the hot atmosphere that rushes out is the solar wind.

The basic question that remains to be answered is that 'What does the temperature difference mean?' Perhaps the structure of the sun's atmosphere over the two poles is different, speculates Posner. We have an analogy here on Earth. The stratosphere over the South Pole is colder, on average, than the stratosphere over the North Pole. The reason has to do with the uneven distribution of land on Earth (most land is in the north) plus complex atmospheric circulation patterns. In the case of the sun, the difference is not land but magnetism. Apparently, something about the sun's north magnetic pole keeps the solar atmosphere above it a trifle cooler. Proof: The "cool spot" follows the north magnetic pole when the sun's poles flip.

Posner points out to an interesting development. The sun's magnetic poles have reversed polarity since the 1994 flyby—an effect of the 11-year sunspot cycle. Lo and behold, "the temperature asymmetry has also reversed. So it appears to be a magnetic phenomenon."

When Ulysses finishes its current South Pole flyby, it will proceed to the other end of the sun for a North Pole flyby in early 2008. This will provide more clues to what's shaping up to be a very cool solar mystery.

(Source: *NASA Science News*)

Mysteries of Rain and Snow

People have lived with rain and snow for millennia, and scientists have studied weather for more than a century. Majority of us usually believe that, after all that time, the phenomena involved with precipitation have been understood quite precisely. If you belong to this school of thought then you'd be wrong. It's amazing how much we don't know about global patterns of rain and snow opines Walt Petersen, an atmospheric scientist with the National Space Science and Technology Center (NSSTC) and the University of Alabama (UAH) in Huntsville. For instance, how much snow falls worldwide each day—and where? How much water falls to Earth in the form of light, drizzly rain? These are just a few of the outstanding questions, according to him. Answering them would fill significant gaps in our understanding of the Earth's climate system. What to do? The best way to study global precipitation is from space.

This perhaps explains as to why NASA has accepted to finance as many as 59 research proposals under its ongoing Precipitation Measurement Mission. The studies will look at ways to improve measurements of rain and snow from Earth orbit. Petersen is among the winners, and one of the things he'll be studying is snow: According Petersen, snow is a huge problem. It turns out that estimating snowfall is very hard to do with radar. Rain is easier because it always consists of simple liquid-filled droplets. Radar echoes from rain clouds can be converted into rates of rainfall with fairly good precision. A radar

onboard NASA's Tropical Rainfall Measurement Mission (TRMM) satellite, for instance, measures monthly rainfall within an accuracy of about 10%.

But frozen precipitation such as snow is much more variable. Famously, no two snowflakes are alike. The differing sizes, shapes, and densities of individual flakes mean they won't all fall at the same speed, complicating efforts to estimate rates of snowfall. Also, snowflakes have lots of crazy angles and planar "surfaces," which can make tricky radar echoes. The problem does not end there because ice and snow have variable dielectric behaviour depending on how much ice and how much air is contained in the particle. It may be recalled that the dielectric constant of a substance tells how strongly the substance will interact with a radar wave. With raindrops, one is dealing primarily with water, which has a known and fixed dielectric constant. With snow, on the other hand we know the dielectric constant for pure ice and we know the dielectric constant for air, but, the amounts of air and ice can vary quite a bit from snowflake to snowflake, explains Petersen. Further, snowflakes also rime and melt. This means snow flakes can also have water on the surface—giving yet another dimension to complications.

It is for these reasons that our estimates of global snowfall are very uncertain, according to Petersen. This applies to both ground- and space-based radars. Only in areas where snow depth is routinely measured via "stick-in-the-ground" methods do scientists have good estimates for the amount of water that falls as snow. The problem in his opinion

is that there are relatively few of these measurement sites compared to the large area that needs to be measured.

Snow plays a big role in climate. When water evaporates, it carries away a lot of heat (which is why sweat cools down your skin as it evaporates). Later, when that moisture condenses inside clouds to form snowflakes, it releases this stored heat, warming the air. As more snow crystallises, more heat is released, which in turn makes wind. When the snow falls, it takes water out of the atmosphere, leaving it drier. Snow on the ground also reflects sunlight back into space, which helps cool the planet. So learning to portray global snowfall correctly in computer climate simulations is critical for accurately predicting how the real climate will behave in the future. It is contemplated that many of the newly funded studies will develop ways to estimate snowfall rates from radar data.

The timing for funding such a large number of studies seems to be most appropriate because NASA plans to launch a new radar, in 2013, onboard the Global Precipitation Mission satellite (GPM). GPM will extend TRMM's

observations by looking at precipitation beyond the tropics for the first time, orbiting at an angle that will bring it almost to the Arctic Circle (65 degrees latitude). At these higher latitudes, GPM will encounter lots of snow. Along with snow, GPM will be able to detect lighter rainfall than TRMM can. If less than about 1 millimetre of rain falls per hour, it is invisible to TRMM. That's rarely an issue in the tropics, but at higher latitudes, light, drizzly rain is common. Although it's light, this rain can last for days, moving large amounts of water and releasing lots of heat into the atmosphere.

In industrialised nations with extensive rain-gauge networks, this light rainfall is well documented. But in much of the world, light rain goes unrecorded, leaving a large gap in our knowledge of global water cycles. GPM will be able to sense rain down to about 2/10 mm per hour. Heavy rain, drizzle, snow—"it's all water," asserts Petersen. We have got to keep track of it in every form to truly understand the climate of Earth.

(Source: *NASA Science News*)
(Compiled and Edited by R.Joshi)

Book Reviews

Chemical Elements in the New Age

AUTHOR: D.V. JAHAGIRDAR

PUBLISHER: National Book Trust,
A-5, Green Park, New Delhi 110 016

Pages 66, **Price** Rs. 35.00

The objects and the materials we see around us are made up of a handful of building blocks called elements. Now, we know of about 90-odd naturally occurring elements ranging from hydrogen to uranium. However, in ancient and medieval philosophy, the elements were thought to be in the form of four simple substances, viz. earth, fire, air and water. The material bodies were supposed to be made of these substances. The word 'element' was first used in its modern sense by Robert Boyle and it was clearly defined by Lavoisier in 1789 as 'the simplest form of matter'.

The book under review provides interesting reading material on some lesser known aspects of chemical elements of the New Age. Running through six chapters, the first chapter 'The World of Elements' after bringing home the concept of elements discusses their origin in the universe. The second chapter 'Elements Atom by Atom' provides an insight into the atomic structure and the Periodic Table. The remaining chapters of the book discuss respectively the common elements, rare elements, radioactive elements and man-made elements. Common elements

discussed in chapter 3 include hydrogen, helium, lithium, beryllium, boron, carbon, nitrogen, oxygen, fluorine, aluminium, copper, silver and gold, and silicon. Common as well as technological applications of these elements are highlighted. Description about some 'rare' elements like titanium, vanadium, gallium, germanium, zirconium etc. along with their varied applications appears in chapter 4.

Radioactive elements like polonium, francium, radium, uranium etc. and their uses form the subject matter of chapter 5. It is interesting to note that an isotope of polonium is used as a source of heat for generation of thermoelectric power in satellites. The radioactive element rancium has the unique property that it accumulates in cancerous tissues in the initial stage of malignancy. Therefore, early diagnosis of cancer can be made from the presence of francium. Radium is used chiefly as a source of radiation in medical treatment of cancers and in the industry for radiography. Uranium is today widely used as a fuel in nuclear reactors for generating electricity. It is also used in smaller reactors to produce radioisotopes which are used in medicine, agriculture and industry. Elements beyond uranium are called transuranic elements. An account of the discovery of such elements appears in the last chapter 'Man-made Elements'.

The book under review meant both for the layman and the scientist has been written in simple language and lucid style. Coloured illustrations and plates included in the book further

enhance its utility. However, there is a serious mistake in the book on page 14 where it is stated that 'An atom is extremely small and cannot be seen even under a very powerful microscope'. Also, the nomenclature of elements (approved by IUPAC, 1977) given on page 66 needs updating as specific names have since been given to various transuranic elements with atomic number greater than 103. These changes/corrections

are expected to be carried out in the future editions of the book.

Nonetheless, the book on the whole is useful and must find place in the shelves of all school and college libraries.

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Priority Areas of Research under ERIC. NCERT

Educational Research and Innovations Committee (ERIC) of NCERT has identified the following priority areas of research. Research proposals related to these areas will receive priority for providing financial support by the ERIC in coming years.

Curricular Areas

In the backdrop of *National Curriculum Framework* (NCF–2005) it is important that each curricular area is revisited by the researchers and probed in depth to find answers to problems related to teaching-learning of different subjects. In this context the status and role of arts, crafts and aesthetics; health, yoga and physical education; work education and peace education also need to be examined. The linguistic diversity of India poses complex challenges but also a range of opportunities. Language teaching needs to be multilingual not only in terms of the number of languages offered to children but also in terms of evolving strategies that would use the multilingual classroom as a resource. Issues related to language as medium of instruction and multilingualism, therefore, assume significance. Research proposals will also be welcome in the area of comparative studies on concerns related to school education.

National Concerns

One of the foremost concerns is ensuring enrolment and retention of all children in the school. Commitment to Universal Elementary Education presupposes representation of cultural diversity, ensuring enrolment of children from different social and economic backgrounds with variations in physical, psychological and intellectual characteristics in the education process. In this context, disadvantages in education arising due to inequalities of gender, caste, language, culture, religion or disabilities need to be addressed. Research related to education of the disadvantaged groups, inclusive education, gender equity, education of rural children and functioning of rural schools becomes significant in this background. Vocational education and environment education are two emerging concerns that require attention from sociological, psychological, economic and

pedagogical point of view. Some other concerns in this context like psycho-social development of children, education for life skills, and education policies and practices related to school education will also receive priority.

Systemic Concerns

The curricular vision presented in NCF–2005 needs to be supported and sustained by systemic reforms. Important among these are the system' for preparing teachers - both pre-service' and in-service, system of producing textbooks and learning materials and the examination system. Integration of ICT in education as a pedagogic, administrative and monitoring tool and the related practices require extensive research for maximum efficiency within the boundaries of democracy, human dignity and freedom. Classroom processes and practices and management strategies are other useful areas of research in this context.

Pedagogic Practices and Learning Processes

Our current concern in curriculum development and reform is to make it an inclusive and meaningful experience for children. This requires a fundamental change in how we think of learners and the process of learning. Within the ambit of child centred pedagogy, research in areas like thinking and learning processes of children, pedagogic approaches of training teachers, text-analysis and text-learning dynamics becomes crucial.

Any other area as per *National Curriculum Framework–2005 (NCF–2005)* not covered above.

Research proposals may be submitted in prescribed format. The format and necessary guidelines can be downloaded from NCERT website (www.ncert.nic.in) or can be obtained by post from the address given below:

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