Effectiveness of Indian Science Centres as Learning Environments

A study of educational objectives in the design of museum experiences

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ABSTRACT

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This study intends to evaluate Indian science centres and focuses on factors which characterise them as effective educational environments. In order to explore the science centre setting, this study follows the approach of methodological appropriateness - that is, employing both quantitative and qualitative research methods according to the purpose and necessity.

Due to the phenomenal importance of the early years in our lives, this study focuses on schools students and out-of-school children. The study mainly addresses the question who - male versus female students and junior versus senior students - really benefit out of a science centre visit and what happens to their impact in the longer term.

This study intends to measure the impact of a visit to the National Science Centre, Delhi on students' affective domain: three parameters - namely, attitudes to science, attitudes to science centres, and continuing motivation in science - have been chosen for their potential significance in the educational arena. Data - through pre-visit, post-visit (within three days of the visit) and later-visit (about six month after the visit) questionnaires - has been collected in the Summer of 1994. The data has been analysed using parametric statistical tests - mainly the tests known as the Analyses of Variance (ANOVA). The supporting and qualifying data has been gathered by unobtrusively observing 50 randomly selected students in the galleries and by interviewing teachers and students.

The findings indicate that all students gain in their short-term attitudes to science and science centres as a result of their visitation. But, the gain is found to decay in the longer term, mainly in the case of girls and junior students. In reference to the poor and the rural students, the reach of science centres is found to be extremely miserable. To ameliorate the situation, much has to be done. To this end, this study makes recommendations for a fine synthesis of people's needs and aspirations, social and cultural knowledge, the objectives of museums, and the highly effective domains of exhibit development.

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LIST OF ABBREVIATIONS

AICTE	All India Council of Technical Education
ANOVA	Analysis of Variance
BITM	Birla Industrial and Technological Museum
CABE	Central Advisory Board of Education
CSIR	Council of Scientific and Industrial Research
FYP	Five-Year Plan
GNP	Gross National Product
ICAR	Indian Council of Agricultural Research
IISTE	International Institute of Science and Technology Education
IMC	Indian Medical Council
JNNSE	Jawahar Lal Nehru National Science Education
NCERT	National Council of Educational Research & Training
NCSM	National Council of Science Museums
NCSTC	National Council of Science and Technology Communication
NFE	Non-Formal Education
NIEPA	National Institute of Educational Planning and Administration
NPE	National Policy on Education
NPERC	National Policy on Education Review Committee
RPF	Revised Policy Formulations
SCs	Scheduled Castes
SPYM	Society for the promotion of Youth and Masses
STs	Scheduled Tribes
UEE	Universal Elementary Education
UGC	University Grant Commission
UNESCO	United Nations Educational Scientific and Cultural Organisation
UNICEF	United Nations Children Education Fund
UPE	Universal Primary Education
UT	Union Territory

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Introduction

Dating back some five centuries, scientific collections have been created by philanthropic and resourceful people for a variety of purposes. While some people used their collections to show off their status in the society, others were compelled by their intellectual thirst, and still others made limited efforts to provide knowledge and skills to a few interested people or groups. In the eighteenth century, when the Industrial Revolution in England was beginning to leave little doubt as to the potential economic effect of invention, museums aimed to encourage artisans and craftsman to produce better work and industrial designs. From the late eighteenth, but particularly in the second half of the nineteenth century, museums underwent a process of democratisation and demonstrated a concern for a broader section of society. The period also saw the rise of 'serious education' as one of the functions of museums, along with collection, preservation and research (Dawkins, 1877; Goode 1895). The potential of museums in providing education, specially school education, was realised during First World War when many schools were used for war purposes (Kavanagh, 1994: 82-90).

During Second World War and immediately afterwards, governments from all over the world mobilised their scientific and technological resources around great technical problems. It was the time when the 'spectacular achievement of wartime research and development encouraged the belief that conscious application of Manhattan Project (code name for the development of the atom bomb in the USA in World War II, to which a team of scientists, including physicists Enrico Fermi and J. Robert Oppenheimer, contributed) methods to problems of poverty, health, housing, education, transportation and communication might eliminate material want' (McDougall, 1985: 6). In order to develop a suitable workforce, an ever increasing emphasis was placed on the betterment of scientific and technical education. Science museums throughout the world were perceived as potential learning environments by both governments and the public. As a result, the number of science museums worldwide, notably in the United States, exploded during the past thirty years.

Responding to the need for more extensive work with children directly and through schools, some of the science museums followed a radically different approach with regard to their contents (natural phenomena, technological innovations and scientific processes) and the activities relating to them. These museums preferred to be known as science centres. The cardinal feature of science centres was to present their contents in ways that prompt visitors to interact with them, to raise questions and construct their own knowledge and understanding of scientific issues.

Today, instead of enjoying privilege of being neutral, a widely recognised myth till recently, science and technology itself is under the microscope. Paradoxically, we defend the citadel of science and, at the same time, we are sceptical. In other words, we have now begun to understand that social problems are much more complex than the technological world. Along with the developmental context, science and technology is being linked with the user as well as environmental and cultural contexts. Indeed, we have a challenge ahead to transform society in order to make technology equitable and simultaneously to transform technology in order to make society equitable. In order to meet this challenge, science centres are increasingly broadening their educational role.

Teaching, learning and understanding can be seen as an all-pervasive phenomenon in science centres. The approach in science centres is keyed to the idea that learning is an active enterprise. Science centres aim to provide opportunity for individual taste, ingenuity and innovation, in contrast to the traditional scheme of science museum experience which held the individual tightly within a given order, subordinate to its structure and patterns.

Science centres: a place for learning, teaching or otherwise

Modern science centres are said to be multi-functional. In recent articles, it is argued that science centres function as a teacher, as an information centre, as a community centre and as structured learning environments. They have been founded to play a specific role in society and to fulfil certain objectives. All science centres have statements of mission which put down in writing these objectives.

> The mission of the Lawrence Hall of Science (LHS), at the University of California at Berkeley, is to develop model programs for teaching and learning science and mathematics, and to disseminate these to an ever increasing audience (The Lawrence Hall of Science, Annual Report, 1992-93: 1).

Unequivocally, the statement of mission of almost all individual science centres emphasises the educational role of science centres. It implies that science centres intend to teach and they expect visitors to learn in their purpose-built environments. But according to constructivist theory, there is no necessary connection between teaching and learning.

> The more we construct a situation that allows and encourages learning, the more likely we are to construct something that is open, ambiguous and able to be manipulated in a variety of ways by the learner; thus, less likely we are to be able to predict precisely what has been learnt (Hein, 1995).

The possibilities of learning and teaching in science centres are far-reaching. But, the science centre approach and practices in science centres are not beyond criticism. David W. Champagne (1975), an educationist from Pennsylvania, says about the Ontario Science Centre that it fails on three counts: first, it obscures what science is and creates false impressions among children and adults; second, some demonstrations present sloppy science; and third, it presents a progressive view of science and so fails to point to the ethical dimension which is linked with almost our every scientific and technological decision. Some educators mainly perceive science centres as a playground where children remain busy in perhaps useless activities.

> You could easily agree once you have spent time in the Sydney Powerhouse's 'Information Machine', or the Canberra Questacon's 'Force', where children jump energetically but mindlessly from button to key board to joystick, unaware of the topic, instructions or explanations offered in labels or by guides (Young, 1991-92).

They believe that when education and entertainment are brought together under the same roof, education will be the loser (Shortland, 1987). What is even worse is that some people designate science centres as the 'sleeping giants of science education' because, in their view, science centres are depriving students of intellectual opportunities. 'When I was young, I visited the American Museum of Natural History and gazed at skeletons of *Apatosaurus* and *Tyrannosaurus*. In my mind's eye, I put flesh and skin on their bones and saw them moving across the landscape. I was doing science,' tells Professor Arnold Grobman of his science museum experiences. But, for today's science centres he has different views.

> Today's students are not being given that opportunity. When observing the dinosaur models, complete with colour patterns, vocalizations, and movement, they simply are observing the conclusions of others. Accuracy of reconstruction is not the problem. Rather, while passively watching these models, students are being deprived of an intellectual challenge and an opportunity to use their imaginations (Grobman, 1992).

The problem

It is quite obvious from the above discussion that "learning in museums" has been becoming a growing fascination, or concern, for academicians and museum professionals alike. Now-a-days, it has become almost impossible to attend a conference, or to go through a recent issue of any of the museum journals, without a mention of the word "learning." For some, learning is a conspiracy (Champagne, 1975; Shortland, 1987) while for most, a faith and practice (Kahle, 1990; Gardner, 1991; Woolnough, 1994). In spite of the existing voluminous research and all sincere efforts, it is truly difficult to find specific answers to questions about learning or knowing in museums. For example, it is not yet possible to be scientific in assessments of the impact of a museum visit. There are far more assumptions, theories, and anecdotal evidence than statistically significant data. It is usually admitted that visitors after a museum visit are not the same as they were before the visit. However, how much they have changed and in what domains of human development is hardly a matter of consensus and thus presents itself as an area where further research is needed.

The above discussion sets out the problem for the present study. Basically, it cautions us that the science centres should not be hailed on the face value. The effectiveness of a classroom can be measured on the basis of examination results. But, there is no 'performance standards' involved in the museum visit. Today, it does not appeal to say that 'something' happens to a visitor after the visit, but we have limitations in defining it what this is and then, obviously, measuring it. This type of vague answers are no longer acceptable to educators and museum professionals and now everybody wants to hear a more succinct reply. In the present work, I aim to answer this question as precisely as is possible.

The typical visitor is heterogeneous in terms of age, knowledge, background, interests, and reasons for being in the science centre. With these many and diverse variables, we face great difficulty in defining what actually is happening to individuals or groups.

These many involved variables, reinforced with our aim to be precise in our conclusion, force us to reduce as many variables as possible, or in other words, to concentrate on any one group. Hence, in the present work, I will concentrate on early age - that is school students and out-of-school children. My purpose of considering school students is to ensure whether they really get some benefits as a result of their science centre visit, and if yes, then I will be concerned how these benefits can be extended to out-of-school children.

Why bother about early age ?

The early years of our life are of great importance. In the present scientific age, each nation's future depends on its youngsters' attitudes, motives, skills and knowledge. The concern in this reference is evident from a series of commission reports, including *A Nation at Risk* (National Commission on Excellence in Education, 1983), *The Public Understanding of Science* (The Royal Society, 1985) and *Turning Points: Preparing American Youth for the 21st Century* (Carnegie Council on Adolescent Development, 1989). The Royal Society's report on the public understanding of science speaks for many countries in its acknowledgement that the process of building long-term positive attitudes to science and technology has to start with young people. There can also be seen convincing evidence that attitudes and experiences that are established at an early age have a substantial impact on our interest, skills and achievements in the future.

Bryan Appleyard, a noted journalist and writer, was born in a family of scientists and passed his early years in the shadow of science. In his childhood, he realised the power of science and, at times, became dumbstruck with it. Surprisingly, in his adolescence, he rebelled and decided not to follow in the pre-ordained footsteps. He insisted on the superior virtues of unscientific creativity. But later, when he found unscientific ventures as groundless, insubstantial and hopelessly trivial, he began to turn back to science.

> Perhaps I was simply recapturing my childhood. Certainly I was capturing old habits, for now I began to acquire a facility with the concepts of science and to use them to humble my artistic coevals (Appleyard, 1992: xii).

In this context, the personal account of Albert Szent-Gyorgyi, a secret diplomat who turned to a versatile scientist and subsequently received the Nobel award for his scientific contributions, is also vivid and enlightening. On his mother's side, he was the fourth generation of scientists. In his home, there was no place for political and financial thoughts and the conversations were mainly concerned with the intellectual achievements of the entire world. He strongly believed that he was a scientist because of his early childhood experiences.

> I strongly believe that we establish the co-ordinates of our evaluation at a very early age. What we do later depends on this scale of values which mostly cannot be changed later (Szent-Gyorgyi, 1963).

In terms of human development also, brain growth occurs very much earlier than general body growth, achieving some 95 per cent of mature size by the age of six years (Gregory, 1987: 316). In the early years, one is also found to be capable of learning the principles of the experimental method, observing, classifying, and proposing generalisation from evidence. Gilberete Pascal, Blaise Pascal's elder sister, tells about her brother's insatiable curiosity by the following event which occurred when he was about eleven-year-old:

> One day when the Pascal family were at table, someone accidentally struck a faience plate with a knife. He noticed that it made a big noise, but that stopped immediately when one put one's hand on the plate. He wanted to know the cause, and began experimenting with other forms of sound (Colemen, 1986: 30).

Few would quarrel with the premiss that most children have devouring eagerness to make a sense of their surroundings. Jean Piaget proposed a theory of development in which individuals progress through a series of invariant stages: reflexive, sensory-motor, pre-operational, concrete and formal. The concrete (8 to 12 years) and formal (12 years and above) stages are of most interest to educators because they span school years and are considered as predictors of our future abilities. But most recent Piagetian research finds that they often do not reach formal operations as early as 12 years. In his review of research on formal reasoning, Lawson (1985) concluded that teaching using extensive exploration of materials, however, can significantly enhance formal and scientific thinking. Keeping all these diverse factors and evidence in mind, it has been decided in this study to focus on secondary and senior secondary school students (13 to 17 year olds).

What to measure

Interest in research on science centre effectiveness amongst policy-makers and practitioners can hardly have been higher. The researchers want to make both substantiative and methodological contributions to the identification of 'good practices' and to the development of frameworks for research and evaluation.

Learning in science centres is self-directed, as it is characterised by flexibility in the use of time, contents and styles of learning. It means the joy of discovering how something really works, the delight of understanding something that was declared almost incomprehensible before, and the fun of creating something alone or with other people. Learning in science centres can equip visitors with new skills, motives, feelings and values that might never be lost.

In a science centre environment, a variety of learning is possible, such as cognitive, affective, psycho-motor, perceptual and social learning. It is commonly believed that each type of learning other than the cognitive one is less certain. But, as the typical visitor spends around two hours in the galleries, we should not expect much "cognitive learning" to occur in this small duration. On their way home, or within a week or two, they may forget most of the facts they noticed in the gallery. At the same time, it is also a fair comment that in respect to understanding of affective learning we have yet to experience anything like the revolution which occurred in the cognitive science in the early 1970s. Nevertheless, in the context of informal education, the role of affect in learning is increasingly being appreciated in recent years.

> The role of affect in learning should be of particular interest to museum professionals since the nature of our medium is profoundly affective. It is the nature of our institutions - multisensory, three-dimensional, interactive - that they should appeal so strongly to that part of the brain [which is] concerned with space, image, affect (Roberts, 1990).

There seems to be consensus among the museum professionals and science educators that the objectives of many exhibits are more to encourage students to participate, to change their naive conceptions, opinions and attitudes than to multiply facts in their minds. In science centres, their concern is to give students "something" of permanent value. They are far more concerned with influencing how students are able to perform in long terms.

> The goal is to stimulate the innate desire to learn, to expand one's horizons. Learning in museums is a spontaneous, individualized process; it cannot be imposed on the visitor. When museum education emphasizes teaching and verbal communication, it does disservice to the museum as a learning environment (Commission on Museums for a New Century, 1984: 59).

From the above discussion, it is clear that the main contribution of science centre education is suggested to occur in the affective domain. Hence, in this work, I shall mainly focus on the affective aspect of learning.

Outline of chapters

The thesis is comprised of 12 chapters. By giving introduction and conclusion in individual chapters, it has been attempted to make each chapter a complete unit in itself, and yet an integral part of the whole. In this attempt, there are situations in which similar matter has to be mentioned in more than one place, particularly in reference to participants and data collection procedures.

Chapter 1 is conceived with a view to give a comprehensive picture of the Indian education system. It discusses the strengths and weaknesses of the education system, the status of science in society and in education, and the need of non-formal education in society.

In Chapter 2, the origin and development of science museum movement in India, its organisation, administrative set up and its exhibition policy are outlined. In the discussion, personal biases and institutional and national loyalty have been taken care of as much as possible.

The next chapter focuses on primary educational objectives of Indian science centres and in what these objectives are different or similar to objectives of other renowned science centres, particularly in the developed world. The chapter opens with a discussion on the interaction of science, society and the role of media. It analyses the features that make science centres unique learning environments. The chapter deals with various possibilities of assessing the effectiveness and identifies three research parameters (attitudes toward science, attitudes toward science centre, and continuing motivation in science) for this purpose.

Insight into human behaviour and development comes from many sources. Social scientists study human behaviour from a variety of cultural, political, economic, and psychological perspectives, using both qualitative and quantitative approaches. The overall format in Chapter 4 is to present the basic approach, procedures and ethical issues involved in quantitative and qualitative research methods, with a view to identify a methodology or format for the present study.

The next seven chapters, that is from Chapter 5 to Chapter 11, form the experimental body of the research. Participant observation study (involving 50 students) is discussed in Chapter 5. Two chapters are devoted to each of our research parameters, for example Chapter 6 and Chapter 7 to "Attitudes toward Science". The preceding chapters (Chapter 6, Chapter 8 and Chapter 10) in each case are concerned with the literature review, concept description and measuring tool (scale) development. The developed scale in each case is employed for data collection and further statistical analysis in the following chapters (that is, in Chapter 7, Chapter 9 and Chapter 11).

The final chapter compiles all the results and findings and is concluded with recommendations for enhancing the level of science centres' utility.

Chapter 1

Science Education in the Land of Goddess *Saraswati*

A review and analysis

Introduction

India is known as one of the oldest and greatest civilisations to have existed on Earth. During its history of around 5000 years, it has seen periods of progress and decline, prosperity and downfall, colonial rule and mass risings, leading ultimately to independence and freedom. Though it is not the scope of the present chapter to discuss the rich cultural heritage of India in any detail, it seems necessary to identify distinct features of India's history which can, in turn, help us understand contemporary culture, and the economic, social and political influences on it. This is what is aimed at in this chapter. The chapter discusses the Indian education system as a whole, the status of science in society and in education, and the need of non-formal education in society. The chapter closes with a comprehensive summary which has been discussed with a purpose to paint a fairly coherent and realistic picture of the education system.

1.1 Education in India: from ancient times

Education has always been accorded a respectful place in Indian society. In fact, learning here has traditionally been embodied as a goddess, *Saraswati*. Women in ancient India are said to have been active in many spheres of life. Several women have been identified as authors of Hymns in the *Vedas*, the most sacred religious books. There were no national barriers as we now understand them. Hundreds of foreign scholars used to visit India to receive education in the ancient universities. *Nalanda University* was then considered as one of the most reputed ones in the world. The dominant feature of this ancient education system was its ever growing emphasis on human values. Its aim was to create holy souls through cultured and *dharmic* minds. The ancients in India used to say, "*Vidya dadati vinayam*"- (Education begets humility).

In ancient times, the society was functionally divided into four groups. The hierarchical functional system was consisted of *Brahmins* (who were supposed to teach and learn), *Kshatriyas* (who were supposed to rule and fight), *Vaishyas* (who were supposed to run business) and *Shudras* (who were supposed to do manual work, for example cleaning, farming, washing and so on). Metaphorically, the 'social functional system' was equated with the 'human body' in which Brahmin was the 'head'; Kshatriya was the 'shoulder'; Vasihya was the 'stomach'; and Shudra was the 'leg'. In order to run the social system efficiently, the importance of all the peoples was unquestionable. Equity was the essence of the ancient education system. Good education was coveted as both a precondition and the recognition of equality, as can be learnt from the following lines from the Bhagvat Gita.

vidy-vinaya-sampanne brahmane gavi hastini
suni caiva sav-pake ca panditah sum-darsinah ll 18 ll

(The humble sages, by virtue of true education, see with equal vision a learned and gentle brahmin, a cow, an elephant, a dog and a dog-eater)

But for all practical purposes, the functional system was gradually transformed into a hierarchical rigid caste system. Rooted in the past, as can be learnt from the poignant tales of Satyakam Jabla, Karna, Ekalavya and many others, the bias in education is very much extant in the present. Today, in India the caste system, an undemocratic institution, is more powerful than ever, and seems to have extended its sphere under the very democratic process of the constitution itself.

According to the ancient philosophy, *Dharmic* (though it is popularly understood as religious but, perhaps, there is no equivalent of *dharmic* in English) are those individuals who reach out in the search of eternal laws and are bound by justice, duty, practical morality, and sometimes even customs. In other words, a person guided by the concept of *dharma* will be incapable of adopting double standards in public and private life.

In ancient India, education was totally free of state control. Even the princes had to go to *gurukuls* (boarding schools run by learned teachers, or rishis, in the woods). This system of voluntary schools was continued until the British rule, when a totally new system of education was introduced. A teacher was the most respected person in the society, and for pupils the teacher's place was above the God, as is evident from the couplets of a famous medieval poet Kabir:

> *Guru gobind dau khare, kake lagu pai;*
> *Balihari guru apne, gobind diyo batay.*

(Both, my teacher and God, are just in front of me, to whom should I pay respect first. I pay respect to my teacher because it is he who has told me the way to approach God)

In contrast, under British rule, the system transferred power from teachers to the state. It empowered bureaucrats to decide the curriculum and lay down the rules for examinations. The old system of *pathshalas*, *gurukuls* and *maktabs* languished because the students educated there did not have avenues of employment.

There can be no disputing the fact that the immediate aims of economic and political organisations of a society largely accounts for the well-being of its members. Science is often linked with the notion of progress, but we do not necessarily find the equation so straightforward. From our own experience we can assert that science is neither a solitary activity nor an end in itself. For example, the first impact of the industrial revolution in the West was not the removal of the drudgery of work, or the making of life easier for the society at large, but profound misery of labour (men, women and children): one person in eight died in the workhouse (MacKenzic and MacKenzic, 1973 : 54). The middle class found itself threatened by a barely-literate and poverty-stricken proletariat. Similarly, the initial impact of the industrial revolution in the colonised countries was disastrous. It came about by destroying the traditional industries in the colonies, by diverting their agriculture from subsistence to cash crops production and by exploiting their human-power. The welfare of local people and their education was simply not the concern of the British administration. At the same time, Universal Primary Education (UPE) and elimination of illiteracy had been an integral part of India's struggle for freedom. As far back as 1882, Dadabhai Naoroji and Jyotiba Phule pleaded before the Indian Education Commission (popularly known as, the Hunter Commission) that steps be taken for providing primary education to all children. But from the British point of view, education for all in India was simply not the need of the hour, as it was bound to reduce the work-force. The enforced education system was, therefore, the reflection of the economic and political purposes of the ruling organisation in India.

In India, the Wood Dispatch laid the foundation of the present structure of education. Lord Thomas Macaulay (1800-59) formulated the education policy in order to develop "a class of interpreters - Indian in blood and colour, but English in tastes, opinions, morals and intellect - between the British and the millions whom they rule." (Tripathi, 1994). Until Independence, the literacy rate in India was deplorably low. According to the 1921 census, 7.16 percent of the population were literate, with the proportion of girls to boys 1 to 4 in primary schools, 1 to 18 in middle schools, and 1 to 34 in high schools (Cormack, 1961: 48). At the time of Independence in 1947, merely 14 per cent of the population were literate. Only one child out of three was enrolled in a primary school. The situation changed, though not drastically, only when a new political organisation took over the system after Independence.

1.2 Post-Independence reconstruction of education

With Independence, the very education system which was reliable and proficient earlier, was no longer so. Being a colonial vestige, it had been accused of socio-economic irrelevance. The aims of education had to change in the direction necessary to serve the changed social, economic and political goals of the country. From 1951, efforts to make primary education widespread were undertaken. Problems of educational reconstruction were reviewed by several commissions and committees, notably the University Education Commission (1948-49) and the Secondary Education Commission (1952-53). But, implementation of the recommendations of these commissions had not been uniform in all the states. While the socio-economic conditions of some states proved conducive to universalisation, others lagged behind. The low status of women, orthodoxy, inequitable distribution of land and other assets among the various castes and communities, difficulties of terrain and inhospitable climate, were their main handicaps.

India embarked on planned economic development in the 1950s when it set up a Planning Commission under the chairpersonship of the Prime Minister and introduced the concept of Five-Year Plans (FYP). Unfortunately, at least till the 1960, India remained pre-occupied with sorting out the problems of modernisation and industrialisation and did not pay much attention to the lower education. In 1961, the setting up of the National Council of Educational Research and Training (NCERT) reflected the Government's concern for education and its determination to restructure education in the country. Education was looked at, perhaps for the first time, from a wider perspective. It represented a most important input in human resource development.

Towards the end of the Third Five-Year Plan (1961-66), a need was felt to hold a comprehensive view of the educational system with a view to initiating a fresh and more determined effort at educational reconstruction. With the intention to have a comprehensive education policy fully oriented toward national development, the Government of India appointed an Education Commission (1964-66), popularly known as Kothari Commission. After reviewing the progress achieved in the first three Five-Year Plans (1951-66), the Education Commission rightly identified the lack of quality in the educational programmes in the system which was largely characterised by the quantitative expansion at all levels. The Commission recommended, among other things, a re-arrangement of priorities in education. The commission laid stress on the transformation of the content of educational programmes so as to relate it to the needs and aspirations of the people.

The recommendations of the Education Commission were discussed widely and following the general consensus that emerged, a resolution on National Policy on Education was formally issued by the Government of India in 1968. The resolution enunciated 17 principles for guiding educational development in the years ahead. In the resolution, a special emphasis was laid on the education of girls, backward classes and tribal people, and also on the development of science and technology. As a result of the 1968 Resolution, there were numerous and notable developments: for example, the acceptance of a common structure of education throughout the country and the introduction of the 10+2+3 system (British equivalent: 10 years of schooling up to GCSE + 2 years of schooling in 'A' Level + 3 years in a university for graduation: the break up of first 10 years of schooling is as; first 5 years in primary classes, then three years in middle classes, and finally 2 years in secondary classes) by most states; and the availability of schooling facilities within a radius of one kilometre for more than 90% of country's rural habitations by the 1980s.

Many ideas of 1968 Resolution - such as, universalisation of primary education, the eradication of adult illiteracy, employment oriented education, improvement in the quality of education, involvement of education in national construction, and development of science and technology in order to achieve self-reliant economic growth - were impeccable, but their implementation raised a host of questions. The authorities laid stress on resources, and more resources. In spite of the impressive growth of infrastructure (Table 1.8), the number of illiterates continued to grow (Table 1.4), and also there was no significant improvement in the situation of school drop-outs (Table 1.1). The target date of achieving universal elementary education (UEE), first eight years of schooling, was 1960, but even in the 1980s we were not in the sight of the goal. Vocational education had not really taken off. The 10+2+3 system had not been really implemented in major educationally backward states. In fact, there accumulated a huge backlog, as the task was only taken half-heartedly for decades.

In spite of the impressive quantitative expansion of education facilities and sustained efforts made for qualitative improvement of education at the elementary stage, the problems of access, participation and quality in respect of elementary education continued to persist. Since the results achieved were limited, it was easy to imply that the earlier strategies were inadequate. Furthermore, it was realised that neither a normal linear expansion of infrastructure nor the existing pace and nature of improvement could meet the needs of the situation. It was also stipulated that a major effort must be made to derive the maximum benefits from the existing assets created as a result of economic and technical developments and also to ensure that the fruits of change reach all sections. With this aim in view, the Government of India, in January 1985, announced the formulation of a new National Policy on Education (NPE) which was implemented the next year (that is, in 1986). As has been said earlier that many ideas of the 1968 Resolution on Education were impeccable, but the problem was due to the failure in a neat implementation. Largely, the new National Policy on Education (NPE-86) was formulated to create an awareness and a sense of urgency in the country.

> What may have to be 'new' is not so much policy as a determination and a concrete blueprint for implementation (Ahmed, 1986).

The National Policy on Education 1986 emphasised the removal of disparities and equalisation of educational opportunities. It called on nationwide support to programmes in educational transformation. The University Grant Commission (UGC), the Indian Council of Agriculture Research (ICAR), the All India Council of Technical Education (AICTE), and the Indian Medical Council (IMC) were specifically named as institutions which were supposed to play an important role in giving shape to the national system of education. These institutions, together with the National Council of Educational Research and Training (NCERT), the National Institute of Educational Planning and Administration (NIEPA), and the International Institute of Science and Technology Education (IISTE) were involved in implementing the education policy.

Reorienting the content and process of education constituted another aspect of the new education policy. It was stipulated that education can and must bring about the fine synthesis between change-oriented modern technologies and the continuity of the country's ancient and rich cultural traditions. On the one hand, the policy stressed the need for readjustment in the curriculum to ensure the cultivation of social and moral values, and on the other hand, it emphasised the need to eliminate obscurantism, religious fanaticism, violence, superstitions, and fatalism.

The National Policy on Education (NPE)-1986 laid an especial emphasis on the reorganisation of the content and processes of education in the direction of promoting national integration. This was intended to be done through the introduction of a national core curriculum. "National Curriculum for Elementary and Secondary Education - A Framework" was developed by the National Council of Educational Research and Training (NCERT) on the basis of national consensus and in the light of the recommendations laid by the NPE-86. In the Curriculum, a list of areas were considered essential for the whole country and for that reason accepted as core elements:

1. History of freedom struggle of India.
2. Constitutional obligations
3. National identity
4. Cultural heritage
5. Democracy, socialism, secularism
6. Equality of the sexes
7. Conservation of the environment
8. Small family norms
9. Eradication of social evils
10. Scientific temper

The core elements, it was intended, should be integrated in the content of many subjects. The goal of full adult literacy and universal primary education was to be pursued through area specific and group specific planning with people's participation. This collaborative approach was a significant departure from the earlier process of planning. Besides, the National Policy on Education (NPE)-1986 had an in-built provision for review:

> The implementation of the various parameters must be reviewed every five years. Appraisals on short intervals will also be made to ascertain the progress of implementation and trends emerging from time to time (National Policy on Education 1986: 29).

It was, therefore, legitimate for the Government to constitute a reviewing committee. The National Policy on Education Review Committee (NPERC or Acharya Rama Murty Committee), appointed on 7th May 1990, submitted its report on 26th December 1990. The Central Advisory Board of Education (CABE) constituted a sub-committee under the chairmanship of Mr N. Janardhan Reddy to consider the recommendations of the NPERC. The recommendations of both these committees have been taken into consideration while deciding priority areas in the Eighth Five-Year Plan (1992-97).

Table 1.1. Drop-out rates among school students

Class Year	V		VIII	
	Girls	**Total**	**Girls**	**Total**
1950-51	-	72.7	-	87.01
1970-71	70.9	67.0	83.4	77.9
1977-78	65.0	60.4	82.8	78.8
1987-88*	49.42	46.97	61.55	62.29

Source: *Fifth All-India Educational Survey - Selected Statistics*, National Council of Educational Research and Training, 1989 (Date of Reference: 30 September 1986)

* (Rajput, 1994)

Table 1.2. Total enrolment of children in primary, middle and secondary classes

Class Year	I - V (6 to 11year olds)		Total students	VI - VIII (11 to 14 year olds)		Total students	IX - XII (14 to 17 year olds)		Total students
	Boys %	Girls %	in millions	Boys %	Girls %	in millions	Boys %	Girls %	in millions
1950-51	71.9	28.1	19.2	83.9	16.1	3.1	86.7	14.3	1.5
1960-61	67.5	32.5	35.0	76.1	23.9	6.7	79.4	20.6	3.4
1970-71	62.6	37.4	57.0	70.7	29.3	13.3	74.2	25.1	6.6
1980-81	61.4	38.6	73.8	67.1	32.9	20.7	70.4	29.6	10.8
1990-91	58.6	41.4	99.1	62.2	37.4	33.3	77	33.0	20.9

Source: *Studies in Educational Statistics No. II*, 1993, Ministry of Human Resources Development, Government of India, p.III.

Table 1.3. Flow of students in grades 1 to 8

Grades / Year		I	II	V	VIII
1970-71	Girls	100	60.7	29.1	16.6
	Boys	100	61.27	34.13	21.59
1980-81	Girls	100	70.6	38.3	21.5
	Boys	100	66.96	44.12	28.75

Source: *Proceedings of Eleventh Conference of Commonwealth Education Ministers*, Barbados, 29 October-2 November 1990, p.104-105.

Table 1.4. State of literacy in India over the years

Year	**Literacy Rate (Percentage of total population)**			**Total Illiterates**
	Females	**Males**	**Total Persons**	**In millions**
1901	0.60	9.38	5.35	-
1951	8.86	27.16	18.33	300
1971	21.97	45.95	34.45	386
1981	29.85	56.50	43.67	430
1991	39.19	64.20	52.19	470
2000	-	-	-	500

Source: *Studies in Educational Statistics No. II*, 1993, Ministry of Human Resources Development, Government of India, p.1.

Chandran (1994)

The Revised Policy Formulations (RPF-92) laid a special emphasis on the removal of disparities especially with regards to women's equality in vocational, technical and professional education. It also reiterated the need for concerted efforts for education of scheduled castes, scheduled tribes and other backward sections.

1.3 Constitutional provisions pertaining to education

The Constitution of 1950 laid down the objective for achieving universal elementary (up to grade 8) education within ten years, that is by 1960. Article 45 of the Indian Constitution enjoins that "the State shall endeavour to provide, within a period of ten years from the commencement of this constitution, free and compulsory education for all children until they complete the age of fourteen years." For administrative purposes, India is divided into 26 states and 6 union territories. The expression "the State" which occurs in this article is defined in Article 12 to include the Government and the Parliament of India and the Government and the Legislature of each of the states and all local and other authorities within the territory of India. Earlier, education had been primarily the responsibility of the state/union territory governments. The 42nd amendment to the Constitution in 1976, however, has made education a concurrent subject, and thus envisaged a new sharing of responsibility between the Union Government and the state/union territory governments in respect of the formulation of educational development plans and their implementation.

1.4 Positive discrimination

The lower castes in the past have been mostly uneducated and their needs were met with verbal/oral communication. They were considered as 'untouchables'. After Independence, the Constitution of India, through Article 46, enjoined to promote with special care the education as well as economic interests of the weaker sections of the people, in general, and of the scheduled tribes (STs) and scheduled castes (SCs), in particular. As a measure, the government provided special concessions which took the form of allocation of seats for these groups in schools and colleges and professional institutions; relaxation in admission requirements for students of these communities; and the provision of scholarships, hostel facilities and special training facilities.

Positive discrimination has certainly promoted the education position of the lower classes. Between 1961 and 1971 the literacy rate of SCs and STs increased much faster (by 60%) than for the entire population (22%). The upper class elites no longer enjoy the monopoly of the student body. Originally, these concessions were meant for only 15 years, that is up to 1965. But, the caste factor is now growing increasingly important in Indian politics. As a result, a new phenomenon is rising up - the middle caste. People of middle castes have already organised themselves to voice their demand of reservations in education and in services as well.

In September 1994, Uttar Pradesh government proposed to set aside 27% of government jobs and seats in higher education for middle castes. Several other governments also sought for the support of an increasingly assertive middle caste population by advocating increased reservation for them, in some cases setting the total reserved quota above the 50% ceiling fixed for all groups by the Supreme Court.

Table 1.5 Education among Scheduled Castes/ Scheduled Tribes (As per the 1991 census)

Social	**Population (in millions)**		**Literacy Rate**	
Status	**Male**	**Female**	**Male**	**Female**
Scheduled Caste	71.9	66.3	49.91	23.76
Scheduled Tribes	34.3	33.4	40.65	18.19

Source: *Studies in Educational Statistics No. II*, 1993, Ministry of Human Resources Development, Government of India, p.IV.

1.5 Infra-structure

In urban areas, there is overcrowding in schools and the condition of buildings, furniture facilities and equipment is unsatisfactory in almost all parts of the country. According to the Fifth All-India Educational Survey (Date of reference 30 September 1986), over 43 per cent of primary schools and 25 per cent of secondary schools in India did not have a concrete structure; over 50 per cent of primary schools and nearly 15 per cent of secondary schools did not have even drinking water facility; 28 per cent were without blackboards, and 60 percent had no library of any kind. Rapid expansion, which was not accompanied by sufficient investment of resources, has caused a deterioration in academic standards.

A contrast of facilities in government schools: even in the Capital city some schools do not have concrete structures

Plate 1.1 A Government Senior Secondary School in Paschim Vihar, Delhi: housed in a purpose-built concrete building, the school has a considerably good range of facilities, such as play-ground, laboratories, toilets, and so on (Photo taken in July 1994).

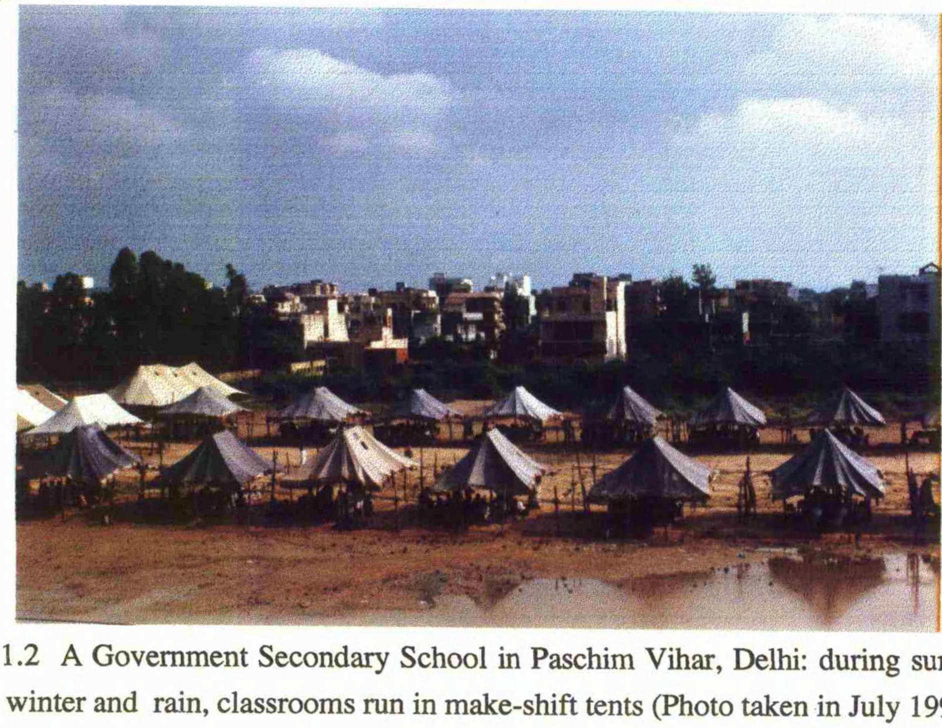

Plate 1.2 A Government Secondary School in Paschim Vihar, Delhi: during summer, chilly winter and rain, classrooms run in make-shift tents (Photo taken in July 1994).

With the view to provide minimum essential facilities in primary schools (Table 1.6), the National Policy on Education 1986 launched a scheme of operation blackboard. The word 'operation' was chosen to salient the sense of urgency and also to express the determination of the government and people to achieve the goal of universal literacy within the stipulated time-frame.

Table 1.6. Essential facilities in schools at the primary stage

1. Teachers equipment i Syllabus ii Textbooks iii Teachers' Guides 2. Classroom teaching materials i Maps - District, State and Country ii Plastic globes iii Educational charts 3. Play materials and toys i Wisdom blocks ii Surface tension iii Bird and animal puzzle iv Animal world v Balance and weights vi Magnifying glasses vii Magnets viii Measuring tape ix Cleanliness, nutrition, language and number chart	4. Games equipment i Skipping rope ii Balls - Football, Volleyball, Rubber balls iii Air pump iv Ring v Swing rope with tyre 5. Primary science kit 6. Mini tool kit 7. Two-in-One audio equipment 8. Books for library i Reference books - Dictionaries, Encyclopaedia ii Children's books (at least 200) iii Magazine, journals and newspapers for teachers and children 9. School Bell	10. Musical instruments- Dholak or Tabla, Harmonium and Manjira 11. Contingency money with teacher 12. All weather classrooms i Classrooms ii Toilets - one for boys and one for girls iii Mats and furniture for students and teachers 13. Blackboard 14. Chalk and duster 15. Water facility 16. Trash can

Source: *Programme of Action*, National Policy on Education -1986, Government of India, P.22.

Although all education policies advocate the importance of science education, the picture of science laboratories in schools is still gloomy. About 40 per cent of secondary schools do not have a science laboratory at all. The majority of secondary schools (48.13%) have combined laboratories for science subjects. Separate laboratories for science subjects are available in only 13% schools (Plate 1.3). Regional disparity in the distribution of facilities is immensely salient. For example, while wealthy urban areas like Delhi and Chandigarh have separate science laboratories in over 30% of their secondary schools, more than 95% of the secondary schools in the states of Assam, Manipur and Tripura do not have any laboratory for science subjects.

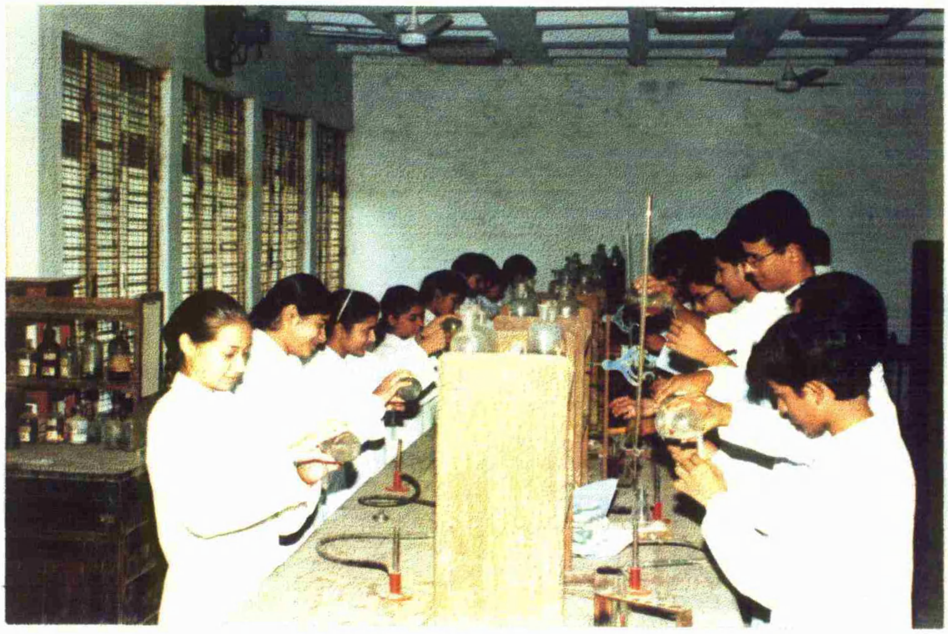

Plate 1.3 An experiment in progress in a separate chemistry laboratory: raising or dampening interest in science?

One of the most striking phenomena of contemporary educational infra-structure is the rapid growth of Public Schools with English as the medium of instruction. The country has by now over 2,500 such full-fledged schools, affiliated with either of the national boards: Central Board of Secondary Education (CBSE) or Council for Indian School Certificate Examination (CISCE) and rarely with a State Board of School Education (Table 1.7). Most public schools are developed in urban areas as their main aim is to make profit. By the way public schools are managed, by the criteria they recruit their teachers and give them autonomy to teach, by the standards (talent and/or money) on which they select their students (Plate 1.4) and to the extent their students are motivated for higher learning, they are doing extremely well in education. These schools, in general, have excellent laboratories and computer facilities.

Now-a-days, the phenomenon of public schools has become a craze especially among the middle and upper middle classes. The demand is so intense that every year about 100 new public schools are being opened.

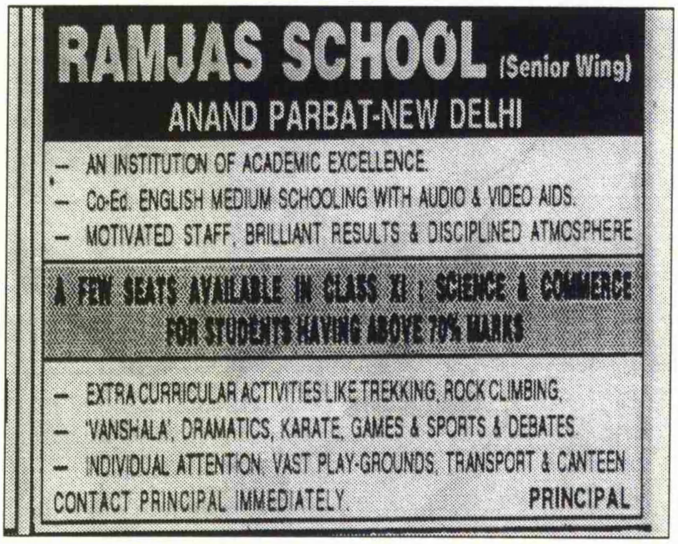

Plate1.4 An advertisement appeared in *The Hindustan Times* 24 June 1994 (daily) shows the way public schools attract students.

Table 1.7 School by management (As on 30 September 1986)

Management	**Primary schools**		**Middle schools**		**Secondary schools**	
	Number	%	**Number**	%	**Number**	%
Government	219837	41.53	59650	43.01	19417	36.88
Local Body	251699	47.54	42568	30.69	4928	9.36
Aided	44701	8.44	24827	17.90	22466	42.67
Private	13155	2.49	11642	8.40	5839	11.09

Source: *Proceedings of Eleventh Conference of Commonwealth Education Ministers*, Barbados, 29 October-2 November 1990, p. 100.

Most conscientious parents take note of the deteriorating standards in the quality of education and general facilities in the government schools and prefer to send their children, especially boys if money is scarce, to fee charging schools. True, there is evidence which reassures parents that the future of their children is bright if they are sent to English medium schools. Convent educated students stand out as a class by themselves in contrast to government or government-aided schools. Secondly, convent educated students, in general, have commendable success rate in competitive medical, engineering and civil services examinations. Sometimes, mediocre public schools also exaggerate their moderate success rates out of all proportion in their advertisements with the aim of luring parents.

Education per child in these schools requires a lot of money, often half or two-thirds of the pay of a government employee. Due to an ever increasing emphasis on the welfare of children and their future hopes and aspirations, there can be seen to be a rapidly growing pre-occupation with money and also with the acquisition of material possession among the people. In other words, a money-culture is heavily contributing to wide-spread corruption in society. For example: teachers coach students privately; doctors instead of attending their surgeries in rural primary health centres do private practice (mostly in urban areas) and give some part of their salaries to the chief medical officer; medical superintendents purchase a full quota of medicine 'on paper,' but in reality they purchase the assignment partly and save money for themselves; engineers get some money back from the contractors for their favour; train ticket inspectors provide a berth in a reserved compartment and take some money in return; and so on. The late Indian Prime Minister Rajiv Gandhi used to say that of every 100 Rupees given by Delhi to anywhere in the provinces, only 15 would reach it (quoted in Rettie, 1994)

Indian politicians and educationists repeatedly blamed, and still often do so, the British education policy for giving rise to bi-polarism in education. Instead of trying to provide good education to all children or, at least, to all able children from every stratum of society, quality education under British rule, they expressed, was available to a few which were usually selected not on the basis of talent but on the capacity to pay a fee. They called this pathway as undemocratic and inconsistent with the ideal of an egalitarian society. The Education Commission (1964-66) called it a 'major weakness' of the system we got in the legacy. Ironically, the contemporary education system has not only kept the very bi-polarism alive, but also nurtured it. The opening by the government of a number of English medium schools, such as Sainik Schools, Kendriya Yidyalayas, and Jawahar Navodaya Vidyalayas, run on the lines of public schools points to the fact that public schools are satisfying a pressing social need of the time, and this validates the bi-polarism in education.

The post-Independence period saw the expansion of infra-structure, but hardly the rise in the quality and standards of education. The number of schools increased, so the pupil-teacher ratio in the classroom (Table 1.8). In the early 1990s, the pupil-teacher ratio at the primary stage was 45 (Table 1.8): it was highest in Gujrat (61) and lowest in Sikkim (5). On the basis of evidence, such as continually increasing figures of the pupil-teacher ratio (45:1; Table 1.8), almost stagnant figure of the average teachers in a primary school (between 2.5 and 3; Table 1.9) and continually decreasing allocation of funds to primary stage (Table 1.12), it can reasonably be concluded that after Independence the government has not put due emphasis on primary education.

Table 1.8 Growth of different levels of schools and change in the pupil-teacher ratio in India

Year	**Primary School**		**Middle Schools**		**Secondary Schools**	
	Number	**Pupil-teacher ratio**	**Number**	**Pupil-teacher ratio**	**Number**	**Pupil-teacher ratio**
1950-51	209,671	32[a]	13,596	24[a]	7416	25[a]
1960-61	330,339	-	49,663	-	17329	
1970-71	408,378	39	90,621	32	37051	25
1980-81	485,538	38	116,447	33	51624	27
1990-91	558392	45*	146636	43*	78619	30*

Source: *Studies in Educational Statistics* No. II, 1993, Ministry of Human Resources Development, Government of India, p.II.

Selected Statistical Information on Education, (pamphlet published in 1994), Department of Education, Government of India) : a - 1947 figures /* - 1993 figures.

Proceedings of Eleventh Conference of Commonwealth Education Ministers, Barbados, 29 October-2 November 1990, p.99.

Table 1.9 Teachers in primary schools

Year	Primary Schools	Number of teacher		Percentage of women teachers	Average teachers in a school
		Men	Women		
1950-51	209,671	455637	82281	15.30	2.57
1960-61	330,339	614727	126788	17.10	2.24
1970-71	408,378	835340	224610	21.19	2.60
1980-81	495,007	1001977	343399	25.52	2.72
1990-91	558392	1167000	470000	40.27	2.93

Source: *Proceedings of Eleventh Conference of Commonwealth Education Ministers*, Barbados, 29 October-2 November 1990, p.106.

Table 1.10 Teachers in upper primary schools

Year	Upper Primary Schools	Number of teacher		Percentage of women teachers	Average teachers in a school
		Men	Women		
1950-51	13,596	72609	12887	15.07	6.3
1960-61	49,663	261696	83532	24.20	6.95
1970-71	90,621	463063	174506	27.37	7.04
1980-81	119,560	570183	260466	31.36	6.95
1990-91	146636	706000	353000	50.00	7.22

Source: *Proceedings of Eleventh Conference of Commonwealth Education Ministers*, Barbados, 29 October-2 November 1990, p.107.

Table 1.11 Teachers in secondary schools

Year	Secondary Schools	Number of teacher (in 000's)		Percentage of women teachers	Average teachers in a school
		Men	Women		
1950-51	7416	107	20	15.74	17.13
1960-61	17329	234	62	26.50	17.08
1970-71	37051	474	155	32.70	16.98
1980-81	51624	658	254	38.60	17.67
1990-91	78619	857	416	48.54	16.19

Source: *Fifth All-India Educational Survey - Selected Statistics*, National Council of Educational Research and Training, 1989 (Date of Reference: 30 September 1986)

Still there are unserved areas in the country where there is no secondary school for 10 to 20 kilometres. The reason for this dismal picture can be attributed to the fact that a substantial proportion of secondary schools (44.92%) are in the private aided sector. Understandably, the private sector is least likely to cater for tribal, desert, and hilly areas where the low density of population does not allow enough children to be enrolled. What is worse is the fact that the figure of average teachers in a secondary school has decreased (Table 1.11) and the pupil-teacher ratio has increased since Independence (Table 1.8). Of the 579,148 villages in the country only 7,765 (1.34%) have the higher secondary schools facility within them (Reference date 30 September 1986).

Table 1.12 Expenditure on education (FYP - Five Year Plans: GNP - Gross National Product)

Plan	Total Education Rs millions	% on primary education	% on ** elementary education	% on secondary education	Share of GNP %
1 FYP	1530	55.6	55	-	-
2 FYP	2730	34.8	34	-	0.76
3 FYP	5890	30.2	37	-	-
4 FYP	8230	18.2	31	-	1.19
5 FYP	12860	31.9	32	-	-
6 FYP	26000	-	32	20.35	-
7 FYP	76329	-	38.4	24	1.68
8 FYP	195997	-	45.59	-	6*

Source: *Studies in Educational Statistics No. II*, 1993, Ministry of Human Resources Development, Government of India, p.V-VI.

* Announced by the Government. The Education Commission (1964-66) envisaged that 6 per cent of GNP be devoted for education by 1986.

** *Proceedings of Eleventh Conference of Commonwealth Education Ministers*, Barbados, 29 October-2 November 1990, P.90.

Adiseshiah (1986)

1.6 Science education in India

Long before Independence, the leaders of India were aware of the importance of science in national development. In 1939, the Indian National Congress appointed a National Planning Committee and invited leading scientists to help to formulate plans for economic development and social betterment. In Independent India, the position accorded to scientific research can be judged from the creation of a *Ministry of Scientific Research and Natural Resources* directly under the Prime Minister, and also from the passing of the *Resolution on Science Policy* in 1958. The resolution stated:

> Science has developed at an ever increasing pace since the beginning of the century, so that the gap between the advanced and backward countries has

> widened more and more. It is only by adopting the most vigorous measures and by putting forward our utmost efforts into the development of science that we can bridge the gap. It is an inherent obligation of a great country like India with its tradition of scholarship and original thinking and its great cultural heritage to participate fully in the march of science which is probably mankind's greatest enterprise today (Rahman, 1974: 10-11).

India's future was envisaged with science. For instance, there was hope of making the country self-sufficient in food only if the farmers themselves (Under British rule, only big landlords were motivated, or forced, to switch over from subsistence to cash crops) were ready to move out of their age-long conservatism through a science-based education, become interested in experimentation, and were willing to adopt techniques that increase yields. The same was true of industry. The role of science was learnt from several countries whose Gross National Product (GNP) shot up rapidly because of their investment in basic science, technology and education. Being aware of the value of science in economic development, the Education Commission (1964-66) strongly recommended to make science education an integral part of the school curriculum during the first ten years of schooling.

> Science education must become an integral part of school education; and ultimately some study of science should become a part of all courses in the humanities and social sciences at the university stage, even as the teaching of science can be enriched by the inclusion of some elements of the humanities and social sciences. (Report of the Education Commission 1964-66, 1970: 12)

The Commission also recommended that the science teaching in the lower science classes should be related to the child's environment (principles and processes in the social, physical and biological environment). It was suggested that schools should encourage gardening as an activity, as it provides pupils with direct and valuable experiences of natural phenomena. The introduction of astronomy by observation of the night sky was also suggested, as it plays an important part in imparting good science education and in developing a rational outlook. The provision of a science corner, with the necessary facilities for storing specimens, charts, and models, in every primary school was also strongly recommended.

At the secondary level, it was suggested that science should be taught as a discipline of the mind with a view to prepare students for higher education. Different curricula was proposed for each rural and urban schools. In rural areas, science education was to be linked to the agriculture environment and, in contrast, the technical and industrial aspects of experimental science were suggested to incorporate in the curriculum of urban schools.

The recommendations of the Education Commission were flawless but the problem remained of their implementation. Science curriculum was set the same for rural and urban schools. In the absence of laboratory facilities, teachers usually followed the lecture method. And even when lectures were followed by practical work, they did not help students generate a proper understanding of subject-matter. Teachers often failed to make science teaching lively, more interesting and useful. Low popularity of science among students, and notably among girls, as a subject is clearly evident in Table 1.13.

Table 1.13 Number of students receiving education in higher secondary schools (10 +2)

	Arts	Science	Commerce	Vocational
Boys	1,753,201	482,920	366,612	77,874
Girls	734,025	218,245	255,642	58,694
Total	2,487,232	701,165	544,954	157,781

Source: *Education in India 1989-90,* Vol -I (S), Ministry of Human Resources Development, Government of India, 1993, p.51-54.

1.7 Non-formal education

At least since 1968 when the National Policy on Education was adopted, there had been a growing concern about the limitations of the formal education system to meet the educational needs of all children in the compulsory schooling age group and in achieving the goal of Universal Elementary Education (UEE). The concern about the limitations of the formal education system in meeting the learning needs of a large proportion of children in the compulsory schooling age-group resulted in a search for alternatives to the formal system of education.

In 1971, the Planning Commission of India noted the dismal picture of literacy in India. The percentage of literacy had increased from 18.33% in 1951 to 34.45% in 1971, paradoxically, so the absolute number of illiterates from 300 million to 430 million

(Table 1.4). The hard realities of the life, where most children (about 70 per cent of the total) have had to work in and outside the family, shattered the Indian planner's dream of creating a learning society. In order to take stock of the position likely to be reached by the end of the Fourth Five Year Plan and to identify bottle-necks, the Planning Commission appointed several task forces. The *Task Force on Adult and Out-of School Education* (1973) recognised the enormous potentialities of the out-of-school youth which remain largely idle human-power and recommended that:

> a network of centres and cells be established for the youth in urban and rural areas irrespective of their social grouping, to develop their interest and capacities for creative activities. These centres should be fully equipped with material and facilities for learning suited to all who undertake the activities (UNESCO, 1974).

Recently, the Revised Policy Formulation -92 laid a more emphatically stress on informal education programmes.

> The non-formal education programme, meant for school drop-outs, for children from habitations without schools, working children and girls who cannot attend whole day school will be strengthened and enlarged (Bagga, 1994).

A centrally sponsored Non-Formal Education (NFE) programme for education of out-of-school children was launched in 1979-80, in nine states (Andhra Pradesh, Assam, Bihar, Jammu and Kashmir, Madhay Pradesh, Orissa, Rajasthan, Uttar Pradesh, and West Bengal) which had a bulk of non-enrolled children and the drop-outs. The main objective of this programme was to develop Non-Formal Education centres which in turn were expected to make education relevant to real life situations and to the needs of out-of-school children. In 1986, the programme was reorganised and expanded to cover the state of Arunachal Pradesh and also to cater to the people living in urban slums and inaccessible areas.

The Non-Formal Education programme is now being implemented on a project basis. A project is being generally coterminous with a Community Development (CD) Block comprising of about 100 Non-Formal Education (NFE) centres. By 1989-90, about 260,000 NFE centres were established in different states/ union territories in the country. About 78,000 Non-Formal Education (NFE) centres have been established exclusively for out-of-school girls.

Table 1.14 Non-formal education programmes for out-of-school children

Programme	**Implementing Agency and Year**	**Assistance From**	**Clients**	**Objectives**
Developmental Activities in Community Education & Participation (DACEP)	NCERT/ States and UTs 1975-76	-	Pre-school, out-of-school (9-14) & women (15-35)	to develop and test new educational activities
Action Research Project on UPE	Indian Institute of Education, Pune 1979	-	Out-of-school children (9-14)	to develop part-time NFE centres in Maharashtra
Comprehensive Access to Primary Education (CAPE)	NCERT/ States and UTs 1979-80	UNICEF	Out-of-school children (9-14)	to develop non-formal system of education
Shiksha Karmi	Rajasthan 1987	Swedish International Developme-nt Agency	Out-of-school children in remote and backward areas	universal primary education for all

Source: *Proceedings of Eleventh Conference of Commonwealth Education Ministers*, Barbados, 29 October-2 November 1990, p.80-89.

1.8 Popularisation of science: a national concern

As has been mentioned earlier that education was seen for the first time from a wider perspective with the establishment of the National Council of Educational Research and Training (NCERT). One of the strongest thrusts of the NCERT was, and still is, in the area of curriculum development. The orientation of science teaching was first initiated through the introduction of new curriculum. The activity-based instruction material developed by the NCERT gradually evolved into a national movement for popularising science among school students through yearly science exhibitions. Since its humble start in 1971, the Jawaharlal Nehru National Science Exhibition (JNNSE) was held for the first four years in Delhi and as such had no particular theme. Since 1975, the exhibition is being organised on and around a theme of national concern.

Every year the very first exhibitions are organised at the district level which are followed by zonal or regional level exhibitions and then by state level exhibitions. Finally, the selected 144 exhibits from state level competitions are included in the national level exhibition. The whole cycle for one national level exhibition takes two years and the number of exhibitions all over the country during this period run into thousands. The Jawaharlal Nehru National Science Exhibition (JNNSE), which opens for seven or eight days, is visited by around 5000 visitors per day (Bhattacharyya, 1991: 188).

Over the past decade, there can be seen a growing enthusiasm among the governmental and volunteer agencies toward popularisation of science movement. The year 1987 witnessed three major events, that is the first National Science Day (28 February), the *Bharat Jan Vigyan Jatha* - a nationwide science and technology event, and institution of three national awards for popularisation of science. The first two events were catalysed and supported by the National Council of Science and Technology Communication (NCSTC). The 'National Science Day syndrome' is primarily characterised by a suitable theme, the organisation of seminars, quizzes, popular lectures, exhibitions, street carnivals, drama shows and get-togethers with brain storming sessions. The general public, however, get a valuable opportunity through 'open houses' to have a fair idea of close door laboratory (generally, the public is not allowed in these laboratories) activities.

The coverage of science and technology in media is gradually gaining strength. In the early 1990s, a variety of popular science programmes broadcast from various science cells of All India Radio (AIR) stations have shown qualitative and quantitative improvement. A radio programme DATE (Drug, Alcohol, Tobacco, Education) broadcast from April to October 1990 was immensely successful. Similarly, a 144-part radio serial on 'Human Evolution' was broadcast from 84 All India Radio (AIR) stations in 18 languages. This serial - a joint project of National Council of Science And Technology Communication (NCSTC) and All India Radio (AIR) - is perhaps the longest radio science serial in the world.

Doordarshan (State television) introduced its First School Television in October 1961 at a very modest level. Its expansion began with the first experiment using satellite technology in 1975-76. The network witnessed an unprecedented growth with the installation of almost one transmitter a day in 1984 and immediately afterwards. The programme of higher education for undergraduates in colleges was introduced in August 1984 in collaboration with the University Grant Commission (UGC). Calcutta Doordarshan also produced 'Science Quest' programmes in collaboration with the National Council of Science Museums. Popularity of the most television educational programmes is low for several reasons; they are syllabus-oriented, they are produced by academicians so do not appeal to the general public; and they are broadcast during odd hours. But in recent years, the popularity of a few programmes produced by professionals and entertainers points to the thirst of good science programmes in the country. For example, a science magazine TV serial 'Turning Point' has indeed been a turning point for Doordarshan.

The situation is really improving in the print media though at a slow rate. English dailies like *The Deccan Herald* (Monday), *The Hindu* (Wednesday), *The Pioneer* (Friday), *The Economic Times* (Saturday) bring out an exclusively weekly science section. The idea of science coverage is not so common in Hindi and other language papers. Popular science magazines like *Science Reporter*, *Vigyan Pragati* (Hindi) and *Science Ki Dunia* (Hindi) continue to be popular among the masses. To meet the growing demand, several new titles such as the *Srishti, Down to Earth, Medinews, Our Health Nutrition and Environment* and *Horizons* all started in 1992.

Popular science books of the Council of Scientific and Industrial Research (CSIR; Golden Jubilee series), National Book Trust (NBT) and National Council of Science and Technology Communication (NCSTC) are all available at nominal prices. A number of science feature services like the Press Trust of India Science Service, Publication and Information Directorate (of the CSIR) publications, Energy Environment Group publications, National Research Development Corporation (NRDC) publications, to name a few only, continue to expand their market.

There are over one thousand people's science organisations in India which aim to promote scientific and cultural literacy. One such organisation whose achievements are noteworthy is the Kerala Sastra Sahitya Parishad (KSSP). It encourages politically and economically powerless people to actively participate in scientific matters that affect them. In 1974, the KSSP successfully worked on the Silent valley hydro-electric power dam. It conducted classes for local people and presented arguments for and against the dam. The KSSP is also engaged in publishing books and magazines like *Eureka*, *Sastrakerakam* and *Sasthragathy* that aim to disseminate science to the masses. The National Council of Science and Technology Communication (NCSTC) often conduct programmes all over the country in collaboration with people's science organisations.

1.9 Indian education system: a bird's eye view

While speaking of education, health, or any other aspect of human development in India, the vastness of the country needs to be remembered. India is a sub-continent with a colourful mixture of diverse races and cultures. In terms of population, the states of Gujrat, Maharashtra and Andhra Pradesh are comparable in size to France, Germany and the UK, while Uttar Pradesh is like France and Germany combined. Some of the states observe twenty religious holidays in a year: Buddhist, Christian, Sikh, Muslim, Parsi, Hindu, Jain and Jewish.

Multi-lingualism is an Indian speciality. There are about 1600 dialects in use in the country and 15 official languages. Hindi is the national language but, unfortunately, it is not spoken in some parts of the country. So, English occupies an important place in the Indian system because it acts as a link language throughout the country. In fact, there can be seen to be a craze for English. A person is taken as educated and cultured in accordance with his or her ability to speak English. In a job (in the private sector) as well as in marriage advertisements, the most used term would surely be 'convent educated'.

Indians profess a number of different religions and speak a number of different languages. Notwithstanding all this mind-boggling diversity, the society has largely enjoyed a unity of cultural practices and an overall national ethos. But in recent years, the scenario has been changing rapidly because of the growing influence of caste and communalism. People are becoming prone to forget 'India' as a result of exponentially growing local, regional, linguistic, and religious loyalties. Innumerable signs of social disorganisation can be seen almost everywhere. These include increasing lawlessness and disregard of public property, strikes and street-violence and corruption in public life.

The Indian education system has long stopped producing 'dharmic minds'. Today, more people than ever, including those who hold responsible positions, say something and do something else. Science and superstition go hand in hand. A scientist though understands the reason for a lunar or solar eclipse occurring, but still goes to have a holy dip in a river the day following the eclipse. Traditionally, India is a land of innumerable gods and of godmen. As the line between faith and political expediency does not exist, these godmen take full advantage of the situation. From the prime minister down, politicians and their advisers know that a vote-bank can be created by paying homage to well-established religious institutions and godmen. Even, the late Indira Gandhi, former Prime Minister of India, remained under the influence of several gurus. Recently, Narsimha Rao, Prime Minister of India, visited Sai Baba, who lived in a palatial ashram in Andhra Pradesh, and was given a gold watch which Sai Baba created as if by magic. But, this could not deceive the state television camera which recorded the event and the trick of the godman (McGirk, 1994). Last year, people also came to know that T. N. Seshan, Harvard-educated Election Commissioner of India, also worships or practices 'a bit of sorcery,' for example when his servant was caught stealing flowers (needed in all religious practices to please God) from a rose garden for his master. So, it appears reasonable to conclude that a little 'incantation' or 'religious service' to start the day is as common in India as a pre-breakfast jog in the West. But, among illiterates, that is among the majority of people, the roots of superstition, witchcraft and mysticism are incredibly deep, complex and strong.

Instead of promoting social and national integration and making an active effort to promote national consciousness, several features of the education system promote divisive tendencies. The most serious one perhaps is the segregation of the rich and the poor. While the former attend the better type of private schools, which charge exorbitant fees and raise capital sums through donations, the latter have no choice but to attend free government or local authority schools of poor quality. Today, there can be seen an 'explosion of expectations' even in the lower middle class people. To earn the money to afford the cost of education, which is often half or two-thirds of the total pay, a person follows illegal ways. Due to an ever increasing emphasis on the welfare of children and their future hopes and aspirations, corruption is increasingly becoming a part of life. Illiteracy and poor quality of education in state schools appears to be a major factor responsible for the downfall. But to continue forward, there is an increasing need to provide quality basic education to all.

The demand for universal primary education, for the first time on a political platform, was raised by Dadabhai Naoroji before the Indian Education Commission in 1932. In 1944, the Sargent Report recommended compulsory schooling of eight years and prepared a long term plan to achieve the goal within 40 years (1944-84). Later, the Kher Committee modified this, setting 1960 as the year for its attainment. The overflowing enthusiasm of the Kher Committee failed to foresee the enormity of the task and set an ineffective trend of narrow planning. Since 1960, the target date has been changed from time to time without taking the trouble to research the roots of the problem.

India plans good schemes on papers. For example, the Education Commission Report (1964-66) is one of the most comprehensive document on education in the world. But, ironically, these schemes, in general, fail to yield some good for the people. According to a well known economist L.C. Jain, the problem was that after Independence, 'we took the bureaucratic road'. Former vice-chancellor of the North-East Hill University in Shillong and ex-member of the Planning Commission of Madhya Pradesh, B. L. Sharma gives a very precise account of how the bureaucracy functions. More than a quarter of a century ago, he caught malaria in Madhya Pradesh:

> But the bureaucracy said that malaria had been eliminated, so my illness was officially recorded as something else. That was how the bureaucracy was, and it has not improved. But they've had to admit that malaria is still a problem (quoted in Rettie, 1994).

Bureaucratic highways also exist in education. School enrolment figures for grades I to V, compiled by the Department of Education, convey the impression that nearly 90 per cent of six- to eleven- year-olds are enrolled in primary schools. Recently, these figures have been mercilessly dissected by Agarwal (1988) on the basis of the 1981 census figures. Following through the responses collected under the 1981 census, Agarwal reveals that only 47 per cent of primary school age children are actually receiving education - either formal or non-formal.

For the majority of children who go to school, staying in school (retention) is still a major problem. According to 1989-90 statistics, out of every 100 students enrolled in class I only 85 reach class II, 52 reach class V, 36 reach class VIII, and only 26 reach class X. At all these stages, the proportion of the girl-dropouts is large (Table 1.3). The problem of low retention in early years has remained a poorly understood one. With a few exceptions, most studies in a recent annotated bibliography of over 500 studies (Patil, 1984) on this subject point out poverty as a major factor that drives parents to withdraw their children from schools. Incidentally, the few researchers who have paid some attention to pedagogical factors in classrooms have considered them as a peripheral aspect of the overall picture. But, the severely high drop-out rate within one or two years of enrolment implies that pedagogy may be at the heart of the problem of early elimination.

A child, even as young as three, is curious enough about the world, and sincerely wants to make sense of whatever comes his or her way. But, as educationists, we are prone to ignore the associations of development, curiosity and knowledge that a child possesses. If we genuinely try to hold even a fractions of these associations in our view we would know how frustrated a child must become after he or she has spent a few days at an average Indian primary school where 'making sense' and 'problem solving' are not on the agenda at all. Indeed, a child is pressed hard to recognise the shape of letters that form the syllabary, chanted them repeatedly and practising writing them out correctly over and over again.

The latest reported figure (1990-91) for the net enrolment ratio for the 6-11 age-group is around 76% and that for 11-14 is about 51%. The ratio for 6-14 year olds works out to around 66.5%. Considering that the child population of 6-14 year olds stands at around 150 million, nearly 50 million of the school-age children are out-of-school. Following the trend set by most educationists, the Indian government also think their economic and social status as a major hurdle between them and schools. Announcing a new scheme on the occasion of the 47th anniversary of Independence on 15 August 1994, P. V. Narsimha Rao, Prime Minister of India, said that his government would pay parents whose children work in hazardous conditions to send them school. The scheme may increase the level of corruption, but may surely not solve the problem. There is an increasing need to ameliorate the pedagogical conditions in primary schools, especially with a view to making education interesting from girls' point of view. In rural areas, parents assign their girls household work and stop them from going school. Parents are to be convinced that the education would equip their wards with skills to perform jobs, including household ones, in a much more efficient way. Understandably, money may not help them understand the value of education.

Around 13.7 per cent of schools cater exclusively for girls. The percentage of exclusively girls' schools varies from 4.14% for primary schools to 39.8% for institutions offering pre-metric diploma/certificate courses. The literacy amongst girls has increased after Independence, but the comparative expansion of girls education in science and technology is rather disappointing. The post-Independence trend of women education was that a girl must attain education if she wants a chance for a good marriage (Cormack, 1961). Still today, for an Indian girl, modern education and her professional career remain a road to marriage. The two role models - one that of a mother and the other that of a house-wife - inherently shape women's attitudes. According to several recent studies, culture, in male-dominated and female-as-dependent society, appears to impose a barrier upon the education and achievements of girls (Chandra, 1987; Gosh, 1990).

From the above discussion, we get quite a fair idea that the Indian education machinery is a very strange one which has been reconstructed twice, but still continues to have essentially the same features it had before Independence. The concept of 'reconstruction of education according to the needs and aspiration of people' still remains a brilliant idea to implement. Our post-Independence achievement is that we have greatly expanded a system and correspondingly magnified colonial features which were so abhorred by Mahatama Gandhi. On 20th October 1931, while addressing at the Royal Institute of International Affairs in London, Gandhi critically analysed the British education policy and pointed to its incompatibility in the Indian context:

> ...the schools established after the European pattern were too expensive for the people and therefore they could not take over the thing. I defy anybody to fulfil a programme of compulsory primary education of these masses inside of a century. This very poor country of mine is ill able to sustain such an expensive method of education (Naik, 1993).

Gandhi's prediction proved true. There are so many parameters, which were pointed out and underlined by the Education Commission (1964-66), but has so far remained only a distant goal. In a paper, Panchmukki (1983) concludes that the reforms have not been effective in achieving their social change. They have been largely piecemeal measures, not part of a total strategy for political and economic reform. Our education system is now stumbling due to its own weight. We always had good ideas but due to our bureaucratic set-up we implemented them light-heartedly. In Professor Rais Ahmed's words, our foremost difficulty is that:

> we in India live in a world of words, of promises, of policy statements and resolutions. We cannot live without these and the concomitant seminars, conferences and high-powered meetings (Ahmed, 1986).

When the Education Commission met Dr Zakir Hussain, then President of India, and sought his advice about its Report, he laid stress on this aspect and said, "Just say three words: implement, implement and implement" (quoted in Naik, 1993).

The points discussed here implies that the Indian education sector is fraught with complex problems and the key to solving most of these problems lies outside the educational sphere itself. Along with educational reform, measures are needed for social reconstruction. And, here lies the test-bed for science museums. Science museums in India have potential and a unique task to complete. In the next chapter, we shall study the origin, development, organisation and functioning of Indian science museums.

Chapter 2

Indian Science Museums and Centres
A nationwide networking with peerless challenges to meet

Introduction

After Independence, the Indian model of development emerged from a series of strategic choices. These choices were based on a set of compromises that blended the experience of wartime planning and control; domestic pressures for a policy of economic nationalism; and the liberal, Gandhian, and socialist ideological cross-currents that existed within the nationalist movement (Williams, 1978). The immediate concern of India's leaders was to build a strong, centralised, industrialised state capable of defending its freedom and meeting the needs of its poverty-stricken masses. The objectives of India's developmental model were to achieve rapid economic growth, self-reliance, full employment and social justice. The policy framework and approach outlined for development underlined the importance of science and technology in economic development. It was realised by the policy makers that there can be no excellence in development without excellence in science and technology education. Largely in this context, science museums came into being in India. In this chapter, I aim to outline the origin, development, organisation and functioning of science museum movement in India, particularly with a view to throw light on its strengths and weaknesses.

2.1 Pressures for a policy of economic nationalism: the creation of science museums

Unlike ancient times, education today is not a luxury, but a demand of the 20th century. Better education has been necessitated by the increasing role of science and technology in human affairs and human development. In our own lifetime, we have seen unparalleled destruction and, side-by-side with it, unimaginable progress. From contemporary world-wide developments, it is quite clear that humanity is undergoing a new transition which is significantly different from the earlier ones, that is from the caves to the forests, from the forests to nomadic, pastoral, industrial and then to post-industrial economies. In India, all the historical transitions can be seen simultaneously, without taking the trouble of travelling back in time. For example, an Indian industrialist lives in the post-modern era; the industrialist's servant in his or her house survives in the cave-to-forest transition era; a teacher who comes to teach the industrialist's wards exists in the forest-to-pastoral transition era; and a industrialist's personal body guard lives in the pastoral-to-industrial transition era.

The role of science and technology in our everyday affairs is well-known and will be briefly discussed in the next chapter. As Indian society is comprised of a mixture of different strata of people, science and technology, understandably, is a tool that is not accessible for *conscious* use to around 500 million people. What is more appalling is that somewhere between 50 to 70 million children of age group 6 to 14 are out-of-school. More than a century back, Swami Vivekananda, a well-known Indian philosopher and preacher, critically evaluated the situation and made the following significant observation which is still, even certainly more, valid today:

> A nation is advanced in proportion as education and intelligence spread among the masses. The chief cause of India's ruin has been the monopolising of its whole education and intelligence of the land among a handful of men. If we were to rise again, we shall have to do it by spreading education among the masses. The only service to be done for our lower classes is to give them education to develop their individuality.
>
> If the poor boy cannot go to education, education must go to him (quoted in Swami and Srinivasan, 1994).

This has not happened in any large measure till Independence and in any satisfactory way as yet. At least since the beginning of the present century, the similar sentiments have remained an integral part of the Indian freedom struggle. Several Indian leaders raised their voice after scrutinising the model of the Soviet Union. The relationship between education, productivity and income was established for the Soviet Union at a time when its economy was still largely under-developed and agricultural and very similar to that of India. When Rabindranath Tagore (1861-1941), a distinguished poet, painter, philosopher and India's first Nobel laureate, visited the Soviet Union in 1930, he said that his greatest pilgrimage would have remained unfulfilled if he had not visited Russia. During the visit, he became greatly impressed with the importance the new Soviet society accorded to education. He ingeniously took account of the situation and appreciated the role of science and technological education in the unprecedented growth of Soviet industry and economy. He observed:

> In science education reading and seeing must be combined, otherwise four-fifths of it is fraud. Such education has been possible in Russia by means of museums of various subjects (mentioned in Bagchi, 1975).

The similar emphasis can also be seen in America where it is asserted that 'never was the day when there was not a museum somewhere in the United States' (Hornung, 1987). In India, the science museum movement grew as a part of the faith what the builders of modern India expressed in 'Science and Technology' for national development. The movement started when these men of vision, notably Jawaharlal Nehru, then Prime Minister, B.C. Roy, then Chief Minister of West Bengal, G.D. Birla, a leading Industrialist and Dr. K.S. Krishnan, Director of the National Physical Laboratory (NPL), foresaw the need for awakening a scientific temper among the millions who were to enjoy the fruits of science and technology. In 1954, V.P. Beri started first science museum, under the Birla Education Trust, in the Birla Institute of Technology and Sciences (BITS) Pilani, an internationally reputed institution developed on the line of the Massachusetts Institute of Technology. But, the scope of the museum was very limited for the general public for two reasons: first, because Pilani was not a tourist place; and second, the museum was affiliated with a teaching institution.

In the 1950s, the National Physical Laboratory (NPL), a unit of the Council of Scientific and Industrial Research (CSIR), was intermittently receiving letters from educational institutions for permission to visit the laboratory, its departments, library and workshop. Having felt the need for a science museum, Dr Krishnan initiated efforts to set up a science museum in his laboratory. The time was perhaps ripe because the United Nations Educational Scientific and Cultural Organisation (UNESCO) was sending in help in various forms, such as science travelling exhibitions. In 1956, R. Subramanian was appointed as scientific Officer and entrusted with the responsibility of developing a science museum in a 3,000 square feet space with necessary facilities provided by the NPL. The UNESCO provided the services of W.T. O'Dea, then a keeper of the Science Museum, London, a six-month fellowship for an Indian graduate to study museum techniques in Europe, and $5,000 worth of equipment (Subramanian, 1973). O'Dea spent 12 weeks in India from January to March 1957 and within this relatively short span a large *India and Science* exhibition was opened for school students and the general public. After observing the great enthusiasm of CSIR authorities and dedication of the museum staff, O'Dea predicted the flourishing of science museums in India.

> I left fully assured that, without further assistance, the museum personnel would expand the nucleus into a proper museum (O'Dea, 1958).

The prediction of O'Dea proved right, but the nucleus of the present science museums came into existence through parallel efforts which were then being made at Calcutta. In the early 1950s, Birla donated to the government of India a palatial house and land for developing a permanent science museum in Calcutta. Mr Amlendu Bose started planning the museum in 1956. The Birla Industrial and Technological Museum (BITM) was inaugurated under the Council of Scientific and Industrial Research in 1959 by Professor Humanyu Kabir, then Union Education Minister. Since the inauguration of the first museum, the science museum movement has never stopped to look back.

To mark the centenary celebrations of the engineer-statesman, M. Visvesvaraya, an Industrial Society was formed in Bangalore. It collected donations and erected a museum building in the heart of the city. By this time the work of Birla Industrial and Technological Museum (BITM), Calcutta, gained nationwide recognition. Perhaps, inspired with a view to harness the expertise gained during the development of the BITM, the society handed the museum building over to the Council of Scientific and Industrial Research (CSIR) in 1962. The Visvesvaraya Industrial and Technical Museum (VITM) was formally inaugurated in 1965. The main objectives of science museums were, and still are, to promote the history of science and technology, to supplement school and college education, and to popularise science among the masses so as to encourage a scientific temper in the country (Bagchi, 1975).

Both CSIR museums flourished and underwent a radical change during the late 1960s when they changed the priority of their objectives, of course in tune with the national priorities, and laid a special stress on supplementing school science education. To this end, it was also decided to launch programmes of mobile science exhibitions and experimental District Science Centres. The concerted efforts of science museums soon achieved a wide recognition. While looking into the functioning of Council of Scientific and Industrial Research (CSIR) and its affiliated laboratories/ institutes, the Sarkar Committee appreciated the role and importance of science museums and recommended the transfer of these museums from them to the National Council of Science Education. Unfortunately, the suggested transfer did not take place at that time.

The Constitution of 1950 laid down the date of achieving universal education as 1960. But in spite of the impressive growth of schools between 1950-51 and 1970-71 [primary school 209671 to 408378 (nearly double); middle school 13596 to 90621 (over six times); higher secondary school 7416 to 37051 (nearly five times)], the number of illiterates were continually running high. By 1971 there were around 386 million illiterates in the country in comparison to 300 million in 1951 (Table 1.4: 18). By this time, it was realised that the formal education system alone could not achieve the objective of universal education. At this crucial juncture, the advice of Swami Vivekananda showed the way: education was to go to those who were not in position to come to education. The demand of the hour was for 'open learning', that is, opening the door of education by eliminating many restrictions and rigidities of formal schooling and education. To this end, several task forces and committees were set up. The *Task Force on Adult and Out-of-School Education* (1973) recognised the enormous potentialities of the out-of-school youth which remain largely idle human-power and (as has been cited in Chapter 1) recommended that:

> a network of centres and cells be established for the youth in urban and rural areas irrespective of their social grouping, to develop their interest and capacities for creative activities. These centres should be fully equipped with material and facilities for learning suited to all who undertake the activities (UNESCO, 1974).

In essence, what was suggested by the *Task Force on Adult and Out-of-School Education* was very similar to the concept of small science centres. In parallel efforts, having recognised the need for developing scientific attitude and creation of scientific awareness, the Planning Commission set up a *Task Force on Science Museums* in 1973. The Task Force observed the relatively slow development of museums under the Council of Scientific and Industrial Research and recommended the creation of a central co-ordinating agency for planning and administration of science museums. Having grasped the tremendous potential of science museums in community development, the *Task Force* also came out with a blueprint for the nationwide development of science museums at all levels - national, state, district and block. Four national museums, one each in the North, South, West and East zone, were conceived which would in turn support a chain of state and district level units.

Following the recommendations of the Task Force, the third in the chain of science museums, called 'Nehru Science Centre' (NSCB), of national status was planned in Bombay. In 1977, a 'Light and Sight' gallery, comprised of 220 exhibits, was opened in a temporary hall. With this addition, the science museum movement adopted a new role: it changed its emphasis from merely being a 'storehouse of artifacts' (Industrial and Technological Museums) to being an 'educator and communicator'.

In 1977, following a policy decision of the Government of India and a resolution of the Union Cabinet and subsequent decisions of the Society and the Governing Body of Council of Scientific and Industrial Research, some of their units were detached to form independent societies under the various relevant ministries. As a result, the National Council of Science Museums (NCSM) came into existence on 4th April 1978 (NCSM Annual Report, 1978-79: 7). The organisation of the National Council of Science Museums is shown in Figure 2.1: the Governing Body takes decisions pertaining to the policies of NCSM and zonal Executive Committees guide the activities of national level science museums/centres and their other units.

Plate 2.1. The presence of Indian President Dr S. D. Sharma, Shri K. Kant, Governor and Shri V.B. Reddy, Chief Minister of Andhra Pradesh at the occasion of the inauguration of Regional Science Centre, Tirupati, on 23 September 1993, reflects a strong governmental support to the science museums in India.

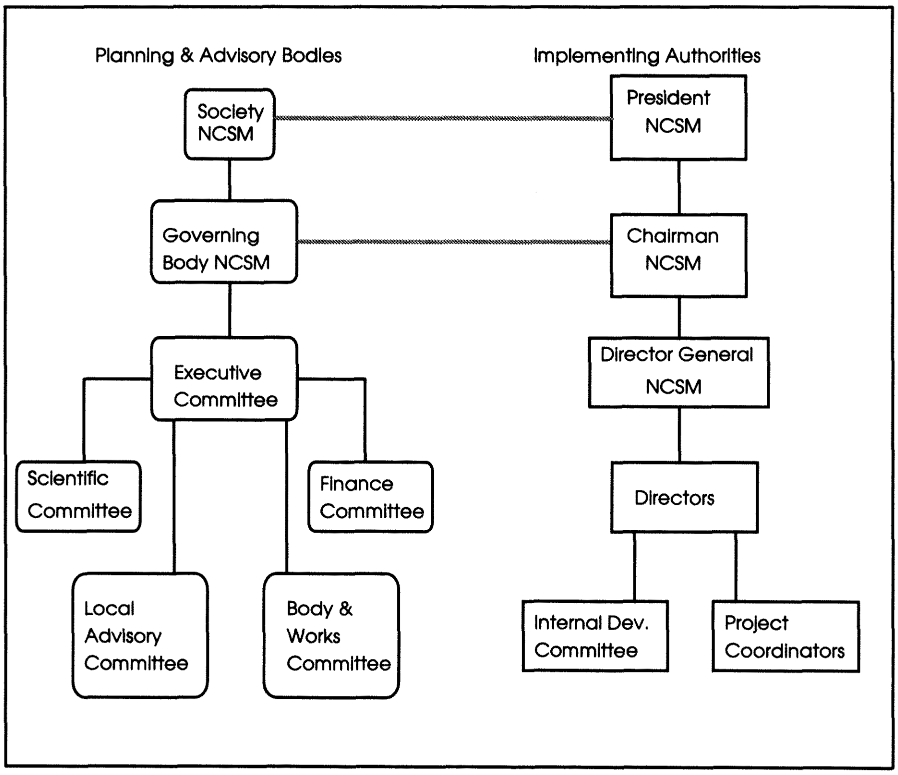

Figure 2.1 Organisation chart of the National Council of Science Museums (NCSM). Currently, the NCSM is an autonomous body functioning under the Department of Culture, Ministry of Human Resources Development, Government of India.

The first year of National Council of Science Museums (NCSM) was proved an overwhelming success from the point of view of expansion. Beside solving administrative problems, a new science centre, called Shrikrishna Science Centre, was added in the list of NCSM when the Government of Bihar permanently transferred 1.23 acres of land and a partly finished building to the NCSM (formerly leased to CSIR) in October 1978. Also at this time, the Governing Body of NCSM decided to develop the first two district level science centres at Purulia (West Bengal) and Gulbarga (Karnataka). The NSCM also started developing the first science park in the surrounding 6 acres land of the NSC Bombay. The park proved advantageous in multiple ways: it acted as a publicity agent for the newly developing facility; it helped in creating uplifting surroundings; it provided natural habitat for animals on display in the animalorium; it created environmental awareness; and most importantly, it brought science, play and nature together. With this first successful experience, it became almost a trend to develop a science park along with a science museum.

The growth of NCSM is really incredible in the last 15 years. Today, there are listed 24 units on the map of NCSM (National Council of Science Museums, Annual Report, 1993-94). The curve of growth is linear, roughly one unit per year. But, the regional disparity is patently evident (Figure 2.2). There can be seen an immense emphasis on the development in and around Calcutta whereas almost no development in several states. The concentration of both power and resources appears to rest in West Bengal. Surprisingly, out of the seven senior officers (curatorial posts) in the Council, five hold offices in Calcutta.

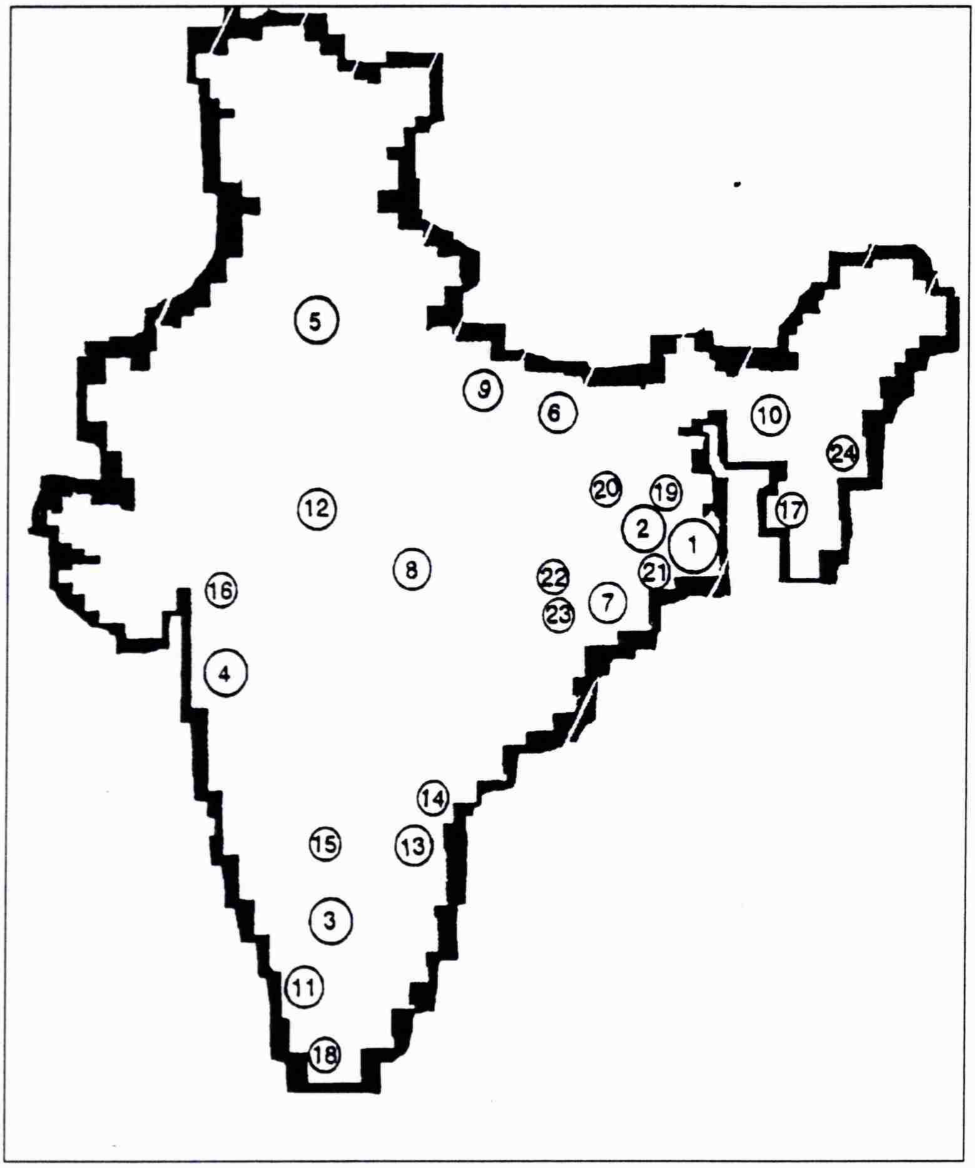

Figure 2.2. Science museums networking in India: details of geographical locations of various satellite units. The regional disparity in development is patently visible.

SATELLITE UNITS OF THE NATIONAL COUNCIL OF SCIENCE MUSEUMS

1	National Council of Science Museums, Calcutta. Central Research and Training Laboratory, Calcutta. Science City, Calcutta.	13	Regional Science Centre, Tirupati.
2	Birla Industrial and Technological Museum, Calcutta.	14	Sub-Regional Science Centre, Vijaywada.
3	Visvesvaraya Industrial and Technological Museum, Bangalore.	15	District Science Centre, Gulbarga.
4	Nehru Science Centre, Bombay.	16	District Science Centre, Dharampur.
5	Rajiv Gandhi National Science Centre, Delhi.	17	Tripura Science Centre, Agartala. (in dispute)
6	Srikrishna Science Centre, Patna.	18	District Science Centre, Tirunelveli.
7	Regional Science Centre, Bhubaneswar.	19	Sub-Regional Science Centre, Burdwan.
8	Raman Science Centre, Nagpur.	20	District Science Centre, Purulia.
9	Regional Science Centre, Lucknow.	21	District Science Centre, Digha.
10	Regional Science Centre, Guwahati.	22	Science Park, Kapilash.
11	Regional Science Centre, Calicut.	23	Sub-Regional Science Centre, Dhenkanal.
12	Regional Science Centre, Bhopal.	24	Sub-Regional Science Centre, Imphal

OTHER SCIENCE MUSEUMS

A	G. D. Birla Science Centre, Hyderabad	D	Tamilnadu Science Centre, Madras.
B	Birla Science Centre, Jaipur.	E	National Museum of Natural History, Delhi.
C	Birla Science Museum, Pilani.		

2.2 Staff structure

The director general is the highest authority in the National Council of Science Museums (NCSM) and the director at its national level units. In an emergency, the director general can almost waive any condition mentioned in the NCSM bye-laws. The director general can, at will but officially on the pretext of public or office interest, transfer any staff-member (artists or technicians are usually not transferred) all over the country. Being an autonomous body, the NCSM has also the privilege of recruiting its own staff by following a standard procedure. In comparison to the director general the financial powers of a full-fledged director is roughly 10 per cent. For example, the director general can sanction an amount of Rs 500,000 and a director can only sanction an amount of only Rs 50,000. Promotions of staff also largely depend on the director general's opinion. The administrative power of director general are enormous and so are the possibilities of manipulation in the NCSM bye-laws.

In the USA and other Western countries, the staff who can sell and promote are becoming extremely important in science and industry museums, since the support of the community and industry is so essential. But, in India, the curator is supreme. Other staff (non-curatorial), however senior he or she may be, cannot become director or project co-ordinator.

Workshop in-charge curators really rule the inside world, as only exhibit development is regarded as valuable work. New posts like that of educationist, psychologist, evaluating and marketing staff, though badly needed in the system, have not as yet been created. For the job of curators, the minimum prescribed qualification is a bachelor degree in the engineering stream and a master degree in sciences. After recruitment, a curatorial training is organised with the intention of providing a functional literacy of the field to new curators. Ironically, proper museology courses are considered irrelevant to the objectives of the organisation. Similarly, fresh graduate degree holders in science or technology are recruited as trainee education assistants. At the end of the training, suitable candidates out of these trainees are recruited as permanent education staff.

The representation of women in the Council is deplorably low. Though accurate figures are not available, nonetheless it can be said that there should be less than 15 per cent women on the staff roll. Most women work either in administrative section or in art section. There is no woman in the seniority list. Out of its team of over 50 curators all over the country, only two are women.

Director General (Curator)					
Head of national level museum/centre	Director	(Curator E1 and above)			
Head of regional level museum/centre	Project Coordinator	(Curator B and above)			
Head of district level museum/centre	District Science Officer	Curator (B) or Education staff			
Curator - electronics/ mechanical/ electrical	Curator Phys/Chem/ Life Sci.	Exhibition officer	Adm. officer	Finance Officer	Works Engineer
Technical Officer	Education Officer		Section/ Store Officer		
Technical Assistant	Education Assistant	Exhibition Assistant	Office Assistant	Finance Assistant	Technical Assistant
Technician		Artist			

Figure 2.3 Staff structure in the National Council of Science Museums (NCSM): A sketch of hierarchy.

West Bengal is only one state of India out of 26 states and 6 union territories. But more that 80 per cent of key posts all over the country are managed by Bengali officers. For example, out of six national level directors, five belong to the Bengali community. In the NCSM seniority list, first six officers in line are Bengali. This staff structure appears more as meticulously designed than one by chance. The profound regional disparity apparent from the museums map of India also supports this premiss or instance (Figure 2.2).

Up to now, there are no evaluation and research staff in the Council. Worldwide, there can be seen a profoundly growing emphasis on evaluation in museums. The objective of any evaluation is to provide information to staff members in a way that will assist them in planning. Getting a baseline on visitor behaviour is considered important in understanding how to develop an effective educational media (Laetsch *et al.*, 1980). Considering why museums do not like to invest in evaluation, Frank Oppenheimer once said:

> Most museums don't do this because, I feel, the ego problems are too great. Have you ever heard museum people talk about "my museum," "my program"? They're not entertaining the notion that what they're doing may not be very good (Whitman, 1978).

There may be ego problems, and also attitude problems, for not conducting evaluation in science museums. Whatsoever be the case, the absence of evaluation and research staff in the Council points to the fact that the evaluation studies are not considered as useful. 'By committing ourselves for evaluation we are engaging in pointless philosophising rather than of much practical work waiting to be done', this is perhaps the stand of senior curators with regard to evaluation studies.

In inter-active science centres, the presence of interpreters in galleries is said to be essential by both museum directors and museum visitors. The potential benefits of employing education staff in galleries have long been identified by museum directors. From its beginning, an essential feature of Frank Oppenheimer's Exploratorium has been its imaginatively trained team of friendly explainers (local high school students). The element of social interaction was a key element of its success which was later to be realised and followed by many other science centres throughout the world, to name a few Bristol Exploratory in the United Kingdom and the Experimentarium in Denmark. The Experimentarium near Copenhagen has about 20 part-time staff for educational purposes employed efficiently and judiciously in such a way that the maximum workforce remain available during rush hours. The Natural History Centre, Liverpool recruits three to ten staff, depending upon the visiting seasons. With a paid staff of only two - the curator and an assistant, the Hutchinson House, a living history museum in Ontario, operates smoothly with the help of 129 volunteers (Rainbow, 1992).

Today, volunteer help appears essential to any museum operating with educational mission for several reasons: volunteer students, on the one hand, get some monetary help and, on the other hand, they learn skills and have better understanding of subject matter; museums operate smoothly, successfully and economically; and, in general, visitors get friendly, social and learning environments in the gallery. In his research, Aubrey Tulley found a profound (51 per cent) improvement in visitor's understanding of the presented subject matter when an interpreter was present (*Museums Journal*, May 1994: 41). In India, most visitors and school groups lament the non-availability of guidance in the museum. For example, a visitor speaks for a majority of people when he writes the following comments in the visitors' book placed at the National Science Centre, Delhi.

> There was no guide or anybody to explain. The staff deputed is not at all helpful. Perhaps the museum works only when a VIP visits or the TV team comes (H.K. Agarwal, Vikas Kunj, New Delhi -70, 19 June 1993).

In India, we have unemployed and interested students who would appreciate the idea of demonstration, galleries devoid of education staff, demand from visitors for the provision of education staff, and money, but, surprisingly, still we do not have part-time staff culture. Visitor books are full of visitors' comments in this regard.

India has about 15 million handicapped people. Out of 15 million about one third fall in the age group of 4-15 years. The National Council of Science Museums does not have any policy for this group of audience and, for that reason, no post of special needs co-ordinating officer exists in the Council.

2.3 Exhibition policy: some issues about the presented science and technology

A significant proportion of visitors enter museums with a specific purpose - "learning" (Borun, 1977; Heady, 1984; Birney 1988). The contour map of visitors' pathways in a gallery tells us that some exhibits are heavily used by visitors, while others are seen infrequently. In other words, we can say that most of the visitors have an unusual discretionary power: they embrace what they like and outrightly reject what they do not; they run towards the exhibit which they consider relevant or interesting or entertaining and remain indifferent to what they anticipate irrelevant, boring and incomprehensible; and they remember what creates ripples in their mind and forget what does not.

In the present, the capability of visitors, their needs and their interests are unequivocally important. But, conventionally, museums began at a time when the people who owned and ran them had a contempt for the masses. The supremacist attitude of curators is the legacy which has well run down to our times. According to Charles Gibbs-Smith (1964), then public relation officer at Victoria and Albert Museum, London, museum curators either patronise, resent, despise, dislike or even hate the public.

The autocrat builders of early museums sought nobody's advice or suggestions as to how the collection should be presented or organised. Visitors were admitted in the museums not as a right but as a favour, and consequently the visitor's feedback was thought in terms of gratitude and admiration. There was no place for criticism. Up until now, this attitude, explicitly or implicitly, persists. Most of the museum professionals publicly appreciate the concept of visitor's involvement in the process of exhibition development, but some of them abhor the very notion in practice. This appears particularly true in the Indian context where the complex process of exhibit development right from the selection of the theme to the installation usually takes place on its own pace, without establishing any meaningful partnership with the actual or potential visitors.

The potential of visitors as partners is largely under-estimated. The theme and the content of the exhibition is decided following a process that is characterised as 'a professional conspiracy, very much against the public interest' (Gibbs-Smith, 1964). The process sees its origin in the 'Deficient Model' of mass communication, and this conventionally empowers the curators to define the world on their own terms. Largely, it is assumed that if the exhibit is a sufficiently expertly designed then a successful transfer of messages is bound to take place. The assumption is the same as has been followed by Roger Miles and his colleagues in the Natural History Museum, London, but with a significant difference. While the expertise in the case of the Natural History Museum has been thought in terms of using widely accepted communication, learning and sociological models, in India it is mainly based on the knowledge, experience, preferences and biases of an individual or a small team of curators. Senior curators appear to be infected by the 'noble syndrome', that is they can give an opinion and pass judgement on any and every aspect of the museum's art and science.

A brief survey of five tables (2.1, 2.2, 2.3, 2.4 and 2.5) reveals a number of interesting features of the exhibition policy: there appears much more emphasis on physical sciences and much less on life sciences; in some cases, the theme has been selected on the basis of regional specialities for example *The Forest* in the Regional Science Centre, Guwahati, *Treasures of the Ocean* in the District Science Centre, Tirunelveli, and *Wealth of Gulbarga* in the District Science Centre, Gulbarga. But, there appears no definite policy with regards to selecting a theme and developing the exhibit. The theme of the ensuing exhibit may be based on either personal preference or on the development taking place in other country or the choice of some powerful person.

The themes also do not address the public concern. The theme which may cause even a little controversy in any way is rejected at the first hand. As a result, we find a number of subjects eliminated from the list of science and technology which are very crucial in society. For example, the control of population is one of the most pressing need of Indian society, but, unfortunately, there is no single permanent exhibition on population or family planning. Many recent exhibit themes in the Council such as engine hall, petroleum, motion, and vibrations, are neither an attraction nor match with the pressing demand of the society. Instead, sex education, AIDs, pollution, biotechnology, nuclear energy, health, hygiene, nutrition, and child development are some of the topics of current interest and concern which have not been touched so far.

Avoidance appears the only exhibition policy on such provocative issues and, to some extent, reflects the policies of the government and major political parties. For example, since Independence, the major thrust of India's family planning programme has relied on vasectomies and involves a policy of incentives to volunteers. But during the Emergency (1975-77), there came a wave of compulsory sterilisation and officials were assigned to fulfil a specific number of cases in their jurisdiction. Incentives were displaced by coercion and the draconian sterilisation - for example, armed police stopping buses and herding men aged between 17 to 70 into sterilisation camps -

became a major issue in Indira Gandhi's 1977 electoral defeat. Since 1977, no political party has called for control of population nor has any election manifesto mentioned it.

In the exhibition space, there appears no place for the 'balanced view of science'. In fact, science and technology is largely seen through a 'tunnel vision' - always linked with the entertainment, achievement, progress and welfare. For example, in *The Forest* exhibit at the Regional Science Centre, Guwahati (Assam), the issue of deforestation has not been taken-up. A tree is presented as wealth and the display presents many wooden house-hold goods, sport goods, building construction and construction material. Once, Assam was reputed to have the largest proportion of planted area in India, but today the rate of deforestation in the state is alarming. And such a presentation of science can only deteriorate the situation further, rather than providing understanding about the complications of deforestation.

Today, the advances in science and technology in India take place more or less in isolation. Recently, the Government decided to build a Sardar Sarover Dam which was to irrigate drought-ridden areas and to provide electricity. But, the construction of the dam was also likely to displace 250,000 farming families. In summer 1993, Medha Patkar, a well-known environmentalist, together with 500 of her fellow activists, threatened mass suicide by drowning at the site of the dam to compel the government to stop the project. In India, with every step there are such instances. The public has almost no say in such matters largely due to their limitation (non-availability of reliable information) or incapacity to understand pro-and-cons inherent in these issues. Evidently, there is a need for science centres to play the role of mediator between the government and the public in such cases. The massive fleet of mobile science exhibitions, which have enormous mobility and astounding penetrating power, can play a major role in this area. But, as can be seen from Table 2.5, most mobile exhibits presents similar themes as covered in permanent exhibitions, that is ones with a technically 'non-political' content.

Table 2.1 Existing permanent galleries in the East zone science museums/centres.

Name of the museum	**Physical Science**	**Engineering**	**Information Technology**	**Life Science**	**Others**
Birla Industrial and Technological Museum, Calcutta	Atom Popular Science Electricity	Motive Power Transport Iron and Steel Copper, Petroleum	Television, Communications, Electronics,		How Things Work, Underground Coal Mine, Children's Gallery,
Regional Science Centre, Patna	Popular Science Perception			Evolution	Srikrishana Singh Ocean
Regional Science Centre, Bhubaneswar	Sun Sustain Life				Space Odyssey
Regional Science Centre, Guwahati	Fun Science Earth Science	Petroleum			Agriculture Forest Coal Mine
District Science Centre, Purulia	Popular Science Vibration				Wealth of Purulia
Sub Regional Science Centre, Bardhaman	Popular Science			Life Science	
*District Science Centre, Dhenkanal	Popular Science				

* Under-Construction **Source:** National Council of Science Museums, Annual Reports, 1991-92/1992-93/ 1993-1994.

Table 2.2 Existing permanent galleries in the South zone science museums/centres.

Name of the museum	Physical Science	Engineering	Information Technology	Life Science	Others
Visvesvaraya Industrial and Technological Museum, Bangalore	Popular Science Electricity	Timber Paper and Metal in Civilization Engine Hall	Electro-technic		Children's Science
Regional Science Centre, Tirupati	Motion Fun Science				
*Regional Science Centre, Calicut					Planetarium
District Science Centre, Gulbarga	Popular Science				Wealth of Gulbarga
District Science Centre, Tirunelveli	Popular Science				Treasures of the Ocean Oceanic Quest

* Under-Construction

Source: National Council of Science Museums, Annual Reports, 1991-92/1992-93/ 1993-1994.

Table 2.3 Existing permanent galleries in the West zone science museums/centres.

Name of the museum	**Physical Science**	**Engineering**	**Information Technology**	**Life Science**	**Others**
Nehru Science Centre Bombay	Sound and Hearing Light and Sight Discovery	Industry			Science for Children C. V. Raman Our Heritage and Evolution
Raman Science Centre, Nagpur	Fun Science				Umbrella Planetarium
Regional Science Centre, Bhopal	Fun Science	Invention and Exploration			
District Science Centre, Dharampur	Popular Science Perception				

Source: National Council of Science Museums, Annual Reports, 1991-92/1992-93/ 1993-1994.

Table 2.4 Existing permanent galleries in the North zone science museums/centres.

Name of the museum	Physical Science	Engineering	Information Technology	Life Science	Others
National Science Centre, Delhi	Fun Science Prakash (Light)		Information Revolution		Heritage C. V. Raman
Hall of Science Technology and Energy					Village 2001 Coal Mine
*Regional Science Centre, Lucknow	Popular Science Aquamobile Fludics Astronomy				

* Still administered and supported by the Nehru Science Centre Bombay.

Source: National Council of Science Museums, Annual Reports, 1991-92/1992-93/ 1993-1994.

Table 2.5 Subject list of Mobile Science Exhibitions

1	Our Familiar Electricity	11	Planet We Live In
2	Man Must Measure	12	Water, the Fountain of Life
3	Popular Science	13	Popular Science II
4	Weather	14	Technology at Home
5	Perception I	15	Perception II
6	Man and Machine	16	Man the Tool Maker
7	Mathematics through Fun	17	Time
8	Food and Nutrition	18	You and Your Environment
9	Light and Sight	19	Energy
10	Heat and Temperature	20	How things work

Source: National Council of Science Museums, Annual Reports, 1991-92/1992-93/ 1993-1994.

2.4 Important features of Indian science museum movement: summary and discussion

The National Council of Science Museum (NCSM) is fully funded by the Government of India. Along with universities, schools, hospitals and religious institutions it enjoys exemption from taxes and other privileges like free pieces of land at central locations from state governments and out of turn allotment of electricity, telephone and similar facilities. Being a government institution, it also enjoys the support of the public sector and the private sector with regard to specific items or needs. The strong governmental support to the NCSM means that it has an unparallel opportunity in the world to focus on achieving excellence in its educational objectives.

But, just like the whole government machinery, the National Council of Science Museums (NCSM) also took the bureaucratic road to development. As a result, there can be seen an ever increasing emphasis on quantity. The annual reports of NCSM brings out only quantitative figures presented in most impressive way, for example so many inaugurations took place, so many school students visited, so many exhibits developed, so many mobile science exhibitions organised, so many planetarium programmes held, and so on. It is never mentioned that only 60,000 students out of total 900,000 school-going population in and around Delhi visited the National Science Centre Delhi.

When proposed the idea of different levels of science centres in different regions, the *Task Force on Science Museums* envisaged the decentralisation of power, that is more and more autonomy to small science centres. It was proposed that small science centres will co-ordinate programmes according to the local needs and aspirations of the people and the zonal science centres will provide them with support. But in practice, most of the schemes are prepared at the headquarters and small units are made to implement the programmes. For example, standard manuals are provided for organising mobile science exhibitions, planetarium shows, science demonstration lectures and other educational programmes. Whereas the organisation of science museums is highly centralised, the education system in India is largely decentralised where states decide on almost all important aspects of education, including curriculum. Hence, there remains, obviously, little venues for any meaningful partnership between local education boards and science centres.

The authoritarian pathway has only one advantage that the work progresses. It does not normally stop or slow down. Concomitantly, the system has the greatest disadvantage that the direction of progress always remain unevaluated. For example, nobody dares to question or write a critical review of the exhibit being developed/displayed at other units, as it may have serious implications for one's career prospects. The system gradually reduces the strength of social bonds between the staff and the institution. In the the longer term, the members learn the short-cuts of survival rather than of doing work whole-heartedly. In conclusion, the quality of work suffers, while target dates are mostly or ostensibly met.

Autonomy encourages staff to work efficiently and thus provides opportunity for experimentation, innovation, creativity and healthy competition between various units. On the other hand, the concentration of power at one place explicitly or implicitly brings about an authoritarian pathway and an environment of dependence where decisions are percolated top-to-down. While in an autonomy all brains work simultaneously, in the authoritarian rule only one brain works and the rest of the hearts implement, or pretend to implement, the decisions. Stagnation prevails as there is no place for self-directing experimentation and innovation in the authoritarian system. Instead of continual evolving, most programmes become a matter of routine which are done for the sake of doing.

For example, in the NCSM, the National Science Seminar is an annual event and conducted first at school level, then at block, district, state and finally at nation level (Plate 2.2). In the seminar, each student has to deliver a presentation on the suggested theme for five minutes. Although there are enormous possibilities of experimentation such as publication of proceedings, change in the duration of time of presentations, questioning-answering sessions and so on, but the seminar has now been organised for years following a standard procedure without any noticeable change in the process. Every year almost the same number of schools (around 460) and students (around 500) participate in the seminar (Annual Report, NCSM, 1991-92/ 1992-93/ 1993-94). In case of evolution of a programme as a result of experimentation, the number of participation would increase significantly every year, particularly with respect to the rural context. But, unfortunately, such is not the case here.

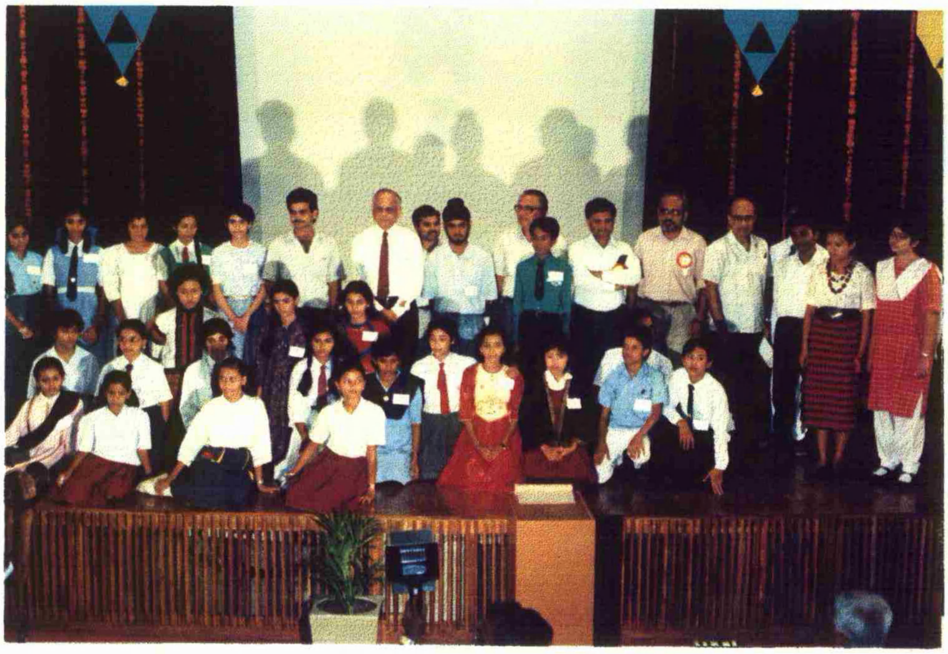

Plate 2.2. The National Science Seminar 1991 (5th October) held in the Nehru Science Centre Bombay: All state level seminar winners, judges, chief guest and organisers in the group-photo session. The theme of the seminar was 'Origin of Life'.

As a further example, the statistics pertaining to the number of visits in zonal museums also points to the stagnation. In fact, the effective figures may be on decline, if calculated after taken into consideration of the growing population in metropolitan cities (Table 2.6). To give an idea, India's urban population has increased from 11 percent in 1901 to 26 per cent in 1991 - some 221 million people. The provisional 1991 census lists 36 cities with a population over 500,000. Greater Bombay is the largest with an estimated population of 12.57 million (8.27 million in 1981 census), followed by Calcutta with 10.86 million (9.16 million in 1981 census), Delhi 8.38 million, and Bangalore 4.8 million (2.6 million in 1981 census). It is patently clear that only a tiny fraction of the population is using the facility of science museums. Given the effective marketing techniques, there is a great scope for building new audiences for museums.

Table 2.6 Number of visits in Zonal museums/centres.

	BITM	VITM	NSCB	NSCD
Visitors in 1979-80	152,995*	673,991	107,292	-
Visitors in 1991-92	237,741	798,236	291,387	29,380
Visitors in 1992-93	257,645	894,839	266,347	177,112
Visitors in 1993-94	236, 757	975,687	293,591	200, 105

Source: Annual Report, NCSM, 1979-80/ 1991-92/ 1992-93/ 1993-94
* Closed for three months
BITM - Birla Industrial and Technological Museum, Calcutta.
VITM - Visvesvaraya Industrial and Technological Museum, Bangalore.
NSCB - Nehru Science Centre, Bombay.
NSCD - National Science Centre, Delhi.

Strong governmental support to an organisation may create two situations: either the organisation may focus whole-heartedly on the entrusted task or the organisation may only function to survive. While in the former case, every staff member will strive for excellence in their task, in the later situation, people will complete the assigned task and will not initiate new task-oriented strategies, as there may not be much at stake. Whether 100 visitors enter the museum or 1000, a director will remain the director. Whether people learn or unlearn, a director will remain the director. But in the case of many science centres in developed countries, like the Experimentarium in Copenhagen and the Science World in Vancouver, which have to generate a lion's share of their revenues from admissions, memberships, fund-raising campaigns, donations and fee-for-service programmes, a director will simply not remain the director. Somebody more dynamic and capable will take the position and contribute to the visitor figures and their experiences in the museums space.

'Marketing museum' and 'evaluation' are still alien terms in the Indian context. Most science museums have magnificent buildings, but only a small name-plate in front of them, and in some cases that too is hidden in the bushes. Extra efforts are usually not made for building new audiences, perhaps because there is not much at stake. Sometimes circulars about new exhibits or programmes are sent to popular schools. For publicity, most museums in India rely on word of mouth.

Primary classes, where the drop-out rate is maximum, mostly do not use the facilities of science centres for several reasons: first, due to poor publicity, most teachers remain unaware of the science museums and its facilities; second, most schools do not have transportation facilities; third, most schools do not have sufficient funds; fourth, most teachers do not want to take risks due to lower age of pupils; and finally, teachers also do not find much material in science centres designed for the use of small children.

Ideally, science centres should cater to the needs of poor schools that either have no science laboratories or have poor facilities. But, these schools rarely visit science centres because of lack of funds. To have funds from local education board, a principal has to run from pillar to post. Women teachers often reject the idea at first hand. Only a few enthusiastic teachers try for funds needed for organising educational trips, and again only very few (influential) teachers can manage funds. For government schools, transportation is a major hindrance. In contrast, public schools have their own transport facilities so they visit science centres frequently.

There is a long way to go. Only a fraction of the total population of India, less than 1 per cent, visit science museums. Among the visitors, poor, special needs, deprived and rural population are almost negligible. Although most of the science centres are purpose-built, they have very poor access facilities. Most physically disabled people in India have neither the money nor basic facilities like wheel chairs, hearing aids, etc.

In the National Council of Science Museums, trial and error seems to be the key idea of progress rather than of informed decision-making on the basis of research and evaluation. Engaging in evaluation and research in the museum setting shows a commitment to the audience, a quest for excellence, and a desire to understand and describe the museum experience (Korn, 1989). In the Indian context, science centres might be more effective if they had been showing greater commitment to public services. In the next chapter, we shall study the primary educational objectives of Indian science centres and analyse in what ways these objectives are similar to and different from the objectives of other science centres, notable in the developed world.

Chapter 3

Primary Educational Objectives of a Science Centre and the Expectations of Students and Teachers

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Introduction

Contemporary science museums have come a long way from the spare rooms once filled with curiosities and out-of-use objects or instruments. They have evolved from traditional styles and functions to "science centres". The profound and wide-spread uneasiness that exists in society about science and technology is said to be the key force behind this evolution. This chapter first examines the social dimensions of science and analyses the issues underlying science-society relations. Basically, three motives or driving forces for developing science centres can be found in literature. These are to explain science and scientific advances to the masses, to improve science education, and to interest young people in scientific careers. But, many other institutions, such as press or television, also state similar intentions in their statement of mission. In these circumstances, it becomes necessary to study the status and role of science centres in a society bombarded with multi-channel communications. In this chapter, I aim to show that science centres in our multi-media society are to play a specific role that other media perhaps fall short to play - that is to provide unique learning environments for one and all. The chapter closes with suggestions how we can evaluate the effectiveness of science centres and thus sets out the objectives of this thesis.

3.1 Science in society

> I am now writing by candlelight & the fog was just now at 2 o'clock as dark as night. It came on very suddenly after we returned from church, & put a stop to my walk (Quoted in Wilson, 1976).

The above is extracted from a letter written in February 1853 by Lady Lyell, wife of Sir Charles Lyell, the most eminent geologist in Victorian Britain, to her friend. It appears difficult to believe that merely around a century and a half ago people, including eminent personalities like Lyell who wrote and revised successive editions of his geological books, were accustomed to use candles for lighting. True, the Victorian scientist, whether in a London house or in the country practiced science by the flickering flame of a candle. Both science and scientists were valued little in society. For example, in his book *Eminent Victorians* written in 1918, Lytton Strachey did not describe any Victorian scientist. He missed out even the very names of scientists, such as Michael Faraday (1791-1867), James Prescott Joule (1818-1889), William Thomson Kelvin (1824-1907), James Clerk Maxwell (1831-1897), Charles Lyell (1797-1875), Alfred Russel Wallace (1823-1913) and Charles Robert Darwin (1809-1882). Such a blunder might simply not be possible today. Indeed, these names will ring down the ages, at least, as long as science is taught and learnt (Wilson, 1976).

Everything has changed within the present century. When the automobile was first introduced, most people would have thought it inconceivable that we would one day have a society in which there was one automobile for every two people. Today, we are conditioned to take everything such as electricity, automobiles, aeroplanes and televisions, for granted. We find ourselves unable to imagine a world without these basic amenities. We live in a world where solar, hydro, thermal and nuclear power produce generous amount of electricity, the average factory is automated, and our houses contain a number of technological gadgets. After the scientific and industrial revolutions, at present we are passing through the information age. Teletext terminal rivals the television set for attention in the average household. With a computer, modem and a telephone connection, sitting in our study, we can have 24 hours a day access to world's reputed reference libraries and information centres.

Over the past few decades, the influence of science and technology in shaping our lives has increased to an extent, perhaps, never imagined before. In order to pass our day without embarrassment, we need to know some information about new devices and gadgets which are flooding into markets everyday. And, with the so-called 'development' is increasing our lust for possession, pleasure and power. Unlike the last century when science was pursued more as a hobby than as a profession, today the organisation of science has been changed altogether. Scientists are engaged by private and public sectors for fixed terms with the responsibility of developing modern tools and demonstrating their successful use. Science no longer enjoys an unblemished and justified reputation as a wonderful adventure pouring out practical benefits.

> Science is like a genetically engineered, fast growing tree. New branches are continually growing from this tree, and sub-branches spring forth from various branches. Today, this tree is growing at an incredible growth rate, never before imagined. Money-minded people, including a handful of scientists - are actively involved in turning its natural growth into artificial. Understandably, by their efforts, spikes and poisonous juices are being produced in this tree, besides palatable fruits and beautiful flowers. And who knows tomorrow whether the adverse effects may outnumber the many positive effects and destroy our dream of the betterment of humanity (Kaushik, 1995a) ?

Our participation in the scientific developments seems mandatory. But in order to participate effectively, we need scientific awareness, background and perspective, so that we can understand and judge the conflicting claims of adversaries.

At work, where we pass most time of our day, we are moving away from the era of 'scientific management' in which brain work and manual or operator work are rigidly separated. Industrial organisations are evolving towards a situation in which all routine or repetitive jobs will be executed by robots or computers. Industries are shifting from high-volume (one product in huge quantity) to high-value (a variety of products) methods of production. These industries now mainly rely on highly skilled employees rather than on physical capital. For example, 3% of the price of a semi-conductor chip today goes to the producer of raw materials and energy, 5% to those who own equipment and facilities, 6% to routine labour and 85% to design and engineering services (IMPULS Science & Technology Center, 1994: 13). It implies that, in future, the only jobs left will be those requiring considerable discretion and judgement in the light of personal understanding of the subjects involved in the job. Any little mistake can bring the project down to dust. For example, in Brown's Ferry nuclear power plant in Decatur, Alabama where:

> a careless worker had set the electrical system on fire while checking for air leaks with a candle (quoted in Tressel, 1990).

Amazingly, the worker was no ordinary person, but the chair of the nuclear engineering department at a major university. The incident suggests that the function of all workers will become more and more like traditional managers.

In sum, science and technology has today permeated our daily livings to the extent that it does not seem bizarre when some educationists describe it as 'the most distinctive enterprise of the twentieth century' (Broad and Wade, 1985: 126). Still, the value of science to society remains problematic and polarised. While some people, awed and overwhelmed by the achievements of science and technology, regard science as the cultural activity for which the 20th century will be pre-eminently remembered' (Gratzer, 1989), others do not see novelty in it and argue that the adult world does not require a knowledge of maths and science (Jenkins, 1994). There is a third group too, that looks at the citadel of science through the rational lenses. For them, science is important but not the supreme and unquestionable:

> I do not hold with the view that our society will be remembered principally for its great technological advances, its mammoth strides in the field of science. Our failure to grasp the implications and the costs of such developments, both human and environmental, are more likely to be an outstanding feature of our collective records (Kavanagh, 1992).

This group lays an increasing stress on the public understanding of science. Ideally, we have two options for the future: with science or without science. As too much has been invested in science and expected of science, no one would probably like to go without science. In other words, no one would like to enter the twenty-first century with the candle light in hand. So, practically there is only one choice, that is with science. Obviously, today it is mandatory to have positive attitudes towards science and technology and some knowledge and understanding of the scientific progress. We have to understand science so that our failure to grasp the implications and the costs of science must not be a prominent feature of our collective records in the future.

3.2 Science communication system

Basically, we receive scientific information through two institutions: formal and informal. In formal education, knowledge is pre-defined, sequenced, structured, controlled and passed (to others), and evaluated by performance tests. The process of learning is represented to the student as a responsibility, a requirement and a duty (Templeton, 1989). Learning outside this systematic and rigid context is called "informal education". In India (the situation, however, can be extended to most of the countries), as we have seen in the first chapter, the majority of school students receive almost no science lessons in elementary school education and only two years of general science in high school, that too mainly through verbal instructions. What is worse is the fact that the majority of teachers also have limited scientific knowledge. They find themselves unable to make lectures interesting either due to the dearth of resources or the lack of ideas. After seeing a science demonstration lecture on 'sound,' one school teacher (Govt. Senior Girls Secondary School, B-3, Paschim Vihar, Delhi) lamented:

> Science demonstration on sound was really very interesting. Like ... the chapter on sound in (our) textbook is equally uninteresting. (In science centre) They showed us a bottle filled with water. We have never thought to tell the students that the air-columns can be changed in this way. We only tell them theoretically (Recorded Teacher's Interview, April 1994).

Most teachers follow the 'deficient model' of teaching which assumes that a teacher supplies knowledge to students of which they are inherently devoid. Our experience as both students and educators tells us that the verbal presentation of science - lecturing to a large group of intellectually passive students and having them read text material - leaves virtually nothing significant and permanent in our mind. Worse is the fact that such science teaching may also greatly dampen the natural curiosity among children.

Apart from formal science education, we receive some information of and about science from informal media or forums, like press, television, science clubs, science museums and science centres. All these institutions, collectively called 'science communication system' hereafter, owe an increasing responsibility in respect to science communication. They all aim to educate masses and to supplement school science curriculum, and therefore face the same kind of pressures - that is, economic, political, cultural, individual and social (Figure 3.1). Presumably, these five areas do not have equal influence on different media.

Being gateway subjects, the sciences filter the relatively few students who occupy certain professions of high status and social influence in civil as well as economic sectors and, therefore, share the responsibility for the over-all development of the nation. Science education in India is quite definitely intended to increase scientifically trained manpower - at all levels from the very modest agricultural (farming) level to the high-tech industrial arena. While discussing about the compelling reasons for scientific literacy in a country, D.G. Chisman, then Executive Secretary of the International Council of Association for Science Education, emphasises that: 'to maintain and expand the worldwide position of the country, its citizens must be at least as scientific literate as those in other countries' (Chisman, 1984). Seen thus, science communication system in India bear an enormous *economic pressure.*

There is evidence that the science communication system frequently comes under pressure from political sectors. The writer and producer of a "Nova" television science serial about the Brown's Ferry nuclear power plant reveals that he did not use any of the footage of the accident due to the removal of the material by the information office of the Atomic Energy Commission from the public files (Tressel, 1990). An example from India is a further evidence in support. Sex education, though very much needed, is still a taboo in the Indian context. A volunteer of the Society for the Promotion of Youth and Masses (SYPM), who made an abortive attempt to include AIDS in his awareness programme on drug addiction, tells his experience with a visibly upset principal of a Delhi school:

> You can't discuss AIDs in our school. Because when you discuss AIDs you discuss sex and other issues. It will create more problem for us (*The Hindustan Times*, 19 June 1994).

Recently, Professor John Durant reported in an article about the controversy over a proposed exhibition on the Enola Gay, the aircraft that dropped the atom bomb on Hiroshima 50 years ago. War veterans' groups took a serious note of the allegedly pro-Japanese script for the exhibition, and in the aftermath Martin Harwit, director of the National Air and Space Museum, was eventually forced to resign (Durant, 1995). In the light of such examples, it is quite clear that our science communication system certainly has the reflection of the political element - influence or interference - in its mission.

Science and technology in the present time is characterised by the rapid occurrences and major breakthroughs. Indeed, there are many ways in which our cultures and social life-styles are now being influenced by the knowledge and applications of scientific advances. For example, today we encounter traditional cultures in some part of the under-developed world, a material culture in developed and developing countries, and a growing drug culture among teenagers. Without having a proper understanding of drugs, more and more teenagers are taking them (one in four teenagers has tried drugs and most of them know how to get them: Survey reported in *The Mail on Sunday* 9 July 1995). Recently, Krissy Taylor, an American 17-year-old model, collapsed from a heart attack. An adrenaline-based Primatene Mist inhaler which carries a clear warning that it should be used only by diagnosed asthmatics took her life. Dr Joshua Perper, who examined her body, said:

It is my understanding that she was completely unaware of the dangers of the inhalant and had not even read the label (McDonough and Ostler, 1995).

Knowledge of science can assist people, rather than creating a culture of subservience as many of us argue, in taking advantage of what science in these days has to offer them. Our science communication system evidently has a greater than ever challenge to face with respect to social and cultural elements.

The image and the role of science is quite subjective. While some consider science as a 'provider' of useful knowledge, others seek personal satisfaction in it, and still others blame it for bringing human and environmental destruction. It, therefore, appears natural for individuals to have different expectations from the science communication system.

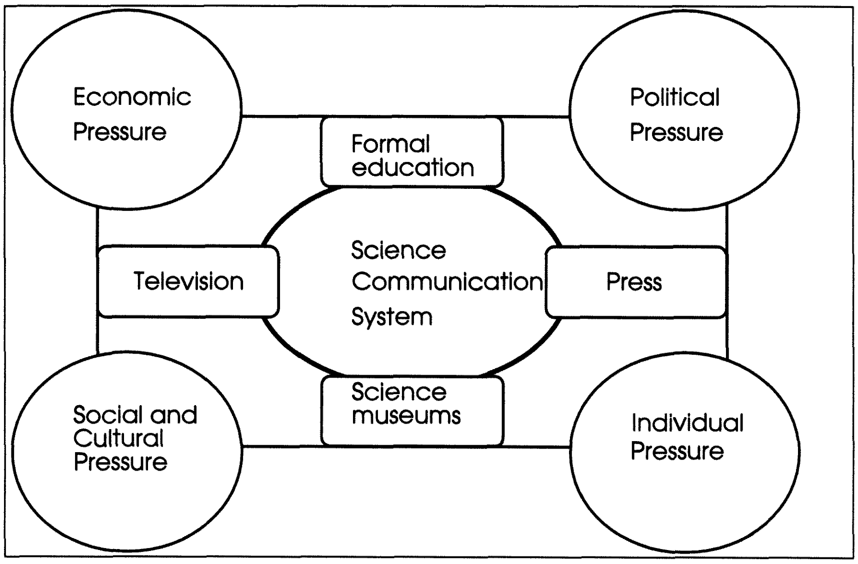

Figure 3.1 Pressure on our Science Communication System (Science museums represent all similar organisations like science clubs etc.)

Today, we expect two specific objectives to be achieved from the science communication system - scientifically based workforce and scientific literate citizenry.

The former objective, related to the top two pressures (Figure 3.1), is needed so that societies and economies can keep pace in a world where scientific knowledge and technologies are being exploited innovatively on a massive scale. The latter objective, more related to the lower two pressures (Figure 3.1), concerns those who should benefit from the personal and social application of science and who will be prepared to respond appropriately. Informal science communication system contributes in achieving both of these objectives.

3.3 Museums and the media

Besides classrooms, we mainly receive information about science from television, press, and science museums. All these media have great many similarities, for example; they entertain, inform, and intend to educate; they write text, edit text, and finally represent text to similar kinds of heterogeneous population; they translate the otherwise unfamiliar and inaccessible, but considered valuable and helpful, into familiar and accessible. They also share the same dilemmas in the process of communication: for example, dilemma of function between information and entertainment; dilemma of mediation between orality and literacy; dilemma of content between fact and fantasy; dilemma about responsibility and role between commerce and public service (Silverstone, 1988).

The decision where to stay on the continuum line of different dilemmas is crucial. Science museums are shifting their stand-point from education towards entertainment, and so theme parks are entering into educational arena. For example, the recent attractions in Disney World's EPCOT Centre, Orlando, such as *the Wonders of Life Pavilion*, *the Living Sea Pavilion*, and *The Land* (depicting the history of American agriculture), are explicitly educational. All institutions of science communication system encounter the similar dilemma of mediation between orality and literacy in order to achieve an effective communication. The newest trend is to mix the oral, written, pictorial and musical facilities in order to facilitate the communication process. Now-a-days, newspapers are available in print, on compact disks, and directly on-line. Similarly, on the role and responsibility dilemma continuum, museums are shifting towards commerce. More and more museums are now charging from the users and customers in lieu of their services.

Due to a varied emphasis on different dilemmas and varied relationship between time and space, there are obvious differences between museums and other media. They present different kinds of science. Both television and press focus on discrete events which in fact mix science with politics such as, hurricane warnings, floods, and other natural disasters. Science coverage tend to emphasise 'first in science', 'work and scientific life of an elite group of scientists' and 'medical science'. Indeed, for reporters and TV producers, anniversaries are a gift. At the more technological end of the business is the increasingly popular technique of exciting the reader with the potential value of any new gadget. Science is, thus, reduced to a kind of home-shopping.

The definition of news itself tends to frame stories about risk in terms of peoples, government or corporations to blame, rather than more deeply examining of political or economic system which makes decisions about risks (Shilts, 1987). In fact, the necessary framework and format for news remains available. Professional reporters do wait for an event. Once it occurs, they collect data - how many died, how many suffered, how much catastrophe and whom to blame - and overnight publish their text. The coverage of discrete events, for example flood, is often stripped of social and economic context. The resulting journalism is therefore formulaic, simplified and often ridiculous.

The coverage of science is 'formulaic' in the sense that potential issues are often neglected if they are not expected to be read by the majority of people or to create sensation among them. By 1985, for example, some 12,000 Americans were already dead or dying of AIDs, but newspapers largely avoided the coverage of the disease. They regarded it as a homosexual problem that would not interest anybody else (Shilt, 1987: xxiii). The situation, however, reversed over night when film star Rock Hudson died of the disease on October 2, 1985.

Notwithstanding best intentions, science in the popular media is largely ghettoised. The nature of science, how science is conducted, the process of scientific discovery, and ethics and values of science involved in the event are often found missing from the majority of news and documentary accounts.

From these media one, therefore, gets a typical view of science - lacking a sense of science as a cultural pursuit. While for scientists, who do science and talk about science in an artistic way, theories are 'symmetric or asymmetric', 'ugly or beautiful', or 'clumsy or elegant', the reporter is accustomed to see theories in terms of 'right or wrong' or 'gloomy or promising'.

Like press and television, museums are also heterogeneous media of science communication, but there are some obvious differences in its organisation, and in its perception of science and presentation. Museums occupy physical space and contain real objects; they encourage inter-activity; they allow the visitor, literally to wander through their texts. Museums have the greatest benefit that they have assimilated, can also assimilate in the future, into their texts all the useful features of other media. For example, museums use television and computer equipped with all the suitable and latest technologies in their text. Like other media, museums also do not always present a balanced view of science as they often exaggerate positive aspects of technology.

3.4 Science museums and science centres

Science museums have long been accorded as beneficial institutions. Since their origin nearly six hundred years before, they have been changing their objectives and roles, their physical appearance, and their organisation, without failing, according to the need and demand of society. For example, today's natural history museums which allow visitors to handle some part of their collection were not always so. Indeed, the earliest natural history museums were filled with specimens from the natural world, representing the individual interests or status. Generally, these collections were shown only to close friends, connoisseurs and distinguished visitors. Gradually, the museums allowed the public to see the collections. Over the centuries, arrangement of collection no longer existed merely to please the eye, but to understand the history of nature and of our planet. Again, a re-invigoration of these museums occurred in the recent years with the advent of new technologies, notably biotechnology and the computer. As a result, scientists employed biochemical similarities in DNA and other molecules to assess evolutionary relationships, and in future they may increasingly focus their efforts in maintaining the diverse life on our planet (Hoagland, 1989).

In another type of development, the introduction of computer technology in museums has spawned a host of information services for specialists and the general public which have shaped our museums as information centres. Patently, science museums took this new role in order to satiate the growing appetite of the public for more information and partly also of the responsible thinkers and philosophers who foresee the potential dangers of a culturally illiterate society.

From the development of museums over the centuries it can be said that they are sensitive, perceptible and discern to the changes in society. It is only for their fluidity, fluxivity (quality of changing with the wave), and adaptability that museums have always been welcomed and accepted as an essential gradient of culture by the people. Today's science museums are no longer dingy and dusty places, particularly for those who have recently paid a visit to a contemporary science museum. The nature of these institutions has changed to the extent that the word 'museum' lost its power to adequately define a coherent body of institutions that have similar missions, goals and strategies. To define a major research-driven natural history museum, a regional science and technology centre, an encyclopaedic art museum, or a local volunteer-run historical society as "museum" is like describing General Motors, Kmart, a regional bank, or a local convenience store as a "business" - accurate, but not helpful (Skramstad, 1993).

In the 1950s, the contemporary science and technology museum movement remained slow, but a number of science centres sprang up in the 1960s, mainly in the United States. These museums were stimulating and attracting places for museum goers but hardly for the populace. For the general public, museums were, and are, still an uninteresting place. In one sense, the early 1960s was the period of 'identity crisis' for the contemporary science and technology museums. The new science museums preferred to be called as 'science centres'. The Ontario Science Centre was created in the late 1960s with a moderate educational mandate - to stimulate the interest of the public in matters depicted by the centre. The opening of the Exploratorium in 1969 can be said a landmark event in the history of science museums. Indeed, some authors, such as (Shortland, 1987), see the event as a beginning when they regard the Exploratorium as the first science centre. But, it appears wise to consider the event a revolutionary step in the history of continually changing science museums.

Science centres and science museums have many features in common. Both institutions claim to further knowledge of science and technology; both welcome the public irrespective of their sex, age or even social status; both have special provision for school groups and claim to supplement school science education; both provide similar facilities to visitors; both charge for admission, if not restricted by the government policy in specific cases; both use working models and audio-visuals; and both are considered as informal science education centres. These many similarities often create a confusion in the mind of many people including museum professionals, as clearly visible from the following discussion at the Museum 2000 conference:

> Conference Participant (no name): The contrast we are facing at the moment is between people-centred activities and object-centred activities. I have nothing against people-centred activities. This is the fundamental contrast between for example, science museums and science centres: they are both honourable professional activities but they are not the same thing. We are concerned with museums: I wish you the great success in India in creating science centres but what you are creating they are not museums.
>
> Saroj Ghose: The difference between science centres and science museums is fast vanishing. There are lots and lots of institutions of a combined nature. The greatest example is represented by Neil Cossons here in South Kensington with Launch Pad in the traditional science museum existing side by side (excerpt from Boylan, 1992: 82).

Interestingly, there can be seen a wide range of misconceptions about the difference between science centres and science museums. Certainly, strictly object-centred ones are not science museums, as some of them also care for people. And similarly, all science centres, as a rule, are not repulsive to the idea of using objects. On the other hand, the ideological differences between museums and centres will not diminish by their merely side-by-side existence. People mainly identify 'hands-on interaction', 'collection-orientation', 'educational potential' or 'focus on past or present' as major elements which help us in making the distinction between a science centre and science museum. In the next few paragraphs, I shall discuss these elements one by one and attempt to make a convincing distinction between the two institutions.

One may encounter in many articles which read, 'The Exploratorium, the world's most stunning science centre, was opened by Frank Oppenheimer in 1969 with about 350 interactive exhibits and among them absolutely no collection at all.' In the 1960s, the potential of a science centre was, perhaps, identified in terms of number of artefacts displayed, as is quite evident in the editorial of *Museum* (UNESCO) quarterly review :

> The great national museums that have been established during the past two centuries still continue to have a preponderance of historical exhibits, perhaps 70% or more, but in the newer museums that are coming along the relative percentages of modern and historical exhibits tend more to be reversed, and it would probably be rare for more than 30% to be of historical kind. This change is so marked that there is a growing tendency to refer to the new museums ... as centres of science and technology (O'Dea and West, 1967).

On analysing such material from such authoritative sources, one gets a fair idea that it is the proportion of collection that matters, nothing else. But, it is absolutely wrong. It is our approach or purpose of using the artefact that matters, not simply artefacts. For example back in the 1930s, we found 'transport' artefacts in the *Children's Gallery* as well as in the *Transport Gallery* (in the Science Museum, London) but the purpose for having similar artefacts was different. In the *Children's Gallery* the purpose was to show how these artefacts were relevant in our daily lives, while in the *Transport Gallery* the purpose was to show their ponderosity and their technological achievement (Hartley and Cawood, 1935: 2).

The thinking pertaining to collections can be thought in terms of two broad categories: traditional thinking and modern (largely post-war) thinking:

> (According to traditional thinking) ... museum collections represent stored material culture of the past, while museum exhibitions are the principal medium through which that past is publicly presented.
>
> (According to modern thinking) ... museum collections are seen as the principal medium through which human relationships are created, expressed and validated (Pearce, 1989: 1)

Seen thus, science centres tend to follow modern thinking in their exhibitions. The fundamental is that science museums have artefacts for the 'benefit of posterity' (Durant, 1992: 8), but science centres have them to explain processes and underlying principles. For example, a vehicle in a science museum may intend to present - first vehicle made in the country, first vehicle used by the president, first vehicle fitted with a particular model of engine, or first vehicle attained so and so speed. It tends to neglect the principles and processes in favour of social, economical and technological achievements. A similar vehicle in a science centre deals with questions like how does a steering wheel work? or how does a brake system work? or how does an engine work? In fact, here simulated environment is created where the visitor can actually participate and see things happening.

Back in the 1970s, it was a debatable issue whether science centres should use artefacts at all and if so then to what extent? Now we can answer easily. There is no quantitative limit, not even 70 %, as long as we follow the science centre approach for the display of collections.

Unlike a science museum where a full gallery could be a result of the modernisation of an old factory, closure of brewery, or fire in a railway yard, exhibits in a science centre are decided on the basis of the school science curriculum and current scientific issues of common interest. Emphasis is given on 'science' which is necessary in our daily lives. First, the exhibit is conceived and then in order to make it meaningful, that is attractive, educative, participatory and experiential, to the extent possible whatever objects are needed that will only be collected. The collected object may also be tailored to the need of the exhibit. For instance, a large cut-out may be made in a petrol engine in order to demonstrate its internal functioning.

Secondly, in a science museum, one finds related exhibits in series which gives the impression of a historical survey of a particular field in a relatively closed space. One can hardly see a heavy 35 mm movie camera in a transport gallery. In a science centre, one finds exhibits in free standing structures and there may not be an obvious relation between any two successive exhibits. Indeed, in order to make the best possible use of the resources and space, the designer can experiment by changing the floor plan of the exhibits, or by using different combination of the exhibits.

Science museums and science centres also differ in their research activities. Science centres do not need to do scholarly research centred around the collection and their preservation. Science centres do 'evaluation' or 'feedback research' (if at all they do) for building new audiences, for enhancing learning experiences of the visitors, and for developing better and relevant exhibits.

My purpose of making distinction between science centres and other informal science communication system is to show that science centres are here to fulfil a specific demand and subsequently to play a very important role in making life better in communities. In the next section, I shall briefly discuss science centre movement in different places from where I shall take example for comparison.

3.5 Development of science museums/centres: a brief review of worldwide efforts

AMERICAN CONTINENT

Contemporary museums of science and technology that followed in the late 1930s and 1940s evolved differently emphasising some special feature. The Buhul Planetarium and Institute of Science was set up in 1939 with the emphasis on its planetarium and observatory programmes; the Dalla Health and Science Museum was created in 1946 largely as a health oriented science centre; and the Discovery Place/Nature Museum was merely a nature museum in Charlotte when established in 1947. Most of these museums were started by philanthropists, scientific societies, community leaders, local governments and school systems.

In general, the progress in the field was almost stagnant in the 1950s, but the 1960s can be regarded as the golden period in the history of science museums. It was the time when the idea of a number of pioneer institutions (the Ontario Science Centre, Evoluon and Exploratorium, to name a few) originated and took a concrete shape. In 1969, the Exploratorium was opened by Frank Oppenheimer in San Francisco which made an unprecedented world-wide impact on the science centre movement. It was opened with about 350 exhibits illustrating scientific principles. The science and technology centre movement experienced its greatest growth in 1970s and 1980s when came many institutions without artefacts and others with relatively few artefacts. In 1970s, the founders were groups of interested citizens - parents, scientists, businessmen, educators and others- who were interested in community betterment and providing more opportunities for learning about science and technology.

In addition to many large exhibition halls full of interactive exhibits, American science centres have a great provision for educational activities, both indoor and out-reach. Many science centres are featured with planetarium and/or big screen Imax or Omnimax theatres. Nearly every science and technology centre has a membership programme or has seriously considered starting one. Besides many other benefits, it provides a source for fairly predictable annual income and also enlists well wishers who advertise science centres by word of mouth. In general, these centres have to generate enough money for their day to day operation.

In Canada, the Ontario Science Centre took a lead position among the science centres in the world just after its opening in 1969. Now a chain of science centres (Nineteen science centres, according to a pamphlet produced by the Canadian Council of Science Centres) is functioning in Canada, like Science North in Sudbury, Science World British Columbia in Vancouver, Saskatchewan Science Centre, and Science Centres in Alberta and Nova Scotia. The Science North provides a traditional laboratory type experience to the visitors. Visitors first interact with a demonstrator and then themselves try things out in their bid to deciphering the magic and mysteries of science.

One trend that Canadian and American science centres share is an interest in providing more customer based services, operating more like business. The gap between science centres and theme parks is becoming closer day by day. On the one hand, in Orlando, Disney World's EPCOT Center develops educational exhibits and hosts travelling exhibits produced by the Smithsonian Institution Travelling Exhibition Service, on the other hand, Oregon Museum of Science and Industry, Portland, organises blockbuster exhibits such as, *Star Trek: Federation Science* and *Super Heros*. While in some area, such as visitor services, theme parks are superior to science centres, in other areas they are learning from museums. For instance, theme parks are seriously including educational elements in their programmes and services. In September and October 1993, EPCOT offered free admission to any Florida school groups (Mintz, 1994).

EUROPE

In the UK based science centres, their great strength is the specific scientific community that is developing around these ventures. Funds for science centre projects have come from the Nuffield Foundation and the Gatsby Trust which introduced the regional notion to initiate projects up and down the country. The Department of Trade and Industry has also injected a small amount of funds, but surprisingly enough, the

Department of Education and Science, the one government department which has most to gain from the science centre movement, has kept itself at a distance. Unlike other European countries, the British science centres have received little support from the government and industry.

In France, Denmark, Finland and Germany, science museums have received the support of their government and industry from the very beginning. For Cite des Sciences et de l'Industrie at La Villette, perhaps the largest science centre in the world with floor area 1,00,000 sq.mt. and Omnimax facility, a government grant of some 4.5 billion Francs (roughly £500 million) was offered to start the project and an operating grant for 1986 came to about 600 million Francs (of the order of £60 million) (Sutton, 1988: 2). In 1986, the museum earned about £5.5 million from admission charges and other activities for which charge was made.

In Europe, there are exceptions too. In fact, the Deutsches Museum had set up a precedence of receiving 'in kind support', in many form, from industry which was later followed by many other science centres, particularly in America. The Experimentarium, the Danish Science center, has also received generous in kind provision from industries and individuals.

Science Museum of Thessaloniki, Greece is one of the exceptional museums in Europe in that it is following America's lead. Like many museums in America, this museum is successfully organised and operated not by museum professionals, but by museum visitors and fans. The first phase of museum was started by 24 individuals in the late 1970s with no expenditure. Everything, including exhibits, manpower, rent, heating, electricity, cleaning, etc., was offered free (Iatridis, 1995).

THIRD WORLD COUNTRIES

In the third world countries science museums and science centres are coming up under the same roof, with plenty of activity oriented programmes. New science museums emerged, mainly through government's effort and massive support, in Argentina, Turkey, China, Ghana, India, Korea, Mexico, and Pakistan.

An impressive and indigenous development took place in India where a network of nearly twenty-two science centres is functioning under the state funded autonomous body the National Council of Science Museums. Science museums in India were set up with certain specific objectives in mind, one of which was related to the non-formal science education. With the adoption of a new national education policy in 1986, a stress has been laid on taking the fruits of planning to the grass-root level and particularly to the rural area as about 74% people are still living in villages. In consonance to the new education policy, the NCSM has decided to launch an ambitious project of developing 1000 school science centres (on an average two for each district) all over the country by the end of this century.

Birla, a leading industrial house in India, is also developing science centre in parallel to the governmental efforts. One ambitious project, Birla Science Centre in Hyderabad, has already been functioning since 1991 and another project in Jaipur is near completion.

3.6 Some common objectives with different emphasis

The term 'science centre' appears to have in its vocabulary no word which carries a sense of limitation with it. A science centre can be very big in size, and can be very small as well (science museums usually are not expected to be too small). It can have over one thousand exhibits in a metropolitan city, also twenty exhibits in a remote rural area. It can be industrially oriented or educationally oriented or scientifically oriented or at the same time can have a union of these features. These centres are concerned primarily with the natural and applied sciences and usually cover subjects as physics, chemistry, mathematics, life sciences, astronomy, engineering and medicine. However, if felt a need, they do cover themes as 'ecology hazards', 'sex education', or 'science and culture'. For example, the Ontario Science Centre has recently produced *Mindworks,* a special exhibition on the science of human nature, under the auspices of the American Psychological Association. It is perhaps the first concerted effort to present the subject of psychology in a science centre.

Similarly, these centres may have their own specific objectives. It can be seen that the science centres in the developing countries have their own agendas, quite different from the agendas of their counterparts in the developed countries. One can get this difference by comparing the following two examples.

Amlendu Bose, former director of the National Council of Science Museums, India, maintains that science and technology centres in developing countries have somewhat different emphasis and explains this difference as :

> The level of understanding about science and technology by a vast majority of the people in these countries is insignificant, if not non-existent. Obscurantism and superstition still persist in many regions: fruits of science did not percolate down to the bottom of the social ladder. To many, science is no more than an object of awe and wonder. Naturally, the

> people, by and large, are not receptive of new ideas or adaptive of new techniques. But the state is committed to make them move forward, and to change the entire social structure ... It has become the obligation of science and technology centres to undertake the responsibility of educating the masses - literate, semiliterate, or even illiterate - about the social benefits of science and need to imbibe a value and practice a way of life imbued with scientific outlook (Bose, 1978)

J. G. Green, an industrialist and chairman of the board of trustees of Ontario Science Centre's formative years, explains the purpose of having a science centre as:

> If Canada is to forge ahead in scientific research and industrial applications, more young people must become interested in careers in the sciences (Young, 1970).

It is not to say that whatever J. G. Green says for Canada is not applicable to India, or on the other hand, Canada is free from the problem of scientific illiteracy. It is only to be emphasised that although the primary motives of having a science centre are quite different in the developing and developed countries, but there are certain objectives which are common agendas to pursue everywhere. For example, all science centres aim to eradicate scientific illiteracy and also to interest youngsters in scientific and technological careers. They have realised that they can achieve their goals through providing them a non-threatening, stimulating learning environment (Figure 3.2). In support, IMPULS, a newly developing science centre in Amsterdam, speaks for many.

> IMPULS aims to attract families, school groups and visitors of all ages, in order to stimulate interest in and appreciation of science, technology and Dutch industry.
>
> To achieve these goals, IMPULS will offer an inspiring and attractive environment, encouraging the visitor to explore, create new experiences and to acquire new insights in the developments and applications of science, technology and industry (IMPULS Science & Technology Centre, Fact Sheets, 1995)

Thus, the growing concern for providing 'learning environment' becomes a primary objective of a science centre. As a learning environment, science centres aim to provide opportunity for individual taste, ingenuity, innovation and invention.

In a survey, 8 per cent people believed that the success in life is more dependent on the 'genes' one inherits from one's parents. In contrast, ninety-two per cent people told 'learning and experiences' as a major factor responsible for success in life (World Opinion Update, Vol. XIX, September 1995). Without stimulation from the environment, more complex intellectual skills and competencies of a child may fail to develop or may develop in only restricted ways. Too much inappropriate stimulation, on the other hand, may be as damaging as a lack of stimulation. The process of learning and understanding is exceedingly complex. In the next section, I shall look into the structure and characteristics of learning in a science centre.

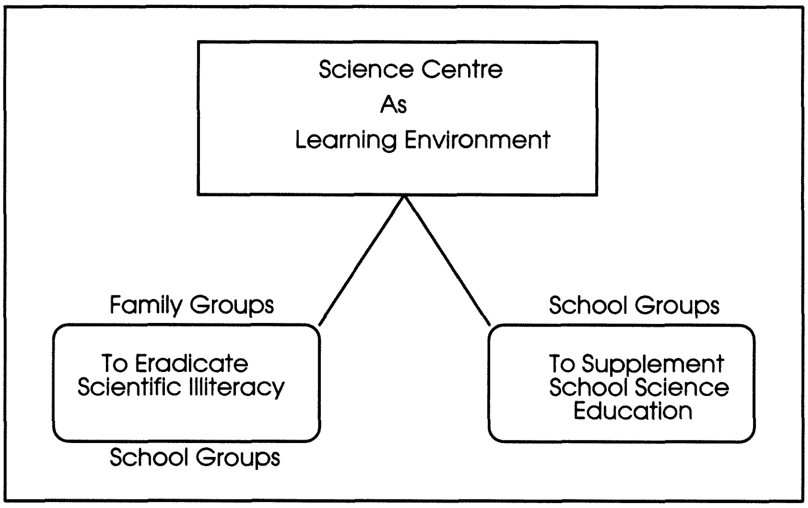

Figure 3.2 Science centres as learning environments: A theoretical framework for measuring effectiveness.

3.7 Science centres as learning environments

Science centres require us to think about the museum environment as a whole: the ways in which physical and social interaction influence information seeking and information using behaviours, and the ways in which museums provide special opportunity for learning. The architects of science centres assert that they have tried to create such an environment where the user should not necessarily feel that he or she is learning or accruing facts, but the user should experience that he or she has gained something concrete, permanent and complacent out of the visit.

Curiosity, exploration and play are important elements of human learning process starting with infancy and continuing throughout the entire life cycle. Hunt's theory of intrinsic motivation and open education suggests that the student's choice is an important variable in instruction (Hunt, 1965). Piaget furthers the notion that certain types of learning are not amenable to direct instruction. He emphasises the importance of exposure to materials, rather than of direct instructions. Commenting on the effectiveness of a classroom demonstration of controlling variables, Piaget said, 'It would be completely useless, children must discover themselves' (Hall, 1970). Research studies have shown that free choice leads to improvements in controlling variables, and such control is important in the development of scientific reasoning (Bowyer and *et al.,* 1978; Linn, 1980). The capacity of young people to resist being educated is often under-estimated. N. G. Ardlie (1993), a retired comprehensive school head, rightly claims that no education system, no teacher can force a child to work against his will. All we can do is to provide the context in which they want to work.

A successful learning experience is based on three important principles- first, learning involves integration and differentiation of an already existing behavioural repertoire, and this requires experiences that are compatible with existing interest, needs and skills. Second, learning must invoke a sense of wonder, excitement and curiosity. Third, the behaviour that is elicited during the learning process must have positive and interesting consequences for the visitor (Chase, 1975).

In almost every country there is a new interest in raising standards at school. To engender an environment that enables pupils to obtain maximum benefit from schools, Mick Norton. Deputy Head of Gwernyfed High School in Powys, identifies the following characteristics:

> Learning has to be an active process because knowledge and understanding are constructions which are built up from within. Good teaching should afford pupils situations where experiments - in the broadest sense are possible; where the child can try things out, manipulate materials or symbols, pose questions and seek answers; where he or she can reconcile what is found out at one time with results on other occasions and can compare ideas and findings with other pupils.
>
> [Secondly, the environment should encourage] corporate learning which allows children to inspect their ideas publicly, to offer tentative solutions for consideration, to juxtapose different points of view: working together enables the children to challenge their opinions, to make re-adjustments to their own, to re-frame knowledge in order to make it personal and meaningful (Norton, 1991).

How can the behavioural principles of learning and characteristics of good learning environment apply to the diverse science centre environment? When someone comes to a museum, what do we know about that person's background, interest, needs, or skills? How do we know the kind of experience most likely to elicit wonder and curiosity? Do visitors get enough opportunities to try things out? Does the corporate (social) learning takes place at all? These are some main questions which we should address and answer in the context of a science centre.

Let us consider first the issue of diversity of visitors. Science centres are increasingly segregating visitors and attempting to design their texts according to the interests, needs and aspirations of the targeted population. Today, one should not be surprised if he or she sees words- like, *the Cite des Enfants, a part of the vast Cite des Sciences et de l'Industrie, Paris, provides separate sections for children; one for the three to five year olds, other for the five to twelve year olds* - printed in publicity brochures. Recently, the Science Museum, London, has opened four age-related interactive areas (*The Garden* for 3 to 6 year olds; *Things* for 7 to 11 year olds; *On Air* for 12 to 19 year olds; *The Secret life of the Home*) for children. In one sense, science centres are becoming like a shopping complex where they have a variety to offer to the customers. In some cases, in order to have an idea about the future prospects of the proposed project, they also conduct a type of survey, called front-end evaluation. For example, Sandra Bicknell conducted a front-end study in 1992 at the Science Museum, London, for *Health Matters* which opened in 1994 (Bicknell, 1995).

Once the target group is decided, the features of the environment and its content follow accordingly. For example, the designer usually selects fast primary colours while preparing the scheme of a children's section. Similarly, the choice of exhibits is made very carefully. It is aimed to provide sufficient concrete experiences that will allow the child to build up his or her concept of the rational world. Identifying, associating, organising, classifying and perceiving relationships are important aspects of learning in the early years. Dramatic play is of absorbing interest to children. In the *Living and Working Together* exhibit at Eureka! The Children's Museum, children are encouraged to participate in the adult world and explore the hidden aspects of a bank, a shop, a garage, a factory, and so on. In the process, they identify a number of things and know about their uses and functions as a way of learning about them. In this way, after taking into consideration the background and special needs of the user, all possible efforts are made to create a stimulating and vibrant learning environment. This feature was found altogether absent in traditional science or other museums where same collection, same way of presentation and same environment was available for all visitors irrespective of their diversity.

Science Centres also intend to give equal attention to both men and women. Behavioural studies reveal that men and women differ not only in physical attributes and reproductive function, but also in the way in which they solve intellectual problems. Men, on average, perform better than women on certain spatial tasks. Men have an advantage in tests that require the subject to imagine rotating an object and manipulating it in some other way. Women tend to be better than men at rapidly identifying matching items, in solving quiz games (Kimura,1992). A recent study (Kremer,1992) recommends seven points to be taken into consideration for providing equal opportunity and for making information equally useful to both, boys and girls. Now, a thought on the sex brain difference is also given at the time of planning full gallery and its individual exhibits.

The motivational aspect of exhibit planning, that are so important for the voluntary museum audience, involves both 'intrinsic motivation' (self-motivating features of the museum environment) and 'extrinsic rewards' awarded for attending to exhibit contents following instruction and so on. Intrinsic features include free exploration, group interaction and social activities, discovery, manipulation, achievement, completion of task, curiosity and challenge that can rise from interaction from exhibit content. But intrinsic motivations may not be sufficient for obtaining the extra effort and time needed for higher degree concepts and attitudinal impact. Extrinsic rewards are necessary when the desired learning activity requires more sustained efforts than most visitors are willing to give. The sustained attention of computer games offers clues for their effective use in educational exhibition strategies. As a result, in new science centres we see the increasing and effective use of the potential of computers which can guide visitor usage of exhibit content and help make learning from exhibits more fun (Bell, 1991).

Inter-active video presentations provide visitors with a flexible and individualised interpretative mode. Being able to select the content, sequence, pace, and amount of information presented, visitors can actively research their own interests selecting from a potentially vast number of presentations. This empowering of visitors is an important advantage for informal learning settings with heterogeneous audiences.

There is growing evidence that recently science centres are using more and more multi-media innovations appropriately with exhibits to increase their effectiveness and attracting power. Although, in these centres, exhibits present an exciting challenge to majority of their users, but there may be a few people who remain uninitiated to new technology or do not like man to machine communication, as according to one report only 30% visitors use computer based exhibits (Serrell *et al.*, 1991). To this group of audience, the gallery assistant or volunteer provides necessary help and makes best efforts to bridge the gap between ignorance and understanding.

Dr W. M. Laetsch, director of the Lawrence Hall of Science erases all the misconceptions one may have about the learning and learning environment in a science centre, he says :

> Informal education is education which permits people to approach it on their own terms. In other words, people bring their own agendas to the learning environment, where they explore their special interests in participatory ways. It is perhaps in such an environment that science can be learned best, not only because people learn in different ways, but because informal learning environments allow different channels of learning (Laetch quoted in Kimche, 1976: 7).

Science centres have far-reaching potential. For their potential benefits science centres have been welcomed all over the world. As a result, today 200 million visitors visit 600 science centres per year throughout the world. Now, people both visitors and museum staff expect a lot more from science centres. A report by the American Association of Museums, *Museums for a New Century,* is evidence that museums seek to foster visitors ability to think. The report states that museums should not only meet the needs of visitors seeking to make sense of their imagination, but also enrich thinking, 'provide opportunities for growth and thinking, as well as seeing' (Commission on Museums for a New Century, 1984).

Museums professionals strive for excellence in their mission and visitors expect excellence in their museum experiences. Basically, museums visitors can be divided into two broad categories: family groups and organised school groups. Both of these populations have different motives for visiting science centres. While the motives of a family group may have usual outing and more to do with scientific literacy, motives of school groups may have more specific in nature, for example preparation of a particular science lesson (Figure 3.2). In the next part, we shall explore both of the possibilities.

3.8 Science centre, mass illiteracy and scientific literacy

> Science museums believe that scientific literacy is as fundamental as reading, writing, and arithmetic skills, and they dedicate their resources to informing the public about scientific phenomena and ideas in an entertaining way (Templeton, 1980).

Scientific literacy is one of the main concerns of science and technology centres. Over the years, there has been a healthy debate on the definition of the term 'Scientific literacy'. It is one of those terms that is often used but seldom defined. Scientific literacy is not a pre-defined universal concept, but has been changing with time and according to the nature of society. In a highly developed technological society, it would have a different structure than a developing or less developed society.

In general, scientific literacy is defined in terms of knowing specified contents of science. In his best-selling book *Cultural Literacy: What Every American Needs to Know*, E. D. Hirsh Jr, an American Professor of English Literature, listed some 5000 concepts and other references which, according to him, must be shared by every American if they were to maintain the unity of their culture. Interestingly, his suggested body of knowledge is comprised of several hundred scientific terms ranging from 'Absolute Zero', through 'Mutation' and 'Nuclear fission', to 'Y chromosome'.

But, some people, such as Jon Miller, exhibit their reservation on the fact-oriented basis of scientific literacy. Jon Miller (1983) proposes three-fold definition of scientific literacy - knowledge of scientific facts, understanding of methods and processes of science and understanding of the impact of science and technology on society. As a matter of fact, the concept of scientific literacy is broadening on the line suggested by John Dewey some 80 years ago. He emphasised the developing of scientific habits of mind - the habits of logical thinking, of quantitative and deductive reasoning, of proper reasoning and reliance on sound evidence.

In the late 1980's, the American Association for the Advancement of Science appointed a group in an initiative 'Project 2061' on the question of 'what understanding and habits of mind are essential for all citizens in a scientifically literate society' (National Research Council on Science and Technology Education, 1989). This scientific literacy initiative does not emphasise more and more issue based knowledge but provides a common foundation for a self-directed and self-sustaining life-long learning. The elements of scientific literacy are placed in four categories:

- The Scientific Endeavour; a union of science, technology and mathematics.
- Scientific Views of the World; which would stress world perspectives illuminated by concepts and principles of science.
- Perspectives on Science; viewing scientific activity as cultural intellectual history emphasising powerful ideas that reach across mathematics, science and technology.
- Scientific Habits of Mind; emphasis on shared values, attitudes, and thinking because of their importance in everyday life.

This concept of scientific literacy, largely defined in terms of competencies in mathematics and natural sciences, heavily emphasises the economic productivity sector of American society.

Recent studies on scientific literacy indicate that all countries have to worry about its dismal state. According to national surveys, only about 6 or 7 percent of British and the United States adults can be called literate about science. Even basic knowledge is lacking. Well under half of the Americans and one-third of the Britons know that the earth is revolving around the sun once in a year (Culliton, 1989; Durant *et al.*, 1989). It means that there are still many who are receiving the world view through Aristotelian spectacles where the earth is the centre of the universe and human is the most important creature. Furthermore, according to recent survey reports, 47 per cent Americans (*Times Educational Supplement* 2, 10 November 1995: 10) and 29 per cent Britons (*The Telegraph*, 13 September 1995) accept the Biblical account of creation as factually true.

Science Centres in North America aim to portray a world view and provide visitors enough opportunity for first three elements of scientific literacy. We live in a society which acts, in fact, like a whole, but in which the holistic view is becoming increasingly obscured, and in which fragmentation and differentiation seem the norm. Science centres, even though they are compartmentalized, somehow make one aware of the wholeness and unified concerns of science, technology, mathematics, medical sciences, art and history. For example, Museum of Science and Industry, Chicago has more than 2000 exhibits spread in 6,35,000 sq. ft. floor space. Among the many fields represented in museum exhibits are physics, chemistry, electronics, computer, aerospace, food and nutrition, electricity, natural gas, petroleum, superconductivity, newspapers, automotive engineering, architecture, machine tools, water management, economic and finance, agriculture, medicine and health, telecommunications, waste management, the postal service, the armed forces, time-keeping, coal mining, the circus, plumbing, scientific and business achievements.

In general, the exhibits look at the scientific principles, technological implications, and social implications of science and technology. The results are encouraging in a specially organised exhibition entitled 'Inquiry' designed to address public understanding of the progress of science. According to an evaluation report, over 80 per cent visitors were able to describe the scientific process, at least partially, after experiencing the exhibits (Ucko,1985).

On the role of science centres in North America, Susan McCormick says, 'As we head into 21st century, science museums in North America will continue to strengthen and broaden as advocates for scientific literacy, and as leaders in their communities in actively addressing the challenges of an increasingly technological society, on both grass roots and national level' (McCormick, 1990).

The American structure of scientific literacy simply cannot be applied to the Third World countries where we have a vast proportions of illiterates who use thumb impression as their identification (For example, literacy rate: India, men 57%, women 29%; Pakistan, men 40% women 19%; Bangladesh, men 43% women 22%; Ghana, men 64% women 45%). Science centres should have to address issue based concerns. For example people are still not conscious of the population explosion. People have firm belief that the new arrival will bring his (always expectation for male issues) food with him. The woman is considered responsible for not giving birth to the male child and for that is often harassed physically and mentally by other family members. The female child is discouraged from pursuing education. Science centres in developing countries have to design exhibits and community programmes to fight illiteracy and superstitions and then scientific illiteracy.

The public in the Third World countries can be placed into three categories - illiterates; non-scientists, including our bureaucrats, future managers and decision makers; and scientists. The print media as a means of promoting scientific understanding is useless for illiterates. About the necessity of a science centre in these countries, Dr. Ghose, then director of the National Council of Science Museums, India, said:

> Mass illiteracy in vast areas of Asia and Africa limits the use of schools for basic science education. Printed matters e.g. newspapers, hand-outs, instruction leaflets, are too passive and beyond the reach of the illiterate. Radio, films and television are impersonal and provide little interaction for the successful program. Popular lectures give the necessary personal touch, but lack in public appeal. We are left with one and only one alternative - a science centre - which can educate a vast proportion of non-school-going people through fun and entertainment (Ghose,1980).

For the remaining two groups, that is non-scientists and scientists, formal school education is a difficult challenge. Non-scientists require a familiarity and 'scientific literacy' that will help them to deal with the problems and decisions of a technological society. Scientists need accelerated, personalised and high quality training in difficult and fluctuating or uncertain fields. In the school courses, designed to purport scientific literacy among the people in both groups, there are inherent problems. The material is delivered much too rapidly and in far too great a volume for any significant understanding of ideas, concepts, or theories to be assimilated. The pace makes difficult, if not impossible, the development of any sense of how concepts or theories originate, how they come to be validated and accepted and how they connect with experience and reveal relations among seemingly disparate phenomena. The courses envisaged and designed as 'streams of words' have not solved and will not solve our educational problem. We have to also follow additional facilities or methods to promote scientific knowledge among school goers.

Emphasising this point the late Frank Oppenheimer once said: 'Explaining science and technology without props can resemble an attempt to tell what it is like to swim without ever letting a person near water' (Oppenheimer,1968a). Aron also supports this notion and says that scientific literacy can be cultivated only from 'concrete observational experience' not through 'verbal inculcation' for most individuals (Aron,1983). Research studies indicate the positive educational value of personalised interactive experience and of 'responsive' systems in the museum settings (Screven,1974 ; Thier and Linn1976). Borun and her colleagues also come forward with the superiority of exhibitions over other conventional methods of communication. They say,

> Given an equivalent amount of time and attention, more scientific facts can be learned from a lecture and a book than an interactive exhibit. But how often do people go to a lecture and pick up a science book? The advantage of exhibits is that they are exciting experiences which stimulate an interest in learning science. In this way they complement other science communication media (Borun, 1977).

Science centres, as a means of fighting against prevailing scientific illiteracy among the general public, are unique in that they are able to use all the media of communication, i.e. static as well as dynamic media. Roger Miles and Alan Tout emphasise the potential of the exhibition in furthering the public understanding of science as these offer a range of choices, learning by doing, static support (labels, graphics, charts etc.), dynamic support (interacting video, computer graphics, audio guides), demonstration by staff (Miles and Tout, 1992).

3.9 Science centres and school science programmes

Much of the rhetoric of being a science centre is ascribed to its education potential. Science centres organise school programmes for students as well as for teachers. The experience of organised school group is similar in science centres anywhere in the world. Everyday in morning hours, a few buses arrive, some from as far as 250 kilometres, and disgorge hundreds of school children. About fifty students from each bus, with heavy bag and water bottle on their shoulders, enter one by one through the centre's main door. The accompanying teacher reports at the reception and within minutes completes the necessary formalities of registration, then he or she instructs them to take their position in the briefing room. A museum education staff briefs them in a short session and later follows up with them in the exhibit halls.

In addition to the guided exhibition programmes, many special programmes are organised inside the science centre, like fixed-time science demonstration lectures, popular science lectures, scientific film shows, competitive science seminars, science quizzes, summer research projects, sky observation programmes, computer awareness programmes, teachers' training programmes, pet clubs, hobby clubs, resource centres, amateur ham radio training programmes and other activities.

Some science centres have attached planetarium facility. Such centres also organise regular planetarium shows. In America, 118 museums and science centres have this facility (Danilov, 1990: 253). In India, science centres organise regular inflatable planetarium shows with sitting capacity of thirty children or fifteen adults. More than fifteen different programmes, each one of half an hour duration, have been designed which are handled by trained museum education staff who make these shows lively and interactive, unlike passive recorded programs of conventional planetarium. In these programmes, viewers can ask as many questions as they like during the show.

In addition to in-door activities, science centres also organise out-reach programmes, like mobile science exhibitions, science by mail, nature awareness programmes, model school science centres, science fairs and other activities.

About museum education programmes, almost all professionals express the same view that these programmes have been envisaged to supplement, not to replace, regular classroom science education. Indeed, there are areas which schools find themselves unable to concentrate due to unavoidable circumstances such as examinations, vacant posts of teachers and less enthusiastic teachers. To illustrate, schools have the responsibility to provide humanised science education to the students. But, classroom lessons focus mainly on products and processes. The feeling that a science education should do more than feed a child a cold diet of product and processes of science is neither recent nor novelty. The issue has been a subject of discussion among educationists since, at least, the turn of this century. But it did no more than lip service. This issue has been largely ignored by the teachers for examinations and other administrative priorities. In these circumstances, science centres should supplement school science education in real sense and adopt humanised science education as one of their objectives.

TEACHERS' TRAINING PROGRAMME (TTP)

> Museums teachers' training programme has a multiplier effect because it benefits hundreds of kids in dozens of schools.

Most science centres have the above philosophy, described by Phyllis S. McGrath, General Electric Foundation's project manager, behind their teachers training programmes (Bailey,1988). The Science Teacher Education at Museums (STEAM) programme is one of the most successful projects ever funded by the General Electric Foundation. The STEAM project has provided funds to the Association of Science - Technology Centres, which in turn has granted mini grants to museums across the country for organising TTP.

More than 100 science centres regularly organise teachers' training programmes. It is not the scope of this section to give the details of all of these but I shall try to give broad spectrum of the picture. In America, the Pacific Science Centre and Lawrence Hall of Science train a large number of teachers every year. The Lawrence Hall of Science trains teachers through its EQUALS programme to provide special encouragement to girls and minority to study science. Its family math programme shows teachers how parents and teachers can work together to help children learn. The Exploratorium is fast coming to see itself as an adjunct educational resource for schools and their teachers. Teachers participate in eighty hour summer programme which is followed during the academic year by activities after school and on weekends.

In India, all science centres irrespective of their size and status organise teachers' training programmes (TTP) in collaboration with the state or district educational authorities on regular basis following standard procedure which is given in the TTP manual produced by the National Council of Science Museums. About twenty in-service teachers participate in each session of fifteen days. In this duration, teachers attend lectures in morning sessions and develop ten kits with their own hands in afternoon sessions. All the kits are given to the teachers for their use in the classroom.

Science centres approach their educational mission somewhat differently depending on the nature of science, varying emphasis on scientific literacy, their historical development and community needs. All try to avoid duplicating or competing with school offerings available in the area. The educational programmes in a science centre, on one level, promote basic understanding of science through a richer, fuller science course than the school could afford themselves. But then science, in turn, becomes the vehicle for reducing social isolation by encouraging the exchange of ideas among classmates of different castes, regional backgrounds and religions.

3.10 Assessing science centres

The educational objectives of science centres are varied. From the following quotations, these objectives appear to lie on a continuum line whose end points are the affective and cognitive goals.

> There is a weakness in the teaching of science in our elementary schools because no specialists are available at that level. One of the centre's functions is to provide strength at this point. Indeed, all students return to formal instruction in their own schools with renewed interest and stimulated curiosity (Douglas A. Penny, first educational director of the Ontario Science Centre, quoted in Young, 1970).

> In informal education, where a required syllabus and examinations cannot be used to keep people studying, the need for depth is probably the biggest single challenge. Informal educators need to provide depth even at the expense of coverage. Informal science educators should invite people to delve deeply into scientific domains and to build organized bodies of knowledge. Only in this way will people be able to remember what they have encountered in informal science settings and use it to develop further knowledge (Resnick and Chi, 1992).

In the past decade, the emphasis on cognitive learning has increased profoundly. For example, in 1984, the American Association of Museums' Commission on *Museums for a New Century* purposefully focused on "learning" in place of "education" and sought to reach consensus about the nature of learning in museums. John Falk (1985) also listed, among other goals of science museums, the successful communication of cognitive information as a criterion of excellence.

Still, there prevails a great confusion over the domain of learning in museums which stems in part from the failure of museum professionals to articulate, to the satisfaction of all involved, the nature of the learning experience (Commission on Museums for a New Century, 1984: 57). But, this is not a simple task. How we can be sure that what and how much an individual or a school group has learnt as a result of the single visitation to a science centre.

> As long as evaluation of the museum experience is carried out with methodologies designed to measure cognitive gains, or the quantity of information absorbed, the danger exists that the museum exhibit will fall short of their potential to be inspirational and provocative stimulator of ideas as well as transmitters of knowledge (Kimche 1978).

The 'meaningful learning' is a subjective concept. While for some a successful visit means the accumulation of facts and information, others see success in terms of process of learning rather than the outcomes:

> The emotions and feeling - responses which give rise to attitudes, values and perceptions are understood to underpin the acquisition of knowledge. It is well understood that at all stages it is the need to learn, the motivation to find out, that is critical for success in learning. It is here that museums and galleries can play their part best (Hooper-Greenhill, 1994: 1)

In the present thesis, I aim to explore the affective domain, partly because there appears almost consensus about the value of this aspect. We are living in the era of expectation revolution. We have expectations of almost everything, actions and events. For example, the museum staff expect school groups to learn, students expect to have fun, and teachers who organise field trips concern students' motivation. According to the 'recorded views' in literature, all these three groups have different expectations of science centres (Figure 3.3). My strategy is simple. I shall assess the effectiveness of science centres against the primary educational objectives of science centres and the expectations of its users (in this case students). In other words, I shall look into the process how science centres are responding to the expectations of schools students and teachers.

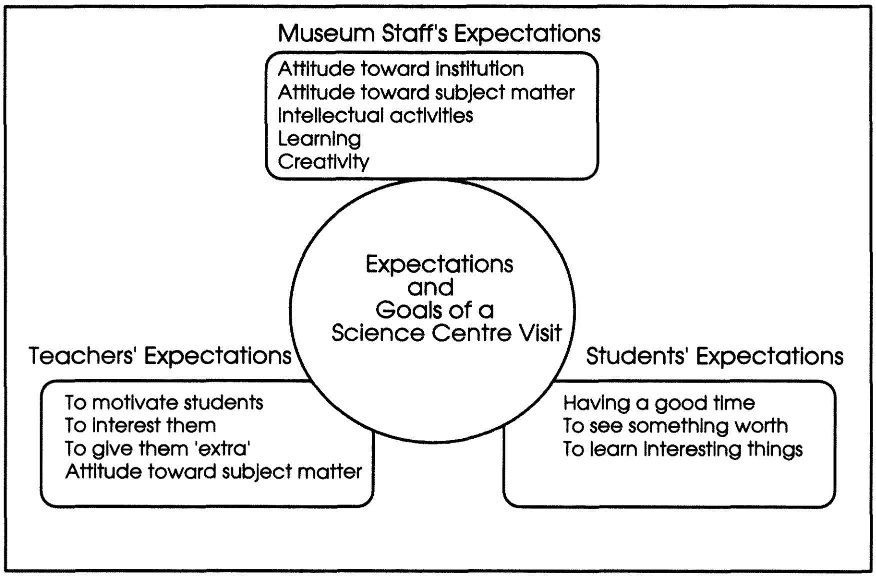

Figure 3.3 The world of expectation revolution: different groups of people have different expectations of an event.

Almost all researchers and practitioners suggest affective learning as a key area. A majority of school students included in this study also show their agreement with this view. Two hundred and four students out of 227 (90 per cent) volunteered to write their experience in the National Science Centre, Delhi, and to tell about one or more exhibits they liked most. As the question addressed to them was an open-ended one, the responses of students varied greatly, but a majority of the responses appear to have concerned with the affective learning. For example, a student who begins his response with criticism about out-of-order exhibits in the science centre says in the last paragraph:

> The science centre was really a nice and interesting place to visit. It helped me to understand so many experiments and phenomena which I could never understood through books. I really liked the place very much and would like to visit very much whenever possible (S. No. 48).

In the study, no student was forced to write. No student was asked whether they would like to visit the science centre again. But, some students preferred to mention it which shows their interest and enthusiasm. For them, the museum was no longer a lifeless place, or "a kind of beachhead with no life of its own" (Taylor, 1981). Students also exhibited their increased interest in the presented science which is, in fact, a greatly desired outcome.

In affective dimension, in order to evaluating the potential of science centres, three parameters have been chosen: Attitudes toward Science Centres, Attitudes to Science, and Continuing Motivation in Science. If a science centre visit prompts the students to come again, helps them in understanding complicated process and phenomena and thus interests them in science, and creates in them the will to learn science and about science, then science centres can be said to be effective learning environments. But, the task of registering visitors attitudes and feelings about science and science centres is not simple, as there is a real dearth of measurement tools.

> New evaluation tools need to be developed that can meaningfully register the museum goer's attitudes and feelings, not only about science but about the informal learning environment itself (Kimche, 1978).

In the next chapter, I will mainly deal with the methodologies which will be used for measuring the changes in the chosen parameters - Attitudes toward Science Centres, Attitudes toward Science, and Continuing Motivation in Science - of school students as a result of their science centre visit.

Chapter 4

Research Methodology and Strategy

A Framework for the Present Thesis

Introduction

The aim of the present study is to understand the impact of a science centre visitation or, put more straightforwardly, the effect of science centre settings on young students. How can knowledge, the dimensions in which students are expected to gain as a result of their science centre visit, be explored and how can the extent to which science centres achieve their educational goals be estimated and verified? This is a central question for the present research to reflect upon and, at the best, to answer. In this chapter, I aim to present the framework of the research design and would also present the chapter plan of work to be followed.

The assessment of the impact of a science centre environment on students is not a simple task, as many clusters of variables are involved in the course of a visit. For example, the nature of intellectual task is represented by one cluster of variables; the personal aspirations, concerns and values (religious and cultural) constitute the second set of variables; the structure of the group (socio-economic level, gender of members and size of the group) as a whole belongs to the third set of variables; the complex and unresolved issues from their actual social world are the fourth set of variables; and so on. Understandably, it is really a convoluted task to consider all the variables simultaneously. Hence, in order to proceed further, the problem is to be simplified.

In simple terms, the students' behaviour and achievements can be properly understood by taking into account the responses of a 'whole person' to a series of intellectual tasks presented in the gallery space. Basically, two complex variables of considerable importance can be seen to be involved here- the visitor (user) and science centre (setting). Therefore, in our bid to understanding the impact of a science centre visitation, we first and foremost are required to look into the complexity of these variables.

4.1 Science centre and the complexity of human behaviour

Traditionally, the understanding of human behaviour is considered fraught with complexities, sometimes to the extent of it being perceived as incomprehensible. In the past, experiments were performed on lower order animals with the expectation of developing a blue print of human behaviour. The complexity of human behaviour was not studied systematically (from the perspective of cognitive and developmental psychology) until the 1950s when the researchers first tried to find the causal inferences of occurring behaviours. In *The Psychology of Personal Constructs*, Kelly (1955) proposed a view of people actively engaged in making sense of and extending their experience of the world. The cognitive revolution of the late 1950s, far from being a mere revolt against behaviourism as it is usually understood, was aimed at discovering and describing formally the meaning that human beings created out of their encounters with the world. Today, the issue is so important that researchers in many fields, to name a few sociology, anthropology, social-psychology, educational-psychology and ethnography, are actively engaged in understanding the complexity of people.

Fifty or so years ago, a science museum was a 'simple' space provided for making science simple and accessible. A 'simple' space was characterised by a mere aggregation of isolated objects which even do not require a special care of the curator (Hoyle, 1912). The displayed artifact (for example, an insect with a pin through it) was seen as being 'inherently communicative' (so it was displayed mostly without a label or, at the best, sometimes with a Latin name beside it), 'complete' (even if it had lost a few of its legs from the attack of mites) and 'sacred' (not to be touched). In the event of non-delivery of the message, the potential of the visitor was mostly suspected: he or she was considered 'mediocre' or 'empty'. An average visitor was a passive spectator who was allowed to behave in restricted way. Both the utility and the simplicity of the space were taken for granted. But, in the light of recent research studies it has been, and is increasingly being, recognised that the process of communication through exhibit media is controlled neither by the artifact itself nor by the curator or the designer. In new research studies, museums are increasingly being explored for their hidden agendas, untapped potential and complexities:

> exploring museums for their conscious agendas, their deliberately constructed messages, for the exchange of experience and meaning between the visitor and the museum, is leading to the greater understanding of the potential of museums to challenge, stimulate and create meaning (Kavanagh, 1992).

Both the complexity of human behaviour and the complexity of the environment multiply when they come together (during the course of a science centre visit). Keeping in view the level of complexity involved, the question arises: can we really measure the impact of a hands-on setting and if so then by what research paradigm - quantitative or qualitative? And within a paradigm, what research methods are to be followed? Before going further it appears reasonable to give a fair idea of the level of complexity during the course of a visit by following an example of a chimp behaviour in a much less complex space (than a science centre space):

> A banana was suspended from the center of the ceiling, at a height that a chimp could not reach by jumping. The room was bare of all objects except several packing crates placed around the room at random. The test was to see whether a lady chimp would think of first stacking the crates in the center of the room, and then of climbing on top of the crates to get the banana.
>
> The chimp sat quietly in a corner, watching the psychologist arrange the crates. She waited patiently until the professor crossed the middle of the room. When he was directly below the fruit, the chimp suddenly jumped on his shoulder, then leaped into the air and grabbed the banana. (Gardner, 1978; vi)

The example clearly demonstrates the level of complexity and uncertainty of behaviour(s) in a relatively much simpler example than a child interacting in a science centre. Recent research studies suggest that the brain of even a three-four year old child is much more advanced than the brain of an adult chimp (Christmas Lecture 1994, delivered by Susan Greenfield). Understandably, a science centre setting, full of 'talking' objects, is quite inter-active, communicative and responsive to prompt even a child to act in predictable and unpredictable ways and perform a range of activities. The recognition that children do already have ideas about the things around them is emerging from a growing body of research into learning. In the description of 'new learning', *the process* in which the existing ideas (of a child) are linked to new events and are tested as possible explanation plays a key role:

> For the child learning science, as for the scientist, the way understanding develops depends both on the existing ideas and on the process by which those ideas are used and tested in new situations. (NCC 1989, A7, paragraph 6.3)

Significant outcome as a result of inter-action with an exhibit depends on motivations, attitudes, informal ideas and skills of reasoning and investigation (hereafter referred to as process skills), such as planning and carrying out fair tests; exploring and processing information at hand; interpreting findings; reviewing evidence and procedures critically and being willing to change ideas in the light of evidence. The process skills involve both mental and physical activities. In order to understand the impact of the science centre setting, one is required to make sense of these mental and physical activities.

Metaphorically, an exhibit can be discerned as a text, or an ambiguous text that is constantly being interpreted and re-interpreted by those who participate in it. As a result of their participation and involvement, an object or exhibit can be read differently by different individuals/groups. In other words, it can have different meanings. According to Bruner (1986: 122), 'meaning is what we can agree upon or at least accept as a working basis for seeking agreement about the concept at hand'. For example, a lady who was leading a large family group explained "Sagar Jyoti", a scale-down working model of an oil offshore rig, as:

> Oye, see everybody. This is a ship. As there is no much place (she was talking about horizontal space - as I could make sense from her hand gestures) here it is going up and down (Noted during 43rd observation).

In the professor-chimp example, the professor set the stage for an experiment from his perspective to understand the world-view of a chimp. But, during the test he encountered a completely unexpected solution. Similarly, in the *Sagar Jyoti* example, the lady used the exhibit differently and constructed absolutely unexpected meaning, reconciled to her background knowledge and experiences. In order to understand the effectiveness of the science centre setting, the major problem ahead is how to enter "the web of meaning" and make sense of it.

4.2 Intended objectives

Our task is really intricate. We want to assess the effectiveness of exhibits and educational programmes in science centres. We are no longer satisfied with the answer that after spending an hour or two visitors gain 'something'. In fact, we want to explore 'something' and want to know about it as precisely as possible. As we have seen in Chapter 3, 'attitudes toward science centre', 'attitudes toward science' and 'continuing motivation in science' form three interesting parameters of this 'something' about which we can attempt to learn more. Basically, from all these interesting measurements we shall get numerical entities. In order to make sense of these numerical entities, we also intend to understand and describe the museum experience of students.

In attempts to measure the effects of exhibits and related activities on participants and to make valid causal inferences, researchers have basically relied on randomised experiments (Campbell and Stanley, 1963: 121; Rossi and Freeman, 1982) and qualitative designs (Lincoln and Guba, 1985: Belenky *et al.*, 1986). The main purpose of this chapter is to decide about the appropriate research methodology and strategy in order to achieve our intended objectives. It requires a deep understanding of practical and ethical issues involved in quantitative and qualitative research methods.

4.3 Nature of quantitative research and its techniques

All of us carry theories about why people behave and think the way they do. In a particular instance, which theory is to be selected or rejected may largely be decided by pure chance. Experimentation enters at this point, not as a source of ideas necessarily contradictory to the traditional wisdom, as a means of sharpening the relevance of the testing, probing and selection process.

Experimental studies are conducted with a purpose: to settle disputes regarding educational practice; to verify educational improvements; and to establish cause-and-effect relationships in which the researcher randomly assigns subjects into groups. In an experimental study, the researcher is required to discuss subjects participating in the study (the dependent and independent variables); the instruments and materials used in the study; the specific type of experimental design; and the procedure for conducting the experiment and testing the hypotheses. The first three components of a typical experiment are briefly discussed in Table 4.1.

Table 4.1 Subjects, instrument and design components of an experimental method plan.

Components of Experimental Method	Procedures	Description and Application of Procedures
Subjects	Random Sampling	Ensures that each individual has an equal probability of being selected from the population and that the sample will represent the population.
	Convenience Sampling	Used when one may need to focus on a particular group of sample.
(Group designs)	Random Assignment	Eliminates the possibility of systematic differences occurring among subjects and the environment of the experiment that could affect outcomes.
	Independent Variables	These variables are under the control of the researcher and typically are manipulated in an experiment.
	Dependent Variable	The variable is the response (or outcome) presumed to be caused or influenced by the independent variables.
Instruments	Scales	A set of questions which can be rated by respondents (During an experiment the researcher obtains data by using scales)
	Materials	This involves handouts, lessons and special written instructions designed to help students in the study.
Experimental Design	Pre-experimental	The researcher does not have a control group to compare with the experimental group.
	Quasi-experimental	Control and experimental groups are used in the study, but subjects are not randomly assigned in the groups.
	Single Subject	This design involves observing the behaviour of individuals over time.
	Pure Experiment	The subjects are assigned randomly to the treatment groups.
	Between-subject	In this design, different individuals are assigned to treatment groups.
	With-in Subject	In this design (repeated measures), the same set of subjects involve in the study two or more times.
	Factorial Design	The design assesses the main effects of each treatment and the interaction effects of different treatments

In education and social sciences, concepts such as attitude or motivation provide a central focus for much quantitative research. The quantitative researchers tend to be concerned to relate these concepts to one another to investigate associations and to make out causal inferences. Thus, the researchers tend to break the world down into manageable parts: for example, a classroom environment can be broken into social class, caste prejudice, discipline, aggression, attitude, aspiration, motivation, and so on. The existing body of literature relating to a particular concept or a cluster of concepts is often used as a substitute for a prior body of theory. For instance, we might observe from the literature and from our general reflections that some students show an unusual interest in science classes, others dislike science classes a great deal, and still others seem indifferent. We gather these feelings and give them collectively a name - attitudes toward science. Here, then, is a concept with which we can proceed.

In the second step, it is required to demonstrate whether the concept actually exists in relation to people, organisations, objects, or whatsoever. But as soon as we begin to ask questions about the concept - such as: why do boys exhibit more positive attitudes toward science than girls? - it becomes necessary to work out an operational definition of the concept so that we can measure it.

Thirdly, we need to develop a precise yardstick for discerning its presence or absence in a person or organisation. The measurement of concepts tends to be undertaken through the use of questionnaire devices or some form of structured observation. The main advantages of the questionnaire are its apparent simplicity, accuracy, versatility (access to dispersed respondents and wide coverage in terms of topics and respondents) and its low cost as method of data gathering. The another advantage is that questionnaires are a relatively well understood technology. A number of guides to designing a good questionnaire are now available (Edwards, 1957; Sudman and Bradburn, 1982; Oppenheim, 1992). The questionnaire method is particularly useful when we wish to make population parameter estimates and to test hypotheses.

Designing a perfect questionnaire is usually considered to be a next to impossible task. A questionnaire can be a set of items (statements in relation to people, organisations, or objects, requiring a response) that may be tested as a potential scale, or a set of sub-scales, to measure the concept. The term 'item' is preferable to 'question' because the request for information is often not phrased as a question (Rothwell, 1993: 4). As concepts and their measurement are so central to quantitative research, there is much concern about the technical requirements of operationalisation. Of necessity, most researchers emphasise the need to establish trustworthiness of the questionnaire, or in technical terms to consider reliability and validity of measures.

4.4 Establishing trustworthiness: reliability and validity

The reliability is concerned with whether an instrument - regardless of what it truly measures - yields scores that are consistently repeatable. In other words, the reliability of a scale is the extent to which it is free from *random error*.

The earliest psychometric measurement theory stems from the work of Charles Spearman and is called Classical Test Theory. Psychometrics means literally 'measurement of mind' and psychometric tests are designed to measure the intrinsic mental characteristics of a person (Hammond, 1995a: 195). Basically, psychometric measurement depends upon estimation rather than direct measurement. As a result, researchers cannot expect to achieve perfectly accurate measurement. The true-score model serves the basis for classical test theory. The model assumes that the test score is influenced by two factors: namely, the true extent of the characteristic being measured and the random error. This may be formally represented as:

$$\text{Observed score} = \text{True score} + \text{Error}$$

A reliable test is one in which the 'true' score is close to the 'observed' score. The job of the test developer is to minimise the error to the extent possible.

A practical method for estimating the reliability of a test is to examine its internal consistency. Charles Spearman suggested an early approach where a test was to be administered to a large population and then it was to be divided into half (for example, even numbered items as one half and odd-numbered as the other half). But, the split-half approach has one fundamental drawback, as different ways of splitting the test can produce different reliability coefficients.

In these circumstances, what is needed is a procedure that gives the average of all. Alpha (α) is the current standard statistics for assessing the reliability of a test composed of multiple items. In the procedure, the test is split into many parts, and each of the parts is inter-correlated with other parts. Because α considers the degree to which items on a scale inter-correlate with one another, it is often referred to as a measure of *internal consistency*. When the item variances are equal, Cronbach's α is given by the formula:

$$\alpha = \frac{N\, r_{ij}}{1 + (N-1)\, r_{ij}}$$

Where N is the number of items and r_{ij} is the average correlation between N items. For a given scale, internal consistency is influenced by two factors: the number of items in the scale, and the extent to which the items reflect a clearly defined unitary construct. The Cronbach α is considered as one of the most accurate estimates of reliability available in the classical test approach.

In estimating the reliability of a test, we examine its viability as a measuring device. A test with low reliability coefficient implies that it does not measure anything with any degree of credibility. On the other hand, a test with high reliability tells us that it measures 'something' with high degree of credibility, but this 'something' may not be the specific trait we intend to measure. This leads us to the problem of validity.

The question of validity refers to the issue of how we can be sure that a measure really does reflect the concept to which it is supposed to be referring. In other words, we must be quite sure that the concept we intend to measure looks like and behaves like the presumed concept. There are essentially three approaches to scale validation. These are termed 'content validation', 'criterion validation' and 'construct validation' (Hammond, 1995a: 208-211).

Content validation simply asks the question, 'Is the content of the test relevant to the characteristic being measured?' We may check the **face validity** of a test which is simply the subjective evaluation of the relevance of the test items. As the procedure lacks objectivity, this particular form of validity is not given much credence. Nevertheless, having a test with clear face validity is found to be useful in obtaining compliance from respondents. In content validation, an important consideration is the complexity of the test item. One strategy for the content validation procedure is to ask 'expert' judges to evaluate the relevance and the complexity of the test items. Content validation is a qualitative process and it depends upon the researcher having a clearly defined idea of what it is he or she wishes to measure.

Criterion validation involves testing the hypothesised relationship of the test with external criteria. This form of validation can be carried out under a number of different headings including **predictive** and **concurrent** validation. 'Predictive validation' asks the question, 'Does the test predict later behaviour?' For example, a student's attitude score may be expected to predict his or her academic success. Predictive validation is vital when developing tests for aptitude or job selection, as these tests are designed specifically to measure the potential of a person. 'Concurrent validation', on the other hand, involves observing the relationship between the test and other criteria that are being measured at the same time. For example, scores on a self-report test of attitudes toward science of a student may be correlated with teacher's rating of the student's interest in science classes.

Construct validity involves testing hypothesis about the structure of the test. In this sense, reliability evaluation (alpha value) may be viewed as a kind of construct validation. One commonly hypothesised structure is that items form a uni-dimensional scale. Researchers often confuse uni-dimensionality with internal consistency. It is important to realise that a high alpha value tells the homogeneity of items - that is, the items correlate well together - but nothing about the pattern of the inter-item correlations. The way to assess the uni-dimensionality of a scale is to use multivariate data analytic methods. It is also common for the researcher to suggest that there may be multiple dimensions underlying test items. The procedure that is frequently used to examine the hypothesis of multi-dimensionality is known as factor analysis.

4.5 Multi-dimensionality of a scale: Factor Analysis

Factor analysis is a statistical technique that attempts to account for the inter-correlations (product-moment estimates or direct estimates of covariation) among variables by a smaller number of underlying dimensions. It examines the inter-correlations among items and attempts to find groups of items that are highly correlated with one another but are not correlated highly with items in other groups. These groups are called 'factors'. A crude example can explain the procedure in a much better way.

Suppose, we have some balls of different sizes and painted in five different colours, say red, blue, green, orange and yellow. Now, we want to segregate these balls on the basis of their colours and also want not to pick up smaller balls. For this we need to fix an optimum limit to select or reject the balls (loading limit). Now we can load the balls into five different containers on the basis of their similarities. That is what the factor analysis does with items.

Factor analysis treats the correlation matrix as a mass of inter-variable variance and it extracts chunks of variance to represent each underlying factor sequentially. These 'chunks' gets smaller as each factor is extracted. The technical terminology for these chunks is the **eigen value.** Thus, the first factor extracted has a relatively large eigen value and each successive factor is built around a smaller chunk of variance or eigen value than the preceding one (Hammond, 1995b: 375).

Factor analysis has a number of pitfalls. The first problem is deciding how many factors to extract. Theoretically, the technique allows the researcher to extract as many factors as there are items, which would lead us nowhere. One of the most commonly used criteria, also assumed by many researchers one of the worst, is to extract only those factors which have eign values greater than or equal to one. With this criteria, it is also advisable to consider a priori expectation of the appropriate number of factors while devising items of the test.

Another problem with factor analysis is the issue of rotation (the initial factor loading matrix is transformed to aid in interpretation). There are two types of rotations: orthogonal and oblique. Orthogonal rotation involves a transformation that forces the underlying factors to be uncorrelated with each other. Oblique rotation, on the other hand, allows the factors to be correlated. One of the most commonly used techniques is orthogonal rotation. Indeed, orthogonal rotation, using VARIMAX technique, is the default option on many computer programs.

4.6 Experimental design

There are two basic experimental designs - namely, 'between-subject design' and 'with-in subject design'. Essentially, these two methods form the basis of all the more complex designs. In between-subject design, two totally separate groups remain involve in pre-treatment and post-treatment tests. For example:

Pre-Test	Post-Test
Subject 1	Subject 21
Subject 2	Subject 22
Subject 3	Subject 23
Subject 4	Subject 24
....	....
....	....
Subject 20	Subject 40

In contrast, if the same group of subjects take the pre-treatment and post-treatment tests then this is an example of within-subject design.

Pre-Test	Post-Test
Subject 1	Subject 1
Subject 2	Subject 2
Subject 3	Subject 3
Subject 4	Subject 4
....	....
....	....
Subject 20	Subject 20

Both these methods carry advantages and disadvantages and the selection of design must be decided on the basis of our research hypothesis. The within-subject designs has one obvious advantage that each individual acts as his or her own control. The within-subject design is particularly useful when we want to assess the effectiveness of a treatment. When the same subjects take the same test before and after the treatment and perform quite differently then the effect of the treatment is believed to be clearly visible.

But, the method has two potential disadvantages called 'carry-over effects' and 'ceiling effect'. In carry-over effects, respondents may gain experiment-relevent skills in pre-treatment test which may spill over into the post-treatment test, and as a result they may have high post-treatment test scores. On the other hand, in ceiling effects, while taking the pre-treatment test, respondents may score on the higher side of the scale and, therefore, have little scope of any further improvement during the post-treatment test.

4.7 Data collection and analysis

This section spells out some aspects of classical hypothesis testing. Hypotheses are predictions about the outcome of experiments or studies. In other words, hypothesis is an informed guess about how an independent variable will affect a dependent variable. Conventionally, we deal with two types of hypothesis: the 'null hypothesis' and the 'alternative hypothesis'. In null hypothesis, a researcher presumes that the independent variable has no effect on the dependent variable in the 'population'. On the other hand, the alternative hypothesis predicts that the independent variable does indeed affect the dependent variable in the population.

The collection of all individuals of interest in a particular study is called 'population'. For example, all people resident in India, all people with a particular disease, all school students, etc. Usually it becomes impractical to study everybody in a huge target population, so we need to select a set of individuals. The selected set of individuals which represent the population under study is called the 'sample'. Inferential statistics are used to make concluding statements about the population by extrapolating from findings based on sample data.

In a quantitative research study, data are typically collected (by questionnaire, postal questionnaire or clinical/structured interview) from a sample of individuals at a juncture. Quantitative research is often highly preoccupied with exploring relationship among data and also establishing differences between the scores. While exploring differences between scores we encounter a number of questions. For example, whether the scores obtained under one condition are similar to the scores obtained under another condition(s)? In order to answer such questions, a number of test of statistical inferences have been developed.

The logic of statistical inference is simple. The researcher usually begins with the null hypothesis and examines it whether it is true or false. For example, we may put forward a hypothesis that there is no difference in the attitudes toward science of two groups of students. In this case, the average score in the two groups might be the same. But, it is more likely that there would be some (probably small) difference. Still, it could happen that in a particular sample most of the scientific minded students fall into the same group. At this point, statistics provides us tools that tell exactly how likely it is that, by chance, a difference of a certain size would appear. For this purpose, t-test and analysis of variance (ANOVA) are often performed. For any observed difference, a researcher can also perform appropriate calculations and find out how likely it is that this difference would have occurred by chance. Suppose, take a case study where a researcher reports the following:

	Mean	**Mean**	**t**	**ρ (2-tail)**
	Group A	GroupB		
Attitude Score	3.61	3.82	2.60	0.01

Here, t value is calculated for the purpose of determining the chances of observing an attitude difference as great as observed here (0.21) in the population. "$\rho = 0.01$" signifies that the probability of observing such a large difference in the sample by chance is one in 100. By convention, if ρ is equal to 0.05, called an alpha criterion, or less than 0.05 then the null hypothesis may likely to be rejected. However, if $\rho > 0.1$ then the null hypothesis cannot be rejected.

In the example, the probability value is referred to as '2-tail'. By convention, it is possible to opt for either '1-tail' or '2-tail' probabilities. With '1-tail' the hypothesis is that the difference will be in a particular direction. On the other hand, 2-tail probability simply concerns with the establishing probability of a difference between the two means.

The t-test is a very widely used test employed to compare two means. It has two versions: 'the paired two-group t-test' and 'the unpaired two-group t-test'. The paired t-test is used when the same person provided the score in two conditions, for example before and after the treatment. But, suppose we have three or more groups. In this case, it would be possible to make separate pair and carry out multiple separate t-tests. However, this technique is problematic because when we make many comparisons involving the same means, the probability that one comparison turns out to be statistically significant increases. In the case of three different groups, the analysis of variance (ANOVA) allows us to do the same in a single, overall, calculation.

4.8 Nature of qualitative analysis and its techniques

In the 1950s, there was a clear awareness of a difference between quantitative and qualitative research. However, much of the discussion at that time was focused almost exclusively at the level of technical adequacy of instruments. But, the situation changed in the 1970s.

> What distinguishes the debate that gained the ground in the 1970s was the systematic and self-conscious intrusion of broader philosophical issues into discussion about methods of research. The pivotal point of much of the controversy was the appropriateness of *natural science model* to the social sciences (Bryman, 1988: 2-3).

In the past three decades, there can be seen a major shift in the relationship between two research paradigms: from the superior-inferior relationship to a mutually-enlightening one. It was argued that the quantitative research methods fails to take into account the differences between people and objectives of individuals. With a paper-pencil test, we can know the percentage of knowledge gain as a result of science centre visit, but we can hardly know how the visitor actually gained or what did she or he actually do. In other words, we cannot know much about the real life situations.

> And the children said unto Halcolm, "We want to understand the world. Tell us, O sage, what must we do to know the world."
>
> "Have you read the works of our great thinkers?"
>
> "Yes, Master, every one of them as we were instructed."
>
> "And have you practised diligently your meditations so as to become One with the infinity of the universe?"
>
> "We have, Master, with devotion and discipline."
>
> "Have you studied the experiments, the surveys, and the mathematical models of the sciences?"
>
> "Beyond even the examinations, Master, we have studied in the innermost chambers where the experiments and surveys are analyzed, and where the mathematical models are developed and tested."
>
> "Still you are not satisfied? You would know more?
>
> "Yes, Master, we want to understand the world."
>
> "Then, my children, you must go out into the world. Live among the peoples of the world as they live. Learn their language. Participate in their rituals and routines. Taste of the world. Smell it. Watch and listen. Touch and be touched. Write down what you see and hear, how they feel and how you feel." (From *Halcolm's Methodological Chronicle* quoted in Patton, 1990; 199)

According to the above quotation, data collection in the actual work place appears to be the ultimate form of research methodology. Many practitioners have also supported this conclusion. Horward S. Baker, one of the leading social scientists, adjudges participant observation as the most comprehensive of all types of research studies (Patton, 1990: 25). Based on his own experience, Michael Patton also convincingly promotes the value of observation method.

> As we completed the six-day leadership retreat we met to compare experiences. Our very first conclusion was that we would never have understood the program without personally experiencing it. It bore little resemblance to our expectations, what people had told us, or the official description. Had we designed the follow-up study without having participated in the program, we would have completely missed the mark and asked inappropriate questions. There was simply no substitute for direct experience through participant observation (Patton, 1990: 202).

Patton has also listed the following advantages of having direct personal contact with people and making observations of a programme in the natural setting:

1 By directly observing programmes, operations and activities the participant observer is better able to understand the context within which the programme operates. Understanding the programme context is essential to an holistic perspective.

2 Firsthand experience with a programme allows a participant observer to be open, discovery oriented, and inductive in approach.

3 Strength of observational fieldwork is that the participant observer has the opportunity to see things that may routinely escape conscious awareness among participants and staff.

4 The participant observer can also discover things no one has ever really paid attention to.

5 The participant observer can learn things about which programme participants or staff may be unwilling to discuss in an interview (Patton, 1990: 203-205).

4.9 Strategy for data collection

For studying a complex environment like science centre, observation method seems promising. But, there is an old saying "Seeing is Not Believing" which cautions us about the highly selectivity of our perception. At times, we see what we want to see. The subjectivity involved in the observation method certainly cast doubt on the validity and reliability of observation as a major method of scientific inquiry. On the face of it, this is a problem but not without solution. Practice makes the human perfect. Scientific inquiry using observational methods requires disciplined training and rigorous preparation (Patton, 1990: 200).

To 'observe' a participant means to know as much as possible about his or her ways of interaction with the world-view of the exhibit, with a view to enhancing an understanding of processes or interactions. But, reading or knowing or understanding one's mind as such appears a next to impossible task. von Wright (1971: 6) defines understanding, as opposed to other forms of knowing, as connected to aims, purposes and intentions of participants. Understanding of human beings, however, can be developed to the extent to which we can dwell in the external workings of their minds from outside. According to Majorie Grene (1969: 20), we can do this fairly well since many tacit functions of our mind are accessible by attending to behaviour of the Participant. Participant-as-instrument simply means that individuals with all of their skills, experience, background, and knowledge as well as biases are the primary, if not the exclusive, source of data collection and analysis.

The next issue is to ensure that participant observation must be "naturalistic" which means ideally no interference with events occurring in the experimental arena. We may make sense of pattern of events if we collect data of what *actually* happens in the environment. Ideally, the word *actually* refers to "no interference with events". For our purpose, naturalistic participant observation seems the most appropriate method of gathering data. Yet there appears to be no standard technique to check whether this requirement has been met or not:

> To find out how much an observer's activities have changed events, we would have to observe the events both with and without the observer, and see how much difference there is. This is, of course, a logical impossibility and therefore we can never be sure how much the research process has changed the people and events being studied (Stern, 1979: 64).

In order to answer the question whether merely observer's presence can change the course of event or not, we have to rely on our daily life experiences. For example, the driving behaviour of people when approaching traffic lights, with and without traffic police in sight, can be observed from the nearest vantage point. Without traffic police in sight, people in Delhi generally have a gross tendency to cross the signal irrespective of its colour. Similarly, in a classroom, there can be seen a great difference in teaching as well as learning practices during annual inspection days. So, in the light of our day-to-day experiences, it appears doubtless true that mere observer's presence in the experimental arena is enough to distort our research procedure. The observee's behaviour is, however, most likely to change when there is some salient relationship (like, teacher- student, employee-employer or junior-senior) between the observer and observee, which, of course, we do not find in the museum context. Next, we have task at hand to examine and pin-point the issues which could hamper our study most and, therefore, need special attention.

Fortunately, social scientists have been able to identify situations, called "on stage effect" (Agnew and Pyke, 1969), in which the research process is most likely to hamper. As the theatrical metaphor suggests, the central problem is that as soon as the participants are aware of the observer they may, deliberately or unconsciously, start acting, and their "resultant actions" may produce subtle and pervasive changes in their subsequent behaviours. Below is the description of some effects, based on classic types of 'on stage' effects, that may add spoiling ingredients to our study during the course of the data collection:

Evaluation apprehension: Participants can be tracked in two ways: obtrusively (participants are informed in advance) and unobtrusively (participants are not informed). In obtrusive observation, no matter whatever the observer says, in whatever way, using whatever words, most people will assume that the observer is somehow judging their personal adequacy or mental health (Intelligence, aptitude). In unobtrusive observation also, participants often come to know at some point of time that 'somebody is doing something with them'. As soon as they are aware of some following or audience they take it as a challenge. Their such belief is called *Evaluative Apprehension* (Rosenberg, 1965).

Social desirability: 'Go to Rome and be Roman' is an old saying. All people desire and attempt to adjust in new situations; though some take little more time than others. In this way, nature has bestowed a great accommodating power upon human beings. In general, one can easily make sense of important features of the culture in which he or she is in and then make all efforts not to be identified as a novice, intruder or foolish. Such people's responses are influenced by their perceptions of social desirability. For example, in a hands-on setting even if one does not want to touch the objects but one is supposed to. And when the participant looks around everybody interacting and somebody with writing pad and stop-watch persistently following, there is a fair possibility that he or she may unwillingly start activities heavily.

Faking bad: As soon as visitors come to know about the tracking they, specially sensitive persons, may feel uneasy or perturbed. Consequently, they may try to look bad and mishandle equipments. They may wish to start their own experiment to know what the follower is doing; they may sit around doing nothing, go to the toilet, go to the canteen and then they may watch the researcher's activities.

Demand characteristics: People sometimes try to please the researcher by doing what they think she or he wants them to do. For example, suppose the researcher seeks the permission of the participants in the following way:

Researcher: ....Excuse me, we are doing some research with a view to improving public facilities. For this, well you know, we would like to follow you if you do not mind....
Visitor: ......What do you mean?
Researcher: I mean we would observe you in the gallery, like how much time you spent in front of exhibits and ....

If visitors come to know the researcher's mind then there should be no surprise if during the study the researcher finds excellent results. The researcher may come across literally magnetic exhibits where the participant may hesitate to leave the exhibit before five minutes or so.

Personal relationship: Jourard (1971) suggests that in typical laboratory experiments, in which the experimenter attempts to be impersonal or interpersonal, subjects may act in a typical manner. For example, in the science centre context during the course of their visit, some of the participants may seek advice from the researcher about what is there interesting to see. Jourard demonstrated in his study that time spent in mutual self-disclosure of personal material by subjects and experimenter could affect the rate of learning of material by subjects. It appears reasonable to think that participants' performance may be affected by the observer's emotional or intimate or rude reaction.

The 'on stage' effects, or extraneous variables are not normally part of the phenomenon the researcher wants to study. So there is a need to reduce their effect to the lowest possible rather than of thinking ambitious plan of eliminating.

> Rather than engaging in futile attempts to eliminate the effects of the researcher, we should set about understanding them (Hammersley and Atkinson, 1983: 17).

The method of unobtrusive observation can reduce effects of all five extraneous variables to some extent (Table 4.2). But, several researchers deplore or discourage this method on ethical grounds. We should also bear in mind that there are various kinds of research problems: for instance, to compare the popularity of various exhibits in a museum; to understand the behaviour of children in a classroom; to explore about the doctor-nurse relationship in hospitals and surgeries; to study the treatment prisoners receive in jail; to know more about private lives of politicians and religious authorities; and so forth. Obviously, unobtrusive measurements do not involve necessarily invasions of individual privacy in all problems. Indeed, some problems demand the use of unobtrusive observation or bugging in order to discover the truth or to understand the problem from alternative perspectives. For example, one can hardly think of finding out the original activities in a jail or in an orphanage using obtrusive method.

Hence, without going further into an interminable ethical debate, it appears wise to follow unobtrusive observation method as long as the participants do not feel uneasy or straightforwardly raise objection about it. The observer has to decide judiciously on the spot and discard the participants from the study who are either feeling uneasy or faking badly. It is also not required to follow the participant like a body-guard: many actions, for example, can be observed from a distant place and a fairly fine conversation can be heard from the opposite side of the exhibit. While observing carefully every occurring event, the observers, in general, have to show they were busy in their own work. For example, if some of the visitors/participants asks the way to the toilet, the observer has to be polite and precise in replying and busy in work. Such conduct of the observer in the field will avoid a number of problems, including the phenomenon of personal relationships.

Table 4.2. Extraneous variables due to the presence of an observer and their methods of control.

Extraneous Variables	**When a problem**	**Methods of control**
Evaluation Apprehension	Clinical interview/ Survey/ **Observation**	Unobtrusive observation
Social Desirability	**Observation**/ Survey	Unobtrusive observation
Faking Bad	**Observation/** Survey/ Clinical interview	Unobtrusive observation
Demand Characteristics	Clinical interview/ **Observation**	Unobtrusive observation
Personal Relationship	Long term surveys/ Experimental designs/ **Observation**	Unobtrusive observation

4.10 Role of the researcher

In a participant-observation study, the observer plays a key role as the impressions and the feelings of the observer become part of the data to be used in attempting to understand the impact of the visit. Participant observation 'simultaneously combines document analysis, interviewing of respondents and informants, direct participation and observation, and introspection' (Denzin, 1978: 183). The observer faces the challenge of combining participation and observation so as to have understanding of the inner world of the setting, and also to become more able to discover what is not known to others. Unequivocally, the task of the observer is a challenging one. The following guidelines may prove helpful for any beginner, like myself. (Commandment 1 and 9 are after Patton's commandment, 1987: 12-13)

Ten Commandments:

1. Thou shalt have no other gods before evaluation - not tight planning, not applied social science, *certainly not* basic research or theory or sociology, psychology or any other -ology or -ism because the fields of research are confused already and if evaluators will not put evaluation first, then who will?

2. Thou shalt have exposure to, and understanding of, philosophical underpinnings of research methods (specially of research characteristics of 'traditional' and 'alternate' paradigms). This will lead the research on the way to the open-endedness. Otherwise, the whole exercise may become fruitless as Maslow apprehends 'when the only tool you have is a hammer, you tend to treat everything as if it were a nail' (quoted in Albrecht, 1980: 36).

3. No method is always good or bad, superior or inferior. Thou shalt have to match the research methods to the purpose of the study, the issues being investigated, and the resources available.

4. Thou shalt have a fair idea of 'ambiguity' and 'vagueness'. Although ambiguity and vagueness are often used interchangeably, but they have different meaning. An ambiguous situation is one which can be understood in more than one way. A vague situation, on the other hand, is one which lacks precision. Thou shalt have the flexibility and ability to hold two or more different interpretation of an event, activity or person in the mind, while wanting to explore precise and relevant interpretation.

5. It can be said that people act and make sense of their world by taking meaning from their own environment. As a researcher, instead of adopting a particular role, thou shalt have to be 'versatile' and 'opportunistic' in the fieldwork as thou have to witness

the 'reflective rationalization' of conduct (May, 1993; 116), that is the continual interpretation and appreciation of knowledge by people in their social environments as an ongoing process.

6. Direct observation and involvement in the setting does not make bias and loss of perspective inevitable; distance is no guarantee of objectivity. Thou shalt have to go into the field, and achieve neutrality against all odds.

7. To capture the events as they unfold, thou shalt have to have a great deal of patience, energy and enthusiasm. To understand these events thou shalt have to have insight of creating tentative patterns, and also wisdom of discarding or re-constructing them.

8. Thou shalt record factual, accurate and thorough observations without being cluttered by irrelevant *minutiae* and *trivia.* The recorded event must be thorough enough to help the analyser to re-visit and understand the situation described. On the other hand, the observee should not feel embarrassed, awkward or trapped.

9. The feelings and impressions of the observer become part of the data to be used in attempting to understand a programme and its effects. Thou shalt not bear false witness against thy neighbour. In other words, honesty is the best policy.

10. Thou shalt never have to assume 'it will be alright'. Think twice about ethical (or unethical) issues. If it appears that the research is going to come into conflict with visitors or aspects of museum policy, management style, it is better to consult relevant parties.

4.11 Quantitative and qualitative research methodology: our strategy

In the 1950s and early 1960s, it was common to find many quantitative policy-oriented educational research studies that used no more than simple t-tests, simple bivariate relationship, or, at the most, analysis of variance. From the late 1960s, quantitative studies flourished, concomitant with the exponential growth in computer technology. Presently, there can be seen a growing use of multiple variable and multivariate analyses, facilitated by easy access to powerful computer software packages, such as SPSS and SAS, and the growing use of personal powerful computers.

Experimental designs are selected when the researcher focuses on a set of predetermined concepts or variables, and thus wants to control the study. In order to carry out the test, the researcher is required to collect data twice, for instance pre-test and post-test, or control group and treatment group. The analysis of the data normally assigns to the variable a numeral quantity, with plus or minus sign expressing the direction of the change; how and why the change is there is least understood. The values that permeate writings on evaluation experiments have concerns about well-controlled settings, reducing threats to internal validity, and precise estimates of programme effects.

Despite the rigorous internal validity of experimental studies, the questionable external validity has led to considerable disillusionment with rarified experiments conducted in impersonal ways. The criticism came not only from outsiders but also from the most prominent "quantifiers". For example, Mohr paraphrases Lee Cronbach, a staunch advocate of experimentation, saying:

> I give up! There is no possibility of developing a theory of learning. I used to think that introducing some interaction terms would do it but now I see that it is still insufficient even to go to 7th and 8th order interaction and my conclusion is that such complexity is impossible to deal with (Mohr, 1978; in Chantavaniach *et al.*, 1990: 5).

In contrast, qualitative researchers focus on capturing on process and exploring important individual differences in experiences and outcomes. A naturalistic inquiry method is selected when the researcher wants to minimise research manipulation by studying naturally unfolding events. It is thought that such approaches can develop a deeper understanding of the involved processes.

A brief literature survey of recent research studies informs us of two general views: the first view digresses that each type of research can prosper, 'with its own order, values and logic'; and the second view stresses on the merging of qualitative and quantitative techniques in a single study or design. While on the one hand, Rist (1977) says that it may be premature and naive to think of there being a merger of quantitative and qualitative methodologies, Denzin (1970), on the other hand, strongly supports the "grand synthesis":

> By combining multiple observers, theories, methods, and data sources, sociologists can hope to overcome the intrinsic bias that comes from single-method, single-observer, single-theory studies (Denzin, 1970: 315).

Far from being independent and mutually exclusive, these two research paradigms can, and should, be perceived as complementary and mutually enlightening. Indeed, there appears no basis to consider qualitative and quantitative research paradigms as independent, as qualitative research is often done as the preliminary stage of quantitative design. For example, a qualitative study could be used to identify important topics to provide the foundation of a quantitative questionnaire. Also, some qualitative data can be coded and converted into quantitative data in our attempt to reveal its new meaning or hidden dimension. Furthermore, some bits of qualitative data can support and qualify our quantitative results and thus can empower us to discuss the results in convincing way. Thus, instead of supporting one method or the other an attempt can be made to focus on what Patton (1990: 39) calls *methodological appropriateness*. The criterion is to check the sensibility of method against the purpose of the inquiry and the resources available. In the present work, it has been decided to use a synthesis of both methods (Figure 4.1).

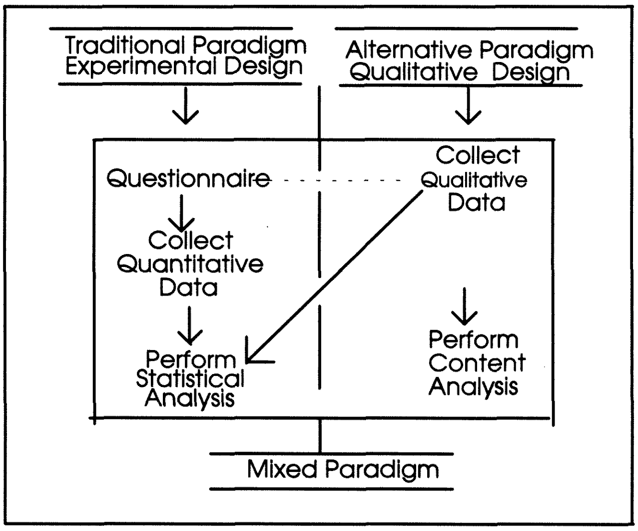

Figure 4.1 Research paradigms: pure and mixed combinations.

4.12 Planning of the questionnaire design

The first question is why we think of designing a questionnaire in the first place? The purpose of the questionnaire is to measure some traits or opinions of its respondents. Self-completed questionnaires, which respondents fill in for themselves, are very efficient in terms of time, effort and convenience. There are problems, as there is no check on the honesty and seriousness of responses. The magnitude of the problem can, however, be minimized if the questionnaire has been well constructed, with very clear and unambiguous instructions, careful ordering of various sections (if the questionnaire contains many parts) and items in each section, and careful wording of items.

The length of the questionnaire is often a matter of an interminable debate. A questionnaire may normally contain 3 to 100 items. This clearly depends on many factors such as the purpose of the study, type of respondents, and the comfort or discomfort where test is to be conducted. We can recall our own frustration when we have been asked to fill in a questionnaire having more than 10 items in a market or public place. But, on our own door step we can easily spare 15 minutes for this purpose.

The goal of the present study is to assess the impact of a science centre visit on students and we have three parameters (attitudes toward science museum/centre, attitudes toward science, and continuing motivation to science) to measure. The purpose of the study is grand and so the questionnaire is naturally anticipated to be quite lengthy. And, an average student may take around 20 minutes in order to fill it in. The length of the questionnaire (Table 4.3; Appendix 1) decided on one factor that it should not be administered in the science centre. It was realised that most of the school groups visit science centre for 2 to 3 hour duration and they would surely be frustrated if they were asked to cut short their visit for filling in questionnaires.

The length of the questionnaire also stressed the need to cut down open-ended questions to a minimum. The disadvantage with the open form is in interpretation. They are also more difficult to code and analyse. Nevertheless, in some situation, particularly when not enough is known to write appropriate response categories, the open form is preferable.

The considerably large duration emphasised the need to make the questionnaire as simple and interesting as possible. To this end, the layout of questionnaire and the sequencing of sections is considered very important. The questionnaire is comprised of four parts (Part A, Part B, Part C and Part D) and it starts with a succinct introduction about myself and the study. The first question is about the demographic data of the respondents. The information in this question is sought mainly with the intention to record the age, class, sex and identification of the respondents (Appendix 1).

The second question (Which of the following items do you have in your home?) have been incorporated to know the socio-economic status and personal interests of the respondent.

The third question is about field trips (Have you been to some field trips? If yes, please furnish details). It was realised that only a negligible student population would be aware of, or had previously visited, the science centres. But, most of them would certainly have had the opportunity of visiting places such as historical buildings, museums and the zoo, for educational purposes. So, in the beginning, students do not necessarily have attitudes toward science centres. But, they certainly possess attitudes toward field trips. One of the main reasons for including this question was to give an idea about the definition of field trips to all students.

Table 4.3. Research framework - 'methodological appropriateness' is the key idea. Details of research paradigm, research methods and research variables.

Paradigm	**Research Method**	**Research Variables**	**Nature of Data**	**Purpose**
	Questionnaire (Section A to Section D)	Demographic* Data	Demographic/ Open-ended	To know Grade and Sex of students.
		Field Trips*	Informative/ Open-ended	To inform indirectly the students the definition of field-trips
Traditional	Section A	Attitudes to Science	Quantitative/ Close-ended	Measurement
	Section B	Continuing motivation	Quantitative Close-ended	Measurement
	Section C	Images of Science	Qualitative/ Open-ended	To have supporting data and qualifying data
	Section D	Attitudes to Field Trips	Quantitative Close-ended	Measurement
Alternative	Human as Instrument	Participant Observation	Naturalistic/ Quantitative	To reach depth and understand of process
	Structured Interview	Teachers' Interview	Qualitative/ Structured/ Open-ended	To have supporting and qualifying data

* Not included in the post-visit questionnaire.

Part A is about measuring 'attitudes to science' and it contains 19 items. The construction of the scale for this section has been discussed in Chapter 6. After this, 'continuing motivation in science' has been outlined in Part B and it contains 8 items. Part C, an open-ended section, is given with a view to know the image of science in the mind of students. In this section, students are asked to lay down their views why they like/dislike science most. It is intended that the qualitative data, collected in this part, may support the quantitative data in Part A (attitudes to science). Finally, 'attitudes to field trips' has been considered in Part D and it contains 16 items. The construction of the 'attitudes to field trips' has been outlined in Chapter 8. In total, the questionnaire contains, 43 close-ended items, two open-ended questions, and two informative questions.

The post-visit questionnaire is the same as the pre-visit questionnaire except of a few minor changes. The introductory questions are removed and an open-ended questionnaire (Which exhibit (s) did you like most in the science centre and why?) is included. The purpose of having this question is to generate data about students' likings and dislikings in respect to exhibits and related activities in the science centre. This data is supposed to be useful in the concluding discussion on the learning environment inventory in the science centre.

Conclusion

As has been said earlier that the experimental study using questionnaires will reveal numerical entities which would not give us rich and deep understanding of the processes occurring in the science centre. As the actions and behaviour of students in the science centre are a central aspect, a natural technique is to be employed to see and understand what they do and why. While questionnaires allow us to ask people about their views, feelings or attitudes, the participant-observation method empowers us to make sense of behaviour, language of the people and other behaviours associated with their language. In Chapter 5, we shall get into the 'real world' of the science centre through the method of participant observation. In Chapter 6 and 7, we shall look into the 'attitudes toward science' of students and shall explore the change in their attitudes as a result of their science centre visit. Similarly, students' 'attitudes toward science centre' will be explored in Chapter 8 and 9. In Chapter 10 and 11, we shall be concerned about the students' 'continuing motivation in science'. Finally, all results will be brought together and discussed in Chapter 12.

Chapter 5

Unobtrusive Participant Observation
Entry into a Complex World of Science Centre Characterised by Small Time and Big Space

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Introduction

In the last chapter, I was particularly concerned to describe the qualitative and quantitative research paradigms, with a view to devise a research framework for the present study. Keeping in view the complexities involved in a science centre visit, I argued, on the issue of selection of research methodology, in favour of following an approach of methodological appropriateness, depending on the purposes of the study and the available resources. Observation in the setting seems to be, and also suggested by many researchers (Patton, 1990; Bauman, 1992), pre-eminently appropriate technique for getting at 'actual events' in 'real world'. By (participant) observation I would mean 'the process in which an investigator establishes a many-sided and relatively long-term relationship with a human association in its natural setting, for the purpose of developing a scientific understanding of that association' (Loafland and Loafland, 1984: 12).

In this chapter, I aim to explore the behaviour of students in the galleries and the factors which prompt, allure or enforce them to behave that way. In the first place, I shall briefly outline the features of the setting in which the present study has been conducted. Then I shall go on to discuss the sample for the study and the method of data collection. I shall mainly follow the 'folk theories of mind' which elaborate on the process of origination of strategic behaviour. This will take us in the world of 'mental verbs' which would, in turn, provide the basis for data collection and codification. In the end of the chapter, the recorded behaviour will be analysed and the results will be discussed.

5.1 Description of setting

The setting for this study was the three permanent exhibition halls, namely *Heritage*, *Fun Science* and *Information Revolution* housed in the *Rajiv Gandhi National Science Centre, Delhi* (RGNSCD). Located in tandem at successive descending floors (Figure 5.1), the exhibits present varied subjects of science, as also apparent from their titles. The ideological approach of presentation also differs from gallery to gallery, for example the use of free-standing structures to present principles and concepts of basic science in *Fun Science* and period room settings, mock-ups and objects related to information science in *Information Revolution*, and sometimes within the gallery. Indeed, the site was selected for the rich and interesting variety of exhibits that might well help us explore even beyond the stated aims. For example, besides measuring the impact of exhibits on students, we may also expect in this study to arrive at conclusions on what kind of exhibits or presentations are most effective, or ineffective.

Plate 5.1 National Science Centre Delhi housed in a purpose-built building.

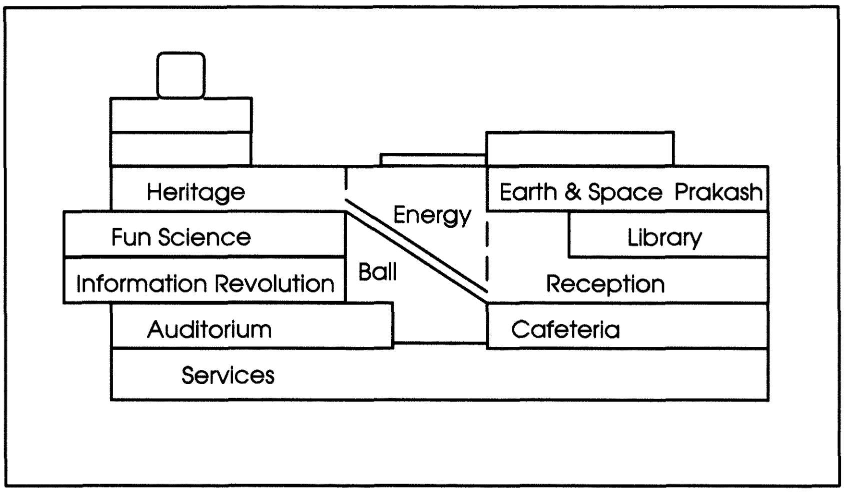

Figure 5.1 Schematic section of Rajiv Gandhi National Science Centre, Delhi.

After purchasing their entry tickets (free for organised school groups), visitors first enter the reception hall where they see a giant 13 metre high *Energy Ball* exhibit. This exhibit can also be approached from different floors. From the reception hall, visitors either take the stairs or escalator to reach the *Heritage gallery* on the third floor (Figure 5.4). Basically, this gallery portrays India's rich cultural heritage of science rooted in the past and very much part of the present. Exhibits in the gallery are panel based interactives, passive models, working models and mock-ups. A few related exhibits are placed in groups, such as Agriculture, Indian Scientists and Nuclear Research. The exhibit is not a popular one, particularly among young visitors. Young visitors on repeat visits usually enquire the way to *Fun Science*. One can, however, get the overall standing or impression of the gallery from the students' spontaneous and natural remarks which have been heard unobtrusively. The presented science was labelled by visitors as old science (that is irrelevant today), distant science or useless science. The numerals in brackets represent the identification of the observee (student).

Observee (2): (near the entry) This is useless.

Friend: What is this system?
Observee (3): This is math's department - pi (π), phi.....

Girl (32): What is all this about?
Mother : This is old Indian science.

An adult: This is not meant for children.
Observee (34): (After a few minutes and around 10 feet away) This is not of our interest.

Observee (43) : It can be anything but not science.

From the third floor, visitors walk down to the *Fun Science* gallery on the second floor (Figure 5.5). This is a typical science centre gallery where visitors can be seen moving enthusiastically from one exhibit to the other. In the gallery, one can see exhibits related to 11 different physical science themes, namely gravity, mathematics, fluidics, oscillation, sound, illusion, light, chemistry, electricity, magnetism and mirrors. Second time or students on repeat visits usually prefer to come here directly. The popularity of this gallery can be judged from the fact that I have encountered several students frantically searching for it during my data collection process.

From *Fun Science*, visitors go down to the *Information Revolution* gallery on the first floor. The exhibit is one of the first experimental galleries in the world, planned in 1988 in order to explore an alternative way of presenting science to a typical science centre approach where emphasis is only put on principles and processes of science (Kaushik, 1995b). Secondly, it was, and is, commonly believed that the implications of information revolution are staggering to contemplate. To understand its effects, we need to study its historical parallels. In agreement with this view, the exhibit adopted an unusual method of presenting science, i.e. presenting scientific gadgets in their social, political and economic contexts. The layout of the exhibit allows visitors to explore the effects of comparable invention in the past, and thus obtain insight into the revolutionary implications of information technology today. The exhibit is comprised of twelve enclaves: dawn of a new era (A), ancient times (B), nineteenth century (C), captive information (D), the transition (E), early twentieth century (F), how things work (G), modern times (H), computer age (I), consumer electronics (J), coded information (K) and activity area (L) (Figure 5.5). Most exhibits are set against the wall in a continuous line with only a few free standing units in the middle. The gallery is mainly comprised of mock-up exhibits and period-room settings.

5.2 Sample

For this study, the sample consists of 50 students. Twenty-six students are female and twenty-four male. The study focuses on school students who either visited the science centre with school groups or with friends or with parents. It was realised in advance that the mixing of family groups (adult-child and child-child pairs) and school groups (child-child pairs) could receive some objections, especially when some earlier studies reported the contrary. For example, in his study, Hike (1988) found interaction partners usually formed by adult-child pairs rather than adult-adult or child-child partnerships. Also, a growing body of research reports parents as equal partners at some of the exhibits (Dierking, 1989; Brown, 1995). Laetsch and his colleagues (1980) also found different interaction patterns between these two types of pairs - adult-child and child-child. According to them, adult-child combination spent more time at the exhibit selected for observation than did child-child and adult-adult pairs. In her study involving 641 visitor groups in the Natural History Museums, London, McManus (1987), found statistically significant relationships, of the order of $p<0.001$, between the group types and the learning related behaviours of visitors. The groups of children and adults were found unlikely to read labels and very likely to participate. So, the decision of mixing school groups and family groups was taken after giving considerable thought, and also on the basis of evidence that was gathered during a brief pilot study in the setting.

It was felt that a person, once in the gallery, usually becomes a part of the heterogeneous social environment. In other words, one no longer remains confined to one's own family or school group. Indeed, some young visitors do not see their parents or colleagues for considerably long time. In these circumstances, we do not foresee a notable difference in the performance of a student who happens to visit in either of the two situations.

The pilot study supported our presumption. It was found that most of the time a student, irrespective of the fact whether he or she is with a school group or family group, enjoys the company of a favourite person, mostly of his or her own age group, that is friend, brother or sister. Even in pairs, most of the time both members, it was observed, work independently and take initiatives on their own. Thus, the participation pattern of a student in a large family consisted of two or more students of similar age-group was found to be no different than a student in a large school group. Fortunately, the final statistics also supported our conviction. As shown in Table 5.1, mostly (60 to 80%), the participants either ventured alone or with someone of their own age group.

Table 5.1 Frequency of 'With whom' postures

With whom approached the exhibit	Heritage Gallery		Fun Science Gallery	
	Frequency	**Percentage**	**Frequency**	**Percentage**
Alone	338	41.2	841	41.3
Peer	197	23.7	730	35.9
Brother	17	2.1	61	3.0
Sister	19	2.3	21	1.0
Mother	18	2.2	24	1.2
Father	24	2.9	36	1.8
Guide	-	-	5	0.2
Others	3	0.4	-	-
Group *	197	24.0	314	15.4

* Group is defined as comprised of three or more than three persons at a point of time trying exhibits or doing activities.

Participants were selected at the entrance of the reception from the incoming large family groups or peer groups or school groups. The criterion of a group selection was that it must have at least two students aged 12 to 17 years. Larger groups (more than two students) are over-represented in the sample. Twenty five observations were made in the morning session (11.30 AM to 3 PM) and the rest 25 in the afternoon session (2 PM to 6 PM). Data were collected in the period spread over four months from April to July 1994.

The final sample is comprised of: 19 participants from family groups (mostly girls) and 31 participants from school and peer groups. There are 32 secondary students and 18 senior secondary students in the sample. The odd grade-based sample is due to the unobtrusive nature of the study. A few apparently older students were later (when inquired of after observation) found enrolled in lower classes than what was adjudged.

5.3 Type of data

It is also important to understand that deciding whether to use naturalistic inquiry or experimental approach is a design issue. This is a separate issue from what kind of data is to be collected - that is, qualitative, quantitative or some combination. Our approach of study-design suggests us to be 'opportunistic'. In other words, our attempt should be to capture all events, presentable in qualitative and/or quantitative form, occurring in the science centre, that is what students say and do during their venture. Basically, this can be done using two methods: *systematic observation* and *non-systematic observation. Systematic observation* is a method of quantitative data collection that involves observing events and behaviours as they occur, and reliably recording their observations by means of previously structured numerical categories. On the other hand, *non-systematic observation* involves recording narrative and qualitative accounts of participants without employing previously structured numerical categories for describing events or behaviours. In qualitative research, it is used to generate research hypothesis.

Our previous experience of participant observation (unpublished work carried out in Experimentarium: The Danish Science Centre and pilot testing in the present study) suggests that the previously structured categories for numerical data collection is both desirable and viable. It is desirable because of short life-span of events. It is really not possible to take a full account of majority of events in a short time, say about 30 seconds. Previously structured categories enable us to take notes of activities under appropriate headings by marking with a tick or by using acronyms like CF for 'called friend' or C x F for 'called by friend'. It is viable because based on our experience (or through pilot studies) we can be sure of finding certain 'patterns in seemingly disorganised events' or 'elements of orderliness in chaos'. For example, some students read labels and others do not; some students observe passively while others participate actively; while some students lead others follow; and so forth. Systematic observations can also be codified and analysed statistically. What is more advantageous is that the systematic observation method accommodates more data in less time and enables us to take a full note of all unpredictable, interesting, unique and bizarre events.

On the other hand, non-systematic observations are equally important, and sometimes much more enlightening, to record as they are the gateways to unknown territory. For our purpose, observations collected in systematic as well as non-systematic ways is needed very much.

5.4 Method of data collection

The groups for the study were identified at the entrance of the reception hall. Participants were, however, selected at the first exhibit in the *Heritage gallery* on a first-approach and second-approach basis alternatively. Participants were observed from the moment of their selection (that is, from the time of their first interaction in the *Heritage gallery*) till the exit of the *Information gallery*.

All events, without purposive discrimination, were recorded in sequence as they occurred. Presumably, it appears impossible to make a complete record of events without being noticed (barring hidden cameras), and it is, therefore, next to impossible to make a record without interfering with events. In order to meet the criterion of minimal interference, the events were observed unobtrusively, that is without seeking the formal permission of the participant in advance. Although while observing I was extra cautious, nonetheless, three participants enquired of me what I was doing there. I also realised that many participants were suspicious about it, but they didn't ask.

An effort was made to capture all 'postures'. A posture is defined as a state or condition taken by the participant at a given time especially in relation to things and other persons. A set of postures evolved as a result of interaction with an exhibit makes an 'event'. In order to save time, a number of acronyms and symbols were used to capture postures (Table 5.2).

Table 5.2. Details of acronyms used during observation to record occurring postures.

CF	called friend (XYZ.....)	C x F	called by friend (or XYZ.....)
CO	casually observed	N/I	seems not interested
C/Op	casually operated	LO	Looking outside
PB	pushed button	O@D	observed 'XYZ......' doing
P	participated	TO	touched object/part of exhibit
O/Op	observed and then operated	RL	read label (before operation)
C/RL	casually read label/grazed	RL/Op	read label after operation
ExpX @	explained by 'XYZ....'	D	discussion
N/Op	not operated	N/Op/P	not operated properly
N/O	not observed after operation	Op/ R	operated wrongly

All actions undertaken by the group members other than those directed toward the observee were ignored. But, whenever possible it was sincerely attempted to capture remarks made by all present within the reach. Usually, the students were watched from constantly changing distances: sometimes from just next to him or her and other times from a position ten or more feet away. It was always attempted to approach the observee quickly when there were possibilities, even bleak intuitions, of happening something noteworthy or interesting, for example when the observee is calling somebody to say something.

In order to measure the effectiveness of a programme, practitioners have traditionally recognised participants' involvement, usually measured by time spent in it, as a good measure. Though it is often apprehended that the time spent is not a direct indicator of 'learning occurred' or 'knowledge gained', but in the absence of any other viable alternatives, the use of 'time spent' as an indirect indicator of the effectiveness of a programme is prevalent. Attracting power of an exhibit (as a whole) is defined as the ability of its individual units (exhibits within the gallery) to grasp the attention of a visitor. Holding power is the ability of an exhibit (as a whole) to retain the visitor's attention. Engagement level of an exhibit is characterised as the observed degree to which the visitor feels like exploring or being involved.

The holding power of an exhibit (as a whole) is a very crude index for defining its effectiveness as the visitors may move here and there, to and fro, and over and under, without exploring anything worth. In this measure, the discrepancy is so glaring that we have to outline some other indices which could help us painting a realistic picture of a visit instead of a rosy one. For this purpose, 'interaction potential' and 'potency index' are being introduced here. The interaction potential of an exhibit is the ability of its individual units to retain the visitor's attention.

The attracting power of the exhibit (as a whole) for each observee was measured by totalling the number of different exhibits within the gallery at which the observee stopped for 5 seconds or more. The total time spent within each gallery was defined as the holding power of the exhibit as a whole. The interaction potential of the exhibit for each observee was measured by totalling the time spent at its each individual units. The potency index for the exhibit was defined as:

$$\text{Potency Index} = \frac{\text{Interaction Potential of the exhibit}}{\text{Holding Power of the exhibit}}$$

In order to calculate the holding power of an exhibit, entry and exit time for all observees were recorded in each gallery. Using stop-watch within each gallery, time of occurring 'events', indicating interaction potential of individual units, was also recorded. The stop-watch was switched on as soon as the participants approached and stood in front of the exhibit and put off when they turned to leave it. Usually, the potency index may lie somewhere between 0.20 to 0.80. Low potency index would represent the wastage of time in the gallery in doing secondary activities such as looking outside, wandering or managing other family affairs and/or the ineffectiveness of the exhibit. In contrast, high potency index would indicate the efficient use of time in the gallery and the competence and ability of the exhibit.

5.5 Sensing data representing strategic behaviour

What is important for visitors in the museum? What do most visitors do first thing when they step in? My experience suggests that they start with information processing. In normal circumstances, they first see the notice boards or exhibits placed in the reception area and then they go to the ticket window. Information processing appears an important purpose, if not the sole aim, of their visit. Their spontaneous behaviour is indeed purposive or strategic. According to Clark (1987), folk theories of mind are important in the production of strategic behaviour. The term "Folk Model" has been perceived differently by the researchers. For instance, Keesing (1987: 380) defines it as "culturally constructed commonsense" and D' Andrade (1987: 112) as "a cognitive schema that is intersubjectively shared by a social group". According to folk theory of knowing, the information processing consists of three general components: **Input, Processing** and **Memory**. The process component is a transient uncertain memory state that relies on information from memory and the external world to produce various outcomes - cognitive, affective and behavioural. The memory component can be thought in terms of internal or personal, that is it includes willingness, perceived relevance or risk, background, experiences, attitudes and knowledge (Figure 5.2).

Basically, we all process information much in the same way but the difference in the outcome arises due to personal factors (Simon, 1981). The acquisition of information, and the problem solving of beginners differ in degree rather than in kind from the mental activities of experts. Experts differ from novices not only in having (organising) more information in their permanent memory but also more significantly, in being able to process it efficiently. In the example of "Sagar Jyoti" (Chapter 4), the model of an off-shore oil rig was processed by a lady as a ship because, most probably, she did not have any information in her internal world about it. Obviously, both a professor who had lectured about it and a student who had visited an off-shore rig will process the information differently, but will definitely not consider it a ship.

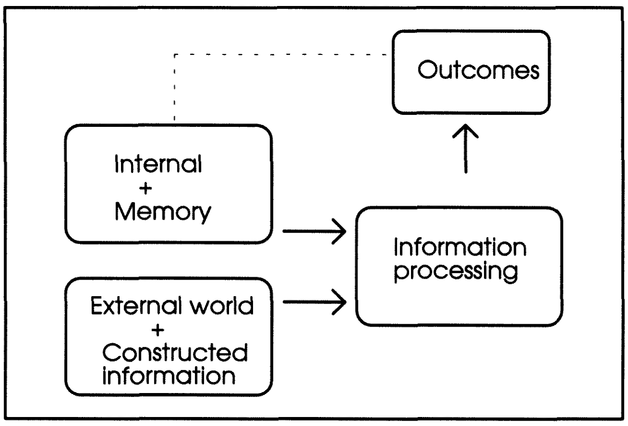

Figure 5.2. Information processing model: the processing component is a transient uncertain memory state that relies on information from memory and the external world to produce various outcomes.

To internalise the information of the external/unknown world, people frequently form naive or folk theories. In 'traditional' teacher's terms, these theories constrain concept formation (accepted version) both on an intra and interconcept level. Largely, they believe in objectivism which subsumes all those theories of knowledge that hold that the truth value of propositions can be tested empirically in the natural world. To them, folk theories which stem from constructivism are meaningless. But, these theories are extremely useful for understanding the process of construction of knowledge in any settings.

In folk theories, the classical notion of truth is replaced by the notion of viability. This notion recognises that people do construct personal knowledge about this world, and with it they construct the intellectual world that they inhabit. Far from being homomorphic with reality, knowledge is adaptive. In evolutionary terms, it survives when it is viable in the experiential world and dies when individuals recognise that it cannot describe their experience. For knowing the world, the concept of engagement appears to be one of the central constructs. Engagement determines whether the people are active or passive while processing information - whether they select and process a subject matter, or merely allow it to wash over them.

McGuire (1968), in his Information-Processing Paradigm (Process theory), proposes that the persuasive impact of messages could be viewed as the multiplicative product of six information processing steps: presentation, attention, comprehension, yielding, retention, and behaviour (12 steps in his 1985 modified model). He argues that the failure of any of six information processing steps to occur causes the sequence of chain to be broken, with the consequence that subsequent steps do not occur. Our science centre's experience supports the hierarchic view of information processing steps. So for our purpose, engagement can be thought of a family of constructs, such as salience, relevance, perceived risks, attention, exploration, elaboration.

To understand how people come to know, the approach of studying the language of mental activities, often called 'mental verbs', has been employed by several researchers (D'Andrade, 1987; Rip and Conard, 1989). In a hands-on setting, 'mental verbs' can be used to determine the engagement level of the visitors. In our systematic observations, engagement is divided into three processing steps from mindlessness to mindfulness: Step1 is comprised of access related mental verbs; Step2 consists processing mental verbs; and Step3 is comprised of memory related mental verbs (details in Table 5.3). Mathematically, the formula of calculating engagement level can be expressed as follows:

Engagement =	Step1 (access related metal verbs) + Step 2 (processing mental verbs) + Step 3 (memory related mental verbs)
=	(Seeing + Doing + Reading) + (Recognising + Citing analogy + Listening + Describing + Guessing) + (Handling + Going creative +Observing + Exploring + Understanding)
Highest Engagement	(4 + 4 + 5) + (3 + 3 + 3 + 3+ 2) + (3 + 3 + 3 + 3 + 3) = 42
Lowest Engagement	(1+ 0 + 0) + (0 + 0 + 0 + 0 + 0) + (0 + 0 + 0 + 0 + 0) = 1

Table 5.3 Framework for systematic observations: information processing steps, mental verbs, and event codification.

Level	Mental Verbs	Code	Description of Posture/event
Step1	**Access related variables**		
	With whom	1	participant by his/her own
		2	with peer (one friend only)
		3	with peer (brother)
		4	with peer (sister)
		5	with adult (mother)
		6	with adult (father)
		7	with education assistant/ guide
		8	with others (school teacher/ other visitors)
		9	group of more than two
	Access	1	gained access naturally/by own initiative
		2	gained access when one or more group members were already interacting with the exhibit
	Look (seeing)	1	casually looked at the exhibit without staying in front of it.
		2	stopped and looked at the exhibit but did not bother/visibly not found interesting
		3	looked intently and participated/found interesting
		4	interacted with the exhibit twice at different point of time.
	Interaction (doing)	1	passive observation/no activity
		2	trial and error interaction
		3	probably trial and error/obvious interaction (for example, with push button most visitors know what to do)
		4	informed interaction, that is after reading labels
		5	interaction after observing others doing things

Table 5.3....continued

Level	Mental Verbs	Code	Description of Posture/event
	Instruction/help (i.e. called by peer; do it like this; calling peer; see, what's written here)	1 2 3 4	no instruction from others receiving instruction to some extent only yes, receiving instruction instructing others
Step 2	**Information Processing**		
	Label (reading)	1 2 3 4 5	not read apparently eye contact/in a bird's view read copied read label after operation
	Recognise (exhibit/some component in the exhibit)	1 2 3	no partially yes
	Analogy	1 2 3	no attempted yes
Conver-sation	Listening (explanation or remark)	1 2 3	no yes, but general type of remarks explanation /remarks directly related to the exhibit
(Talking)	Describing exhibit	1 2 3	no yes, but general type of description yes
	Guessing	1 2	no yes

Table 5.3....continued.

Level	Mental Verbs	Code	Description of Posture/event
Step 3	**Making Sense**		
	Handling	0.5 1 1.5 2 3	mishandled not operated but observed operated but not properly touched / casually operated operated
	Creativity	1 2	no yes
	Level of Observation	1 2 3	minimum average attentive
	Level of Exploration	1 2 3	minimum average better
	Level of understanding (intended message)	1 2 3	certainly not understood probably not / can't be sure yes
	Level of enjoyment / Fun	1 2 3	apparently not enjoyed to some extent yes

5.6 Description of mental verbs and their codification

Most of the mental verbs, like seeing, doing and reading, are described clearly in Table 5.3, but some need further clarification and explanation. In this section, some of the participants' remarks will be used in order to elaborate the point to be made. The number cited in the bracket would be the identification of the participant. The postures are coded on the basis of the quality of the statements.

Recognising

Recognising 'something' is important as it is one of the antecedents for learning to occur. It has been demonstrated in several studies that learners more readily appreciate new knowledge when they are able to relate new ideas to already existing ideas (Ausubel, 1968; Novak and Gowin, 1984). In a gallery, it is commonly observed that people often rush towards an exhibit after recognising it, or some component of it, and then reflect on it. For example, a boy demonstrates the *Magnetic Lines of Force* exhibit to his friend. His friend quickly recognises the exhibit and gives him response spontaneously.

Friend: (pushed the button and told) Just see. All (compass needles) will move.

Observee (22): Oh! This is magnet's experiment. (coded as 3)

On the basis of the extant evidence, it appears reasonable to assume that a visitor will have a far brighter chance of having serious engagement with the exhibit wherein he or she perceives familiarity or relevance, and thus have a significant opportunity to know about the subject matter.

Making Analogy

The topic of analogy has a history dating back at least to Aristotle, but an active interest in it has spread to all sorts of disciplines in the 1970s. Cognitive psychologists then suggested the potential role of analogies in the development of language, thought and understanding. Making connections or analogies is believed to be an important part of the creative process that promotes learning and understanding of a subject matter. For example, consider reading the following sentence with and without the word 'bean-shaped'.

Our body consists of billions of cells, each featuring a number of **bean-shaped** structures called mitochondria.

Visitors use analogies in the gallery usually when they think that a literal interpretation or description of an event is either hard or incompatible within the context. For instance, in *Cone Runs Uphill* (an exhibit displaying the principle of gravity where a cone, after releasing from the lower position on a special type of rail, appears to move upwards), a student named the cone a 'belan'.

Observee: Do you know what is this? This is a 'belan' (a wooden tool used to prepare *chapatis* in households). (coded as 2)

A further example, in the *Message from the Depth* exhibit, a student enthusiastically identified the reflecting surface of rising air bubbles in a liquid-column as a disk of mercury.

Observee: Oye! see there, a disk of mercury is going up. (coded as 3)

Drawing an analogy where there is none before is to provide a model for achieving a new insight. In making analogies, students manipulate their points of view, largely shaped by socio-economic backgrounds and cultural contexts, in attempts to achieve new or more complete understandings. The use of analogies no doubt attaches personal meanings to their experience and is desirable, as analogies help developing long-term memory of the event.

Conversation

Like in our day-to-day activities, there can be seen almost limitless type of conversations in science centres. Although it is a next to impossible task to meticulously categorise these conversations, we can, however, divide them into vague categories, for example, irrelevant conversation and meaningful conversation. One of the examples of what has been considered as an irrelevant conversation is observed when two students tried the *Planetary Motion* exhibit. In this exhibit, when released the ball rolls down onto the black hole-type surface, then goes up and down in elliptical pathways, goes into the central hole, and finally travels back to its starting point. It takes little time in its journey from the central hole to the starting point. After releasing the ball at the periphery the conversation goes like as below:

Observee: It will come shortly.
Friend: No, it will not.
Observee: Auntie ji, please come; Auntie ji, please come.
Friend: It will not come so early.
Observee: What, will it come tomorrow? (coded as 1)

In contrast, meaningful conversations, though may not pin-point the exact cause of the event, add a bit to the extant understanding. For example, in the *Head on the Platter* exhibit, a tricky use of mirrors creates an illusion - a situation where only the head (above neck) of a person remains visible and the rest of the body looks as if disappeared.

Observee (23): Only head is visible. I go in to see what is happening. Friend: Yes, you should. Observee: There is a small room. You insert your head through that hole (explained after participation) Friend: Yes! magicians do show like this only. (coded as 3)

Guessing

While interacting with the exhibits, instead of reading labels most people, children as well as adults, have a tendency to make wild guesses. Visitors frequently make guesses in quiz exhibits and the subject matter they have only casually heard of before. In the process, sometimes they also misguide their children or partners.

Observee (34): Papa, what is this? (for radio telescope) Father: This is a telescope. We can see a far distant place from it. (coded as 1) Mother (34): (at 'Rising Arc' exhibit) Light will emit from it and that will grow as broader as high it goes.

Handling

The verb 'handling' is quite different from the verb 'doing'. While 'doing' represents an initiation posture, 'handling' gives the over all flavour of the event

Going Creative

While some researchers (for example, Shortland, 1987) maintain that when education and entertainment come together under one roof, education will be a loser. On the other hand, others assert that there is not any sharp division between the two:

> My father, who was a professor of human genetics at University College London, was very keen on puzzles and chess problems ... There weren't any lines drawn between his serious work and having fun. I think that rubbed off on me (Penrose in a interview with Hall, 1995).

Indeed, discovery learning or student-initiated inquiry is believed to be an important part of the creative process. There can be seen some anecdotal evidence that some creative behaviours occur in science centre settings.

Observing

The verb 'observing' is quite different from the verb 'seeing'. While 'seeing' represents initiation posture, 'observing' gives the over all flavour of the event

Exploring

The verb 'exploring' explores whether one pushes the button and runs away or hangs on there to see what happens; whether one reads the label after operation; whether one appears to think what is happening and why; whether one discusses the outcomes with colleagues or teachers; whether one repeats the operation; and so on..

Understanding

The understanding of understanding is a complex issue. Most students usually do not think about the event they are experiencing. They have a tendency to make generalisation or attempt to internalise the event in the easiest possible way. For instance, a student who describes *Wireless Communication*, an exhibit employing an induction tube to produce electric discharge through air at one of its end, as:

> Observee (25): (This) light comes from laser. Laser is just like Sun. It is found in ozone layer. (coded as 1)

While most students (for example, observee 33 at the *Colour Shadow* exhibit which primarily intends to demonstrate the principle of the addition of colours) do not even try to wander into the complexities of the subject matter, others (such as, observee 4, at the *Vanishing Coin* exhibit which intends to demonstrate principle of refraction) really try to make a sincere effort.

> Observee (33): (to her friend) Colour lamps will naturally cast colour shadows. They are making us fool. They think that everybody else is a fool. (coded as 1)

> Friend: (bent down to see through a low height 'marked' level and told the observee) Look! there is no coin now.
> Observee (4): Image is visible (This is only an image of the coin which is visible). The coin is placed below. (coded as 3)

5.7 Results and discussion

Forty-nine students in the study stopped in total 820 and 2035 times at individual exhibits in the *Heritage* and *Fun Science* galleries respectively (Table 5.4). The absence of comparable data for *Information Revolution* is due to the different nature of exhibits in it. All but three students saw the exhibits in a continuous spell. The first exception, a student in a family group, went to the canteen after 33 minutes of his visit and stayed there for half an hour. His total stay in the science centre was 108 minutes (from entering *Heritage* to leaving *Information Revolution*). Another student (25), in a peer group, went to the canteen after 50 minutes of his visit and stayed there for 20 minutes. His total stay in the centre was 95 minutes. The third female student (32), in a family group, went to the canteen after 11 minutes of her start and stayed there 28 minutes. Her total stay in the centre was 123 minutes.

Only one participant group out of fifty turned back from the first gallery. Unequivocally, the visitors' heightened interest and choice of "being between the exhibits" provided a measure, may be a very crude one, of the exhibit effectiveness. According to Koran and colleagues (1986), attracting attention and evoking curiosity are two worthwhile objectives for any science exhibit, as these two factors may ultimately lead to other learning and memory outcomes. In support, in his detailed study on exhibit effectiveness, Shettel (1973) also observed that the amount of viewing time and the motivation of the viewer definitely influenced the amount of knowledge gained from the exhibit.

Table 5.4. Time spent in *Heritage, Fun Science and Information Revolution.*

	Valid observees	Total events	Range (in minutes)		Average holding
			Min. Time	Max Time	power (in minutes)
Heritage	49	820	3	41	17.7
Fun Science	49	2035	10	100	37.9
Information Revolution	45	-	3	52	17.9

On average, students spent 18 minutes in the *Heritage* and *Information Revolution* galleries and 38 minutes in *Fun Science*. The figures of average viewing time are common and can be seen in several other studies. For example, in his study conducted in the National Museum of History and Technology, Shettel (1973) reported that the casual visitor spent 20 seconds at an exhibit unit (there were 41 units in total) and 14 minutes in the gallery.

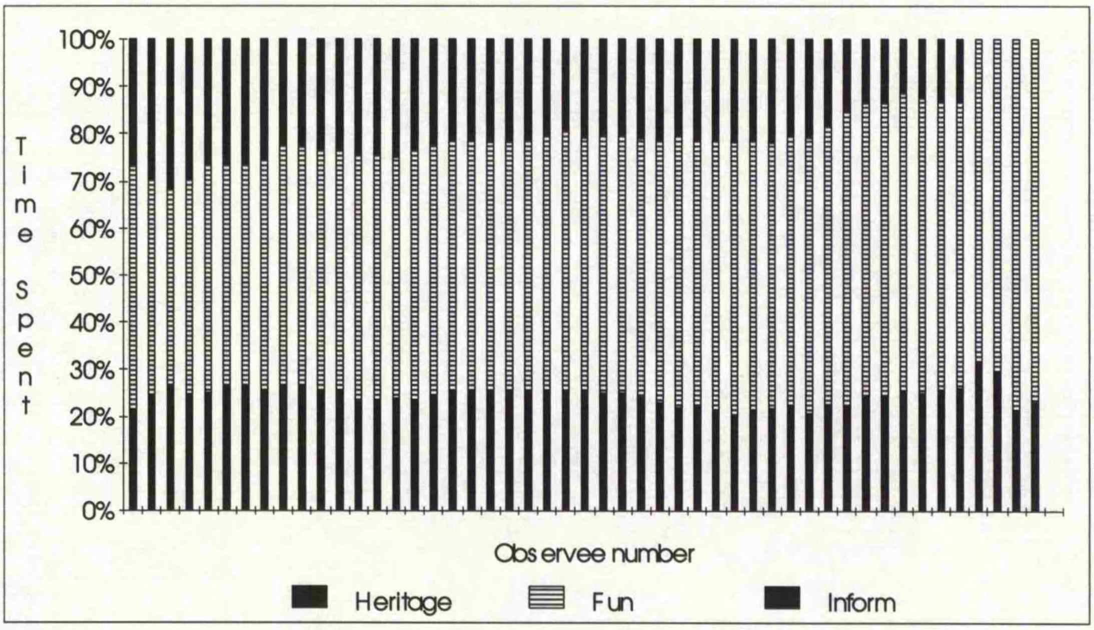

Figure 5.3 Percentage of time spent by each observee in *Heritage, Fun Science and Information Revolution.*

On average, the students spent almost equal time in the *Heritage* and *Information Revolution* exhibits and a little more than double in *Fun Science* (Table 5.4). The graph shows that individual students spent approximately 50% of their time in the *Fun Science* gallery, and the rest 50% time in the *Heritage* and *Information Revolution* galleries (Figure 5.3). The pattern of engagement was found to be almost the same for all observees but five who did not participate in the *Information Revolution* gallery. The results explicitly suggest the merit of interactive exhibits. Sixty-three percent of the total events occurred in the science centre were found to be related with manipulative exhibits (Table 5.5).

From the findings here (viewing time and number of events), the visitors' concentration appears to be far more in the *Fun Science* exhibit than the *Heritage* and *Information Revolution* exhibits. The results are in agreement with similar findings elsewhere, such as one in the Science Museum, London where the visitor concentration is reported far more in *Launch Pad* (714 visitor per square metre) that in other exhibition areas (44 visitors per square metre) (Thomas, 1994). Furthermore, the qualitative and spontaneous remarks made by the students and accompanying teachers clearly support the finding.

> In science centre ... there ... the children enjoyed the *Fun Gallery* more because they could handle things on their own. They were very happy, they were making noises, they were halla-gooling ...you know... and really having fun (Mrs Mahendru, Language Teacher, Government Girls Sr. Sec. School, Paschim Vihar, Delhi)

The "survival curve" graph confirms that the *Fun Science* exhibit has more holding power than the other two: it can engage visitors more than five half-life times (Figure 5.7). While the flow of the visitors was observed to be uni-directional in *Heritage* and *Information Revolution*, most students preferred to take a second round in the *Fun Science* gallery.

Although the holding power projects the triumph of manipulative exhibits but it does not tell us anything about the pattern of interaction with individual exhibits. The potency index, however, throws light on this aspect. Almost similar potency index curves show that the students uses their time in an equally efficient way (Figure 5.8). They were selective: in *Heritage and Information Revolution* exhibit, they chose only a few exhibits to interact and did not waste time on what really does not appeal to them. In the post-visit questionnaire, the students' response to the question, 'which exhibit did they like most and why?,' represented the exhibits and activities in the whole centre. For example, out of 204 students 80 students liked the most *Fun Science* related exhibits and 61 liked the most *Information Revolution* related exhibits.

The colour map of students' usage of the exhibits also throws light on their interaction patterns in different galleries. The maps clearly show the selectivity on the part of students (Figure 5.4; Figure 5.5; Figure 5.6). In *Heritage* and *Information Revolution* galleries, a vast proportion of the exhibits was seen by no more than 20 percent of the students in the sample. In other words, students used and liked particular exhibits and they left behind without seeing a large part of the exhibition hall. The interaction pattern can be said "bi-modal" in these two galleries. On the other hand, in *Fun Science*, most exhibits were seen and used by more than half of the students. The finding supports to the premiss that young students respond very favourably to inter-active exhibits and is consistent with other visitor studies conducted since the 1930s.

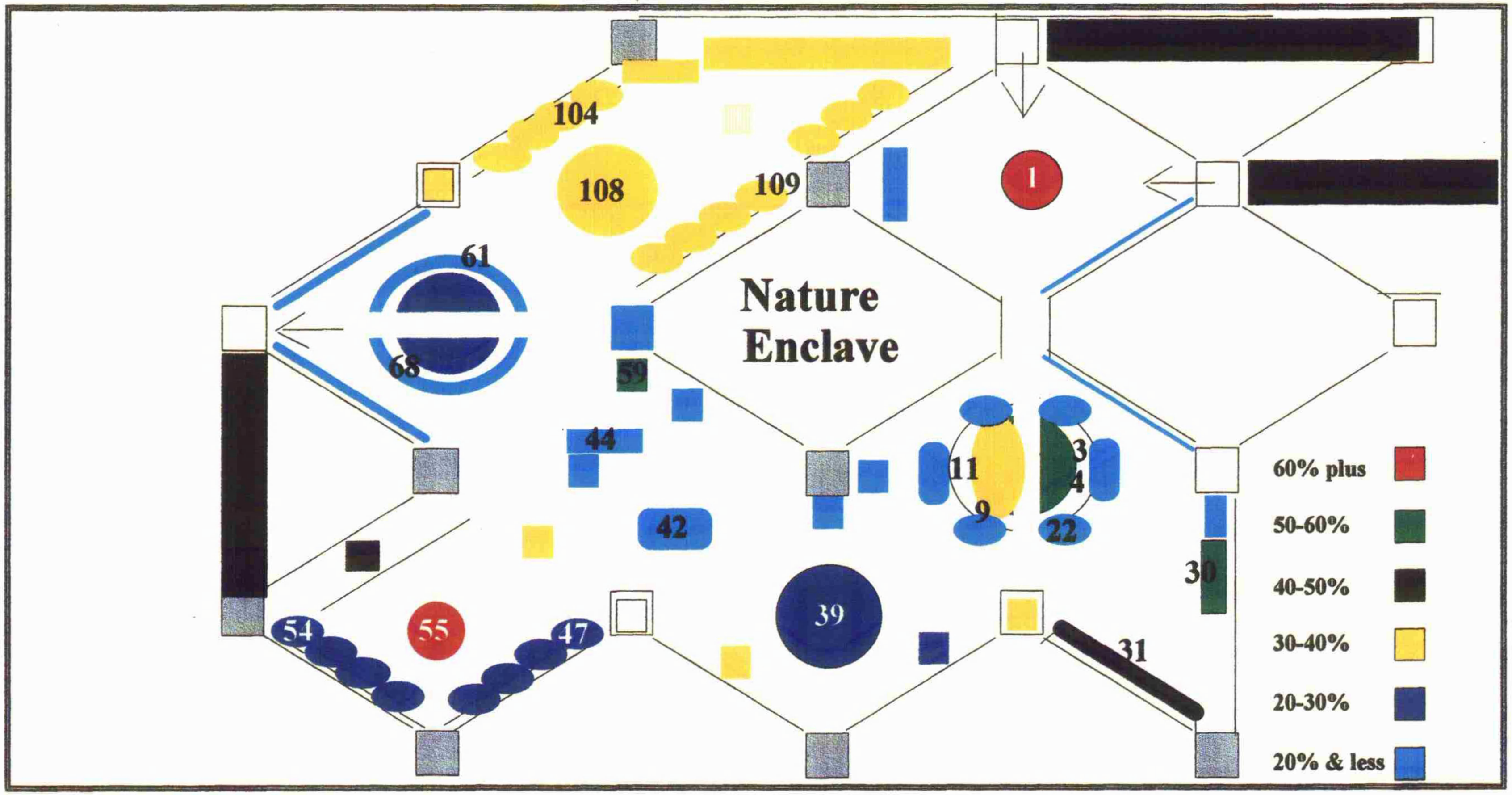

Figure 5.4 The *Heritage* exhibit: colour map of what students paid attention to. The location of the exhibits can be identified by following serial numbers given in Appendix 2.

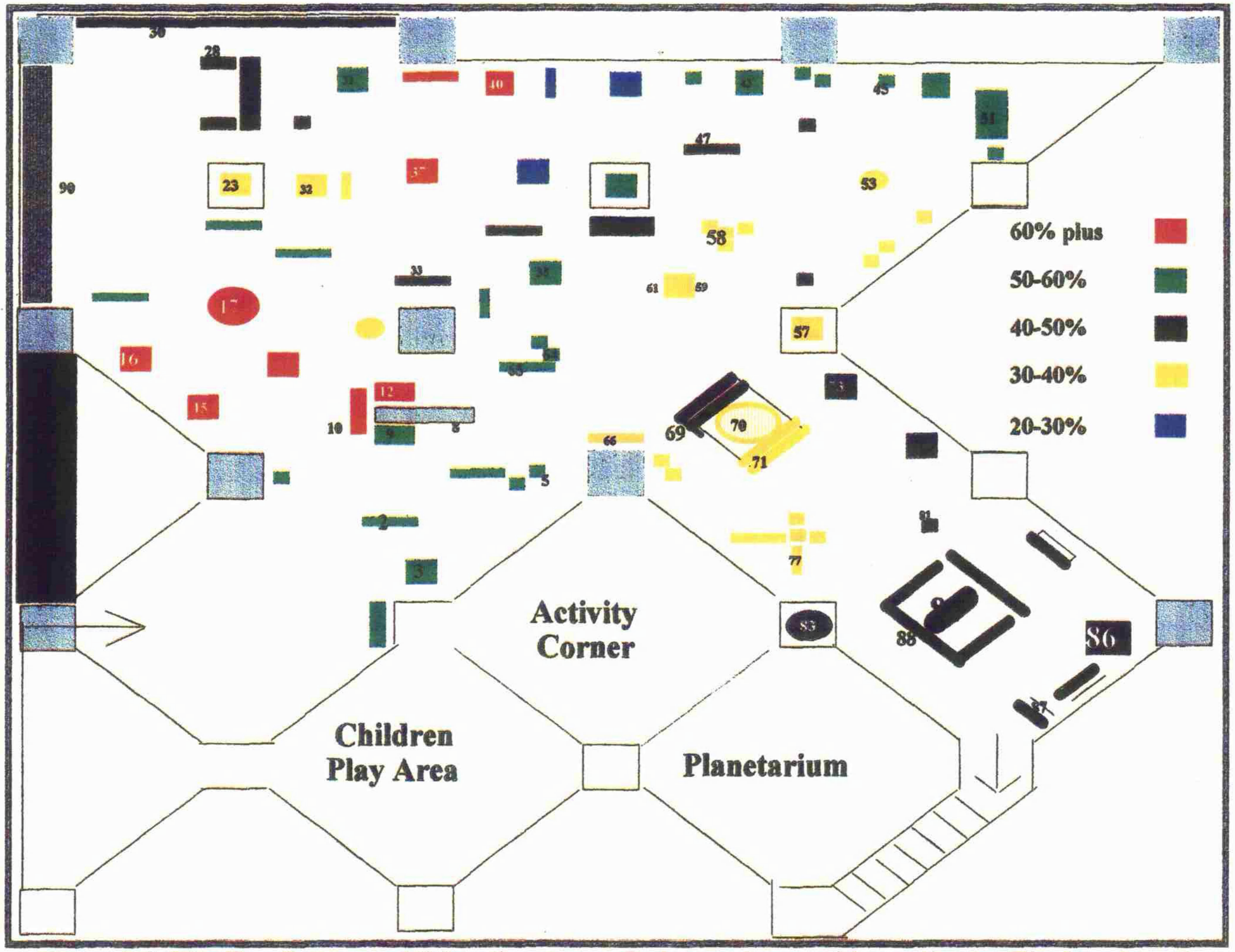

Figure 5.5 The *Fun Science* exhibit: colour map of what students paid attention to. The location of the exhibits can be identified by following serial numbers given in Appendix 2.

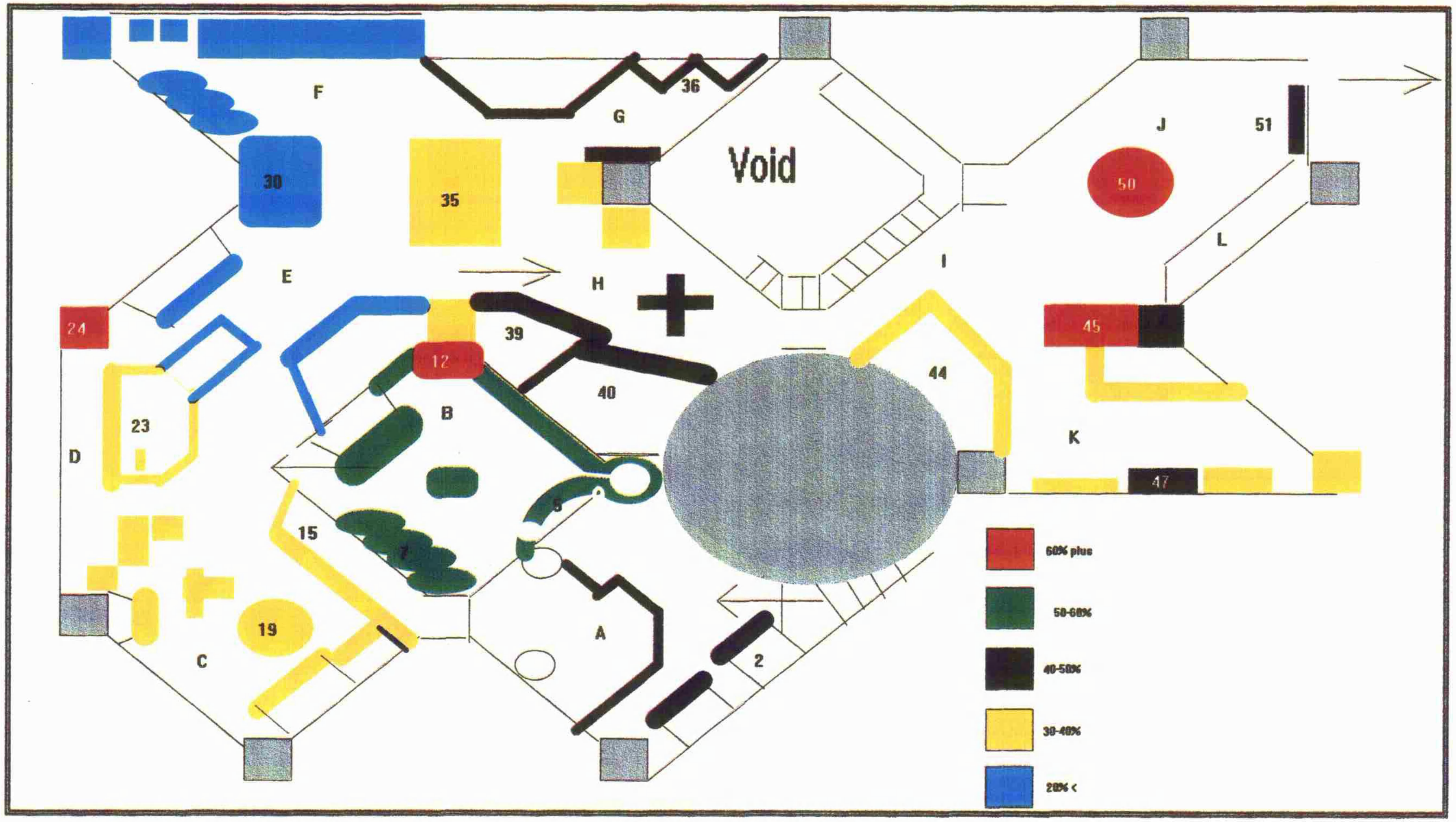

Figure 5.6 The *Information Revolution* exhibit: colour map of what students paid attention to. The location of the exhibits can be identified by following serial numbers given in Appendix 2.

In 22% *Fun Science* events, students tried to explore the exhibits and in additional 35% events they explored contents seriously. They read labels to some extent in 7% events and went through labels seriously in approximately 12% events. The results suggests the distribution of the label reading behaviour as "bi-modal". Around 80 percent students did not bother to read the label at all. The findings are consistent with the other studies which report that up to 90 per cent visitors do nor read the label, or at the best, they glanced at it for a couple of seconds (Falk and Dierking, 1992: 70). The label reading discrepancy is so glaring that anyone who stroll in the galleries for a little while reaches the same conclusion. For example, a senior secondary school teacher says about her students:

> They were not reading the labels. We stressed them to read the labels first and try to understand and if they do not understand then come (to us for clarification). But, they were not (Physics Teacher, Government Girls Sr. Sec. School, Paschim Vihar, Delhi)

In about 45 to 55% events students appeared to explore things, that is they were doing 'mindful play'. In about 40% events, students appeared to gain knowledge and understanding as a result of their engagement, and for additional 10 to 13% events, it can be said with some degree of certainty (Table 5.7).

Table 5.5 Frequency of engagements with various type of exhibits *Heritage, Fun Science and Information Revolution.*

	Frequency of events with various type of exhibits (percentage of particular type of events in a gallery)				
	Aesthetic	**Passive**	**Working model**	**Push button**	**Manipula t-ive**
Heritage	52 (6)	109 (13)	122 (15)	331 (40)	206 (25)
Fun Science	-	57 (3)	-	252 (12)	1726 (85)
Information Revolution	5	210 (49)	-	69 (16)	149 (34)
Total	57 (2)	376 (11)	122 (4)	652 (20)	2081 (63)

Table 5.6 Potency index of *Heritage, Fun Science and Information Revolution.*

	No. of observees	Sum of potency index	Mean (N = 50)
Heritage	48	24.70	0.49
Fun Science	49	29.75	0.60
Information Revolution	45	26.60	0.53

Table 5.7 Frequency of postures in *Heritage, Fun Science and Information Revolution.*

		Percentage of events	
Mental Verb	**Code**	**Heritage Gallery**	**Fun Science Gallery**
Reading Labels	1	73.3	77.8
	2	5.0	7.1
	3	14.1	12.0
Exploring	1	15.1	23.0
	2	20.6	22.4
	3	26.1	34.7
Understanding	1	17.6	26.8
	2	32.8	40.5
	3	11.8	12.8

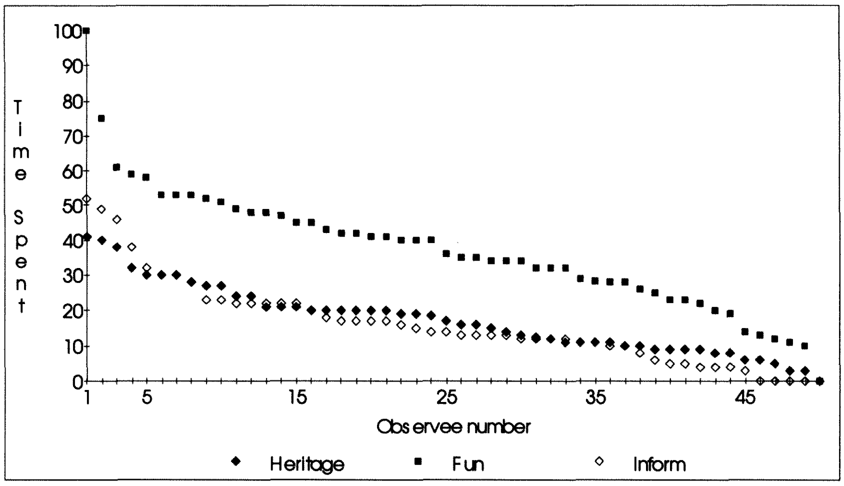

Figure 5.7 'Survival Curve' for time spent by participant groups in *Heritage, Fun Science and Information Revolution.*

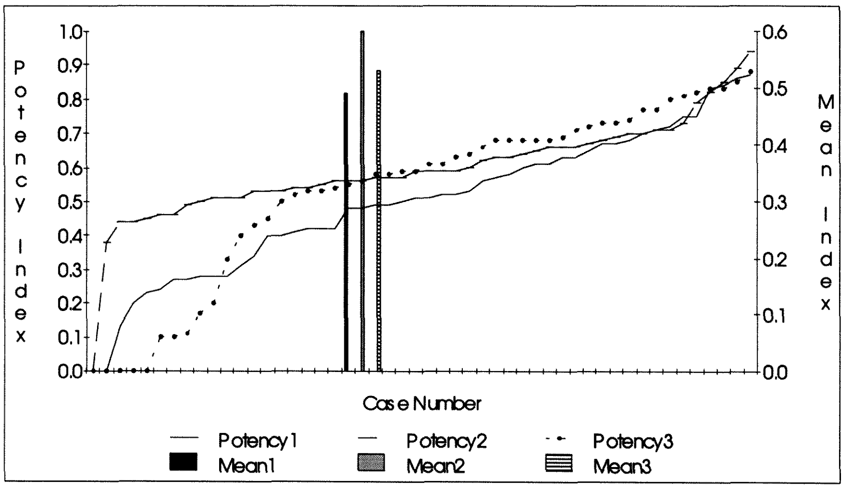

Figure 5.8 Potency index for each observee (Left Y-axis) and mean potency index (Right Y-axis) in *Heritage, Fun Science and Information Revolution.*

Gender based results

On average, female students spent less time in the *Heritage and Information Revolution* exhibits and interacted with less number of exhibits than males. An unpaired t-test indicated significant difference in the number of exhibits seen by males and females (Table 5.9). Male students interacted more times with exhibits in the *Heritage* gallery ($t = 1.36$) and significantly more times in *Information Revolution* ($t = 2.20$). On the other hand, females tried less number of exhibits, but spent more time in *Fun Science* than males (Figure 5.9).

Average engagement level was observed slightly more for females than males, but an unpaired t- test indicated no significant difference between the two (Table 5.9). More male students (24.1% postures in *Heritage*; 37% postures in *Fun Science*) followed the trial and error approach than the females (11.1% postures in *Heritage*; 29.6% postures in *Fun Science*). Females read more labels (17.4% in *Heritage*; 16.2% in *Fun Science*) than males (11.5% in *Heritage*; 8.7% in *Fun Science*). Female students initiated their actions slightly more (9.8% in *Heritage*; 12.5% in *Fun Science*) in an informed way, that is after reading labels or observing others doing, than males (7.5% in *Heritage*; 8.9% in *Fun Science*). Female students listened to explanation from friends and described to them events more often than male students (Table 5.8a).

More female students did not handle exhibits in comparison with males. For example, in *Heritage*, female students did not handle exhibits in 21.7% postures in comparison to only 12.8% male postures. Similarly, in *Fun Science*, 10.6% female students did not attempt to handle the exhibit, in comparison with 5.3 % male postures.

The observation that the female students spent more time in *Fun Science* implies that they prefer inter-active exhibits. An inter-active element in exhibits has a positive impact on female students. In *Heritage*, female students looked at the exhibits, but did not try the exhibit in 51.6% postures. The corresponding figure in *Fun Science* is 18.2%. Similar gender differences between the viewing time and the nature of the exhibits has also been reported by several other researchers (Koran *et al.*, 1986; Boisvert and Slez, 1994).

Less dependence on trial and error approach, more label reading tendencies and mindful observation and exploration appears to lead a slightly better understanding in case of female students than males. In *Heritage*, female students were observed to have understood the message of exhibit in 13.9% events (9.7% in case of males). The similar trend was observed in *Fun Science* (Females understood in 15.1% event and males in 11%) (Table 5.8a).

Table 5.8a. Summary of frequency of male and female postures.

		Heritage Gallery		Fun Science Gallery	
Mental Verb	**Co -de**	**Female postures %**	**Male postures %**	**Female postures %**	**Male postures %**
Doing	1	51.6	39.4	18.2	16.4
	2	11.1	24.1	29.6	37.0
	3	18.2	17.9	26.7	26.0
	4	9.8	7.5	12.5	8.9
Reading	1	70.4	75.5	72.2	82.4
	2	5.7	4.4	9.6	5.1
	3	17.4	11.5	16.2	8.7
	4	1.6	0.4	0.1	0.0
Listening	1	44.6	55.8	74.0	73.0
	2	3.5	2.2	3.4	1.7
	3	12.0	4.6	5.1	3.9
Describing	1	44.6	53.3	75.5	72.0
	2	3.8	3.1	3.4	2.1
	3	11.7	6.0	3.6	4.5
Handling	1	21.7	12.8	10.6	5.3
	2	6.3	10.0	12.5	15.5
	3	32.9	36.3	52.0	51.2
observing	1	9.0	23.7	21.5	25.8
	2	19.0	16.6	19.0	20.8
	3	32.9	26.6	41.5	31.7
Exploring	1	7.9	21.0	20.9	24.8
	2	22.6	19.0	24.9	20.2
	3	30.2	22.8	36.4	33.3
Understanding	1	10.6	23.2	22.8	30.1
	2	36.4	29.9	44.3	37.3
	3	13.9	9.7	15.1	11.0

Table 5.8b. Summary of male and female postures.

		Heritage Gallery		Fun Science Gallery	
		Female postures %	**Male postures %**	**Female postures %**	**Male postures %**
With Whom	1	35.6	45.8	41.5	41.2
	2	9.2	35.4	19.9	48.8
Instruct	1	88.9	86.3	88.0	91.6
	2	0.3	0.2	0.7	0.1
	3	6.0	5.5	8.0	1.6
Enjoyment	1	13.6	25.4	18.0	24.3
	2	35.1	29.2	31.9	29.3
	3	12.2	8.4	32.5	24.8

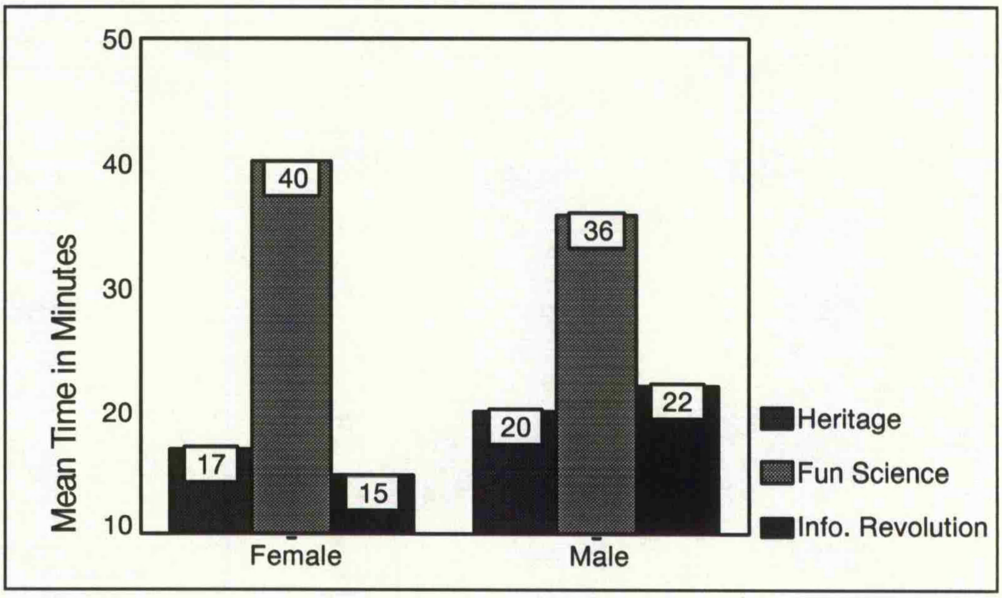

Figure 5.9 Average time spent by male and female students in *Heritage, Fun Science and Information Revolution.*

Table 5.9 Unpaired t-test: sex based comparison in *Heritage*, *Fun Science* and *Information Revolution* galleries.

	Heritage		**t-value**	**Fun Science**		**t-value**	**Information Revolution**		**t-value**
	Female	**Male**		**Female**	**Male**		**Female**	**Male**	
No. of exhibit	15	19	2.05	38	45	1.44 NS	8.90	13.05	2.26
Engagement Level (mean)	15.45	15.16	0.22 NS	19.31	18.51	1.04 NS	-	-	-
Interaction Potential	8.55	11.35	1.36 NS	23.39	22.05	0.44 NS	8.67	14.68	2.20
Holding Time	16.39	19.10	1.00 NS	39.49	36.42	0.63 NS	14.13	21.27	2.13
Potency Index	0.47	0.56	1.65 NS	0.60	0.62	0.58 NS	0.55	0.63	1.38 NS

Grade based results

On average, secondary (junior) students spent less time in the *Heritage and Fun Science* exhibits and interacted with less number of exhibits than senior secondary (senior) students. An unpaired t-test indicated a significant difference in the number of exhibits seen by junior and senior students (Table 5.10). Senior students saw more exhibits than junior students in the *Heritage* and *Fun Science* gallery. In the *Information Revolution* exhibit, both junior and senior students interacted with equal number of exhibits, but junior students spent significantly more time (t = 1.94).

The unpaired t-test indicated no significant difference in the average engagement level in the *Heritage* and *Fun Science* gallery between junior and senior students (t = 0.32 for Heritage; t = 0.98 for *Fun Science*). The unpaired t-test, however, revealed a significant difference in the potency index between junior and senior students: In *Heritage*, potency index for senior students was found significantly greater (t = 1.22); in contrast, in *Information Revolution,* the potency index for junior students was found more (t = 1.06); and almost no difference was observed in the potency index of *Fun Science* (Table 5.10).

The results indicate that both junior and senior students find the *Fun Science* equally interesting. In the rest of the two galleries, comparatively, senior students appear to be more interested in *Heritage* and junior students seems to be at more ease in *Information Revolution.*

Table 5.10 Unpaired t-test: grade based comparison in *Heritage*, *Fun Science* and *Information Revolution* galleries.

	Heritage		**t-value**	**Fun Science**		**t-value**	**Information Revolution**		**t-value**
	Sec.	**Sr. Sec**		**Sec.**	**Sr. Sec**		**Sec.**	**Sr. Sec.**	
No. of exhibit	16	21	1.98	40	44	0.78 NS	11	11	0.24 NS
Engagement Level (mean)	15.46	15.02	0.32 NS	18.63	19.42	0.98 NS	-	-	-
Interaction Potential	8.6	12.24	1.71 NS	20.98	25.63	1.61 NS	13.5	7.86	1.94
Holding Time	15.98	20.79	1.73 NS	35.26	42.68	1.49 NS	20	13	1.97
Potency Index	0.49	0.56	1.22 NS	0.605	0.61	0.15 NS	0.61	0.55	1.06 NS

Relationship between attracting power, holding power, interaction potential, and engagement level.

Attracting power is the ability of an exhibit to grasp the attention of a visitor. Holding power is the ability of an exhibit to retain the visitor's attention. Interaction potential of an exhibit is the ability of its individual exhibits to retain the visitor's attention. Engagement is the observed degree to which the visitor feels like paying attention to individual exhibits. All these measures can help us evaluating the effectiveness of a learning environment.

Researchers usually define the term 'holding power' in their own ways: for instance, some relate it to the total time spent in an exhibit (Falk, 1983; Boisvert and Slez, 1994), while others think holding power in terms of actual viewing time (Peart, 1984), referred to in this study as 'interaction potential'. Our correlational results pertaining to the engagement level (Table 5.11) suggests that 'holding power' and 'interaction potential' do not necessarily point to the same thing and so should not be taken as homomorphic. Both our common sense and our correlational results suggest 'interaction potential' a more realistic tool than the 'holding power'.

Over the last few decades, museum educators have been engaged in designing exhibits that attract hold and actively engage visitors with the expectation that this will enhance visitors' knowledge and understanding. Falk (1983) found a significant relationship between holding power, engagement, and visitor learning. Similarly, Peart (1984) also found a positive correlation between holding power (analogous to interaction potential here), engagement level, and visitor's knowledge gain. This study confirms a highly positive relationship between attracting power, holding power and interaction potential.

Table 5.11 Relationship between attracting power, holding power, interaction potential and engagement.

	Attracting Power & Holding Power	**Attracting Power & Interaction Potential**	**Engagement & Holding Power**	**Engagement & Interaction Potential**
Heritage	0.81 (0.001)	0.79 (0.001)	0.31 (0.31)	0.46 (0.001)
Fun Science	0.69 (0.001)	0.82 (0.001)	0.18 (0.226)	0.20 (0.169)

The relationship between interaction potential and engagement was found to be moderate and concomitantly dependent on the nature of the exhibit. For example, in *Fun Science*, the correlation coefficient is 0.20. This means that in *Fun Science* more viewing time does not necessarily indicate the corresponding occurrence of the meaningful engagement with the exhibit. In other words, the spontaneous behaviour during interaction is as likely to be play as learning.

Summary and conclusion:

1. Most of the students in the random sample are found to be energetic and enthusiastic. Their heightened interest and choice of "being between the exhibits" provide a measure, may be of a very crude nature, of exhibit effectiveness.

2. Holding power of the exhibit as a whole declares the unquestionable triumph of the typical science centre approach, but the potency index is found to be nearly same for all the three exhibits. The uniformity of potency index predicts two possibilities: the availability of interesting and competitive exhibits in each of the galleries and/or the efficient use of time on the part of students. The colour maps showing the use of exhibits by the students support both possibilities.

3. On average, in approximately 12 to 15% events students are found to be reading labels seriously. Female students are found to be reading labels more than males. The results indicate that male students rely more on trial and error approach than females.

4. In about 40% events, students appeared to gain knowledge and understanding as a result of their engagement, and for 13% events it can be said with some degree of certainty.

5. The average engagement level was observed slightly more for female students than males. The study does not support to accepted wisdom which sees science mainly as a male domain.

6. Female students preferred a typical fun science approach to any other style. If this finding can be generalised, the potential of interactive designs in creating a gender-free environment is clear.

7. Female students spent much less time in the Information revolution exhibit than males. It should also be pointed out here that male students also spent most of their time in few technology (computer) - oriented units. It suggests either the intensional relationship of female students with computers and other gadgets or lack of opportunities for them due to being in a predominantly male (of serious nature)

environment. The darkness in the gallery may also be a contributing factor to this finding.

8. The *Information Revolution* exhibit is most liked by junior students and the *Heritage*, by senior students. *Fun Science* is liked by all, as there is found to be no significant differences in the results.

9. The study appears to confirm a highly positive relationship between attracting power and interaction potential and suggests a moderate relationship between interaction potential and engagement.

10. The correlational results suggest that, in behavioural studies, 'interaction potential' should be used in place of holding power.

Chapter 6

Construction of Attitudes toward Science Scale for Organised School Groups in Science Centres

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Introduction

The influences of science and technology are increasing more and more in our everyday activities and so is widening the gap between science and society. While most of the people remain unable to understand the language of science, some are greatly concerned about the consequences of the uneasy relationship between science and society. This concern has recently given rise to efforts to improve the public access to this field of knowledge. National leaders and thinkers throughout the world emphasise the need for building attitude of the public in a favourable direction toward science. It would be no exaggeration to state that the centres of science and technology have been created to play a fundamental role in this area.

In this chapter, I shall first examine whether science centres, theoretically, have the potential of building positive attitude toward science or not. I shall then review the studies made in science museums and centres on this subject. This retrospection will point to the need of defining 'attitude' concept and also emphasise the need of developing a reliable and valid scale in order to measure the attitude and attitude change as a result of a science centre visit. The developed scale will be used to generate data. Data will analysed and, subsequently, the results will be presented in the next chapter.

6.1 Attitude development in science museums

In the following discussion, I shall mainly focus on hands-on and inter-active settings but will often consciously use the word 'museum' in place of 'science centre'. By using the word 'museum', it is intended that the argument, philosophy or understanding constructed in the context of science centres can be extended to other settings such as science museums, zoos and aquariums.

Now, our next task is to ponder over what constitutes a museum - a curator, an architect, a building or a few objects? If we pose a simple question to ourselves - Can a museum run without a curator? The right answer would be, probably yes and sometime even runs better. For example, the science museum of Thessaloniki, Greece, has been organised and successfully operated not by curators, but by visitors and fans (Iatridis, 1995). Again, if we pose another question - Can a museum run without visitors? Perhaps, the answer would be - no, never or who says? This question-answer session leads us to three essential building blocks of a museum, that is museum (container), exhibit (content) and visitor (user).

In this chapter, I shall take 'essential building block triangle' as a criterion in order to elaborate the impact of a museum visit on attitude development toward science. In other words, I shall discuss prominent features of museums, exhibits and visitors which may successfully nurture interest in the presented subject-matter, and eventually build positive attitude among visitors toward science centres.

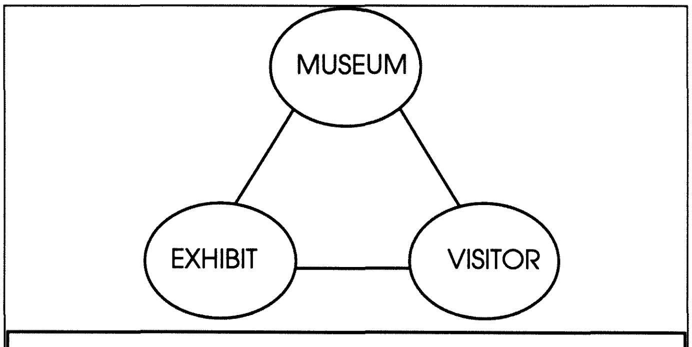

Figure 6.1 Essential building blocks of a museum system

Institutional perspective

> We assembled on the spot, about ten in number, all strangers to me, perhaps to each other. We began to move pretty fast, when I asked with some surprise, whether there were none to inform us what the curiosities were as we went on? A tall genteel young man, *in person*, who seemed to be our conductor, replied with some warmth, 'What! would you have me tell you everything in the Museum? How is it possible? Besides, are not the names written upon many of them?' I was much too humbled by this reply to utter another word. The company seemed influenced; they made haste, and were silent (quoted in Hudson, 1975: 8).

The above is the museum experience of William Hutton, a bookseller from Birmingham, who visited the British Museum in 1784. Once upon a time, museums were indeed depressing, and sometimes even excruciating, environments. But, since then, much has been changed. The present is an era of revival for museums as their aims and basic functions have either been changed or are in a transitional phase. For example, their stress has now been shifted from 'collection' to 'interpretation' and 'learning' or, in other words, from 'collection as a great achievement' to 'collection for a great achievement'.

Recognising that most visitors do not come to museums to acquire specific knowledge, it has been, and is increasingly being, realised that learning is informal, spontaneous and individual process in which experience itself is much more important for any significant learning to occur. Like previous times, visitors are no more 'unwanted intruders' in museums. On the contrary, today they are 'guests' (In Experimentarium! the Danish Science Centre, Copenhagen, visitors are called 'guests'). Most of the museums have either created a public services or similar department or are thinking seriously in this direction. In the recent past, the majority of museum professionals have emphasised the importance of the museum as a whole in creating an environment that encourages active participation in a thoughtful and meaningful way. Ever increasing thoughts have been, and are being, given on each item of learning environment inventory (Table 6.1).

Table 6.1. Details of Learning environment inventory (LEI) in a science centre.

Item	Description
Accessibility	Location (City Centre - high rating), transportation facility, parking and similar facilities, provision of equal opportunities for special needs publics.
Transitional Areas	Information desk, cloak room, baby changing facility, toilets, drinking water, cafe, museum shop, relaxing area, public telephone booth, children play area and first aid facility.
Orientation	In person briefing of facilities, slide shows, introduction panels, museum guide book, pamphlets, sign boards, touch screens and audio guides.
Circulation Choices	Provision of multi-entry and exit points, free standing exhibit units in the hall, provision of demonstration islands, small theatres, cave and dome inside the hall.
Total Stimulus Control	General lighting, interior plants, thermal control, humidity control and odour control.
Exhibit Editing	Colour scheme, exhibit lighting, human factors, labels (type-size, length, contrast and style, and content)
Exhibit Stimulus Rating	Cleanliness, protection, maintenance, replacement of consumable items and lost components and education staff.
Total Integration	Indelible museum experience - minimum physical or psychological problems; exhibits - convey the feeling and knowledge that it is worth exploring; over-all time needed - manageable; space and time - enjoyable.

To some extent, powerful drives, such as the need for personal affiliation, can mitigate many of the physical barriers. However, where the desire to learn is a less than powerful drive (an all-too-common-situation), a little inconvenience may have a marked effect. This 'long overlooked or ignored' factor has now been, or is increasingly being, identified by museum professionals as an important one:

> We believe we should be delivering quality to them (visitors), not just in terms of the content of our public galleries but also in the way in which the place is run, its cleanliness, the public facilities in it, and so on. So, we have refashioned the museum over the last three years to include high quality retailing (Neil Cossons in a interview with Januarius, 1990).

The desire to make visitors feel psychologically and physically at ease and to make the museum more attractive, both inside and out, forms undoubtedly the underlying purpose of this revival and it has largely been possible through the cooperation between museum professionals, architects, political leaders, industrial houses, and local communities. As a result today, most museums follow an holistic approach. They want the building to convey also the message in conformance with the exhibits. For example, the Centre for Understanding the Environment, Horniman Museum, London, where has been desired that the building's design itself should speak out about environmental matters:

> It will be built from sustainable timber, insulated with recycled newspaper, finished with non-organic toxic paint, and topped with a living grass and wild-flower roof. Hollow timber beams and columns will create a natural passive ventilation system, reed beds will recycle waste water and solar panels will generate electricity (*Museums Journal*, November 1994: 8).

There is evidence that many non-users, including those who had formulated their negative image about museums long ago, perhaps in their childhood, and have not attended museums since then, still hold the conventional image - museums as glorious depository of a nation's heritage (Prince and Schadla-Hall 1985; *Museum Development*, March 1991: 25). But, the scenario is gradually emerging as a promising one. Dr Michael Gore, who visited the Exploratorium in 1975 with his family, and on his return developed his own science centre called Questacon in Australia, gave a very interesting account to this effect. He revealed that:

> He had to drag his family in and then, three hours later, drag them out (Duensing, 1987).

There can be seen unprecedented increase in attendance and change in visitors' behaviour after opening up a gallery based on the science centre approach in an old museum accused of inertia by the general public. For example, following the opening of its prestigious art and science extension in October 1993, the National Museum of Wales, Cardiff, witnessed a leap of 36 per cent in visitor numbers (*Museums Journal*, May 1994: 25). As a result of revival, visitors can be observed now exploring things enthusiastically in new museums. What is more impressive is the observation that in some cases visitors themselves are not ready to accept that they are in a museum.

> It was four-year-old Rory who summed it up. After spending an hour going round the exhibits at Eureka!, he turned and asked: "When are we going to the museum then?" (Millar, 1992)

The over-all perception of a visit is an extremely important factor in attitude development. Robert M. Hazen, a research scientist at the Carnegie Institution of Washington's Geophysical Laboratory, observes that 'museums can have tremendous influence. We have an opportunity here to change our national attitudes toward science' (Lantos, 1994).

Objectives of exhibits

The exhibit is the heart of the museum, and learning from exhibits is known to be one of the prominent motivation for a visit to museums. The exhibits here are usually built upon certain objectives. According to Shettel (1968), the underlying purpose of scientific and technical exhibits is generally the same - to impart knowledge about various technical subjects, and/or to change the attitude of the viewer in a favourable direction toward science, its practitioners, and its institutions. The objectives of scientific and technical exhibits are mostly found to be educational. In general, these educational objectives can be crudely conceived in terms of cognitive, affective and psychomotor areas. By means of exhibits, science centres first aim to kindle in visitors' hearts the wonder and loving sympathy for their content and ultimately for science, and thereafter they hope for facts to multiply in the memories of visitors:

> They expect most visitors to browse, directing their attention where they will. Through such episodic encounters with engaging material, science centres *hope to lure, stimulate, and invite* visitors to discover something new - just one thing - about the structure of the physical world' (my italics) (Grinell,1992: 13).

In exhibition halls, hands-on exhibits are changing in quality (from push button type to ones rich in varied psychomotor skills) as well as in quantity. Contemporary learning and teaching theories are increasingly being integrated with the process of exhibit development. New technologies are being employed in the exhibits to provide visitors links that would presumably facilitate learning. The interactive exhibits are found to be the most popular ones among visitors (Thier and Linn, 1976; Alt, 1983). Though interactive exhibits have been discovered to be successful in conveying information effectively (Zelig and Pfirman, 1993), most researchers believe that individual, or a group of, exhibits may not contribute immediately and directly to the deeper understanding but their indirect effect in affective domain must not be under-estimated (Wellington, 1989).

Learning theorists have long championed the idea that situational stimuli - events in the environment - directly influence our attitude and behaviour. Roberts (1990) asserts that the stimulating nature of exhibits should appeal so strongly to that part of the brain which concerns with space, image and affect. Similarly, Stephan Pizzey, of Science Projects, emphasises that hands-on exhibits are meant more to generate curiosity and enthusiasm than to be formally didactic (Arnold, 199). True, visitors may in due course forget the detail of what exactly was displayed and encountered with, but they are unlikely to forget the enthusiasm such exhibits can generate.

N. Reids goes further in suggesting in his Ph.D. thesis that it is the achievement of inter-activity, rather than the exact format, whether it be simulation, group discussion, or role playing, which is central to attitude development (quoted in Byrne and Johnstone, 1988). In a very extensive review of literature, Bredmemeier and Greenblatt (1981) conclude that under certain circumstances and for some students simulation-gaming can be more effective than traditional methods of instruction in facilitating positive attitude changes.

In conclusion, all the above arguments and evidence suggest that the science centre approach provides a nutritious substance for attitude development toward science.

Visitors' perspective

Learning is strongly influenced by personal world views, knowledge, attitudes and aspirations, and social interactions. Active involvement of students rests at the heart of effective science learning. Recent research point to the dominance of information processing actions in the museum environment. In a large metropolitan museum of natural history that provides ready access to novel information through its traditional displays and interactive exhibits, Hike (1989) reveals that 86 per cent of all events undertaken by visitors concern the exhibits themselves. McManus (1989), in her study of detailed discourse analyses of the recorded conversations of visitors, finds how close and personal visitors' talk is, but at the same time mediated by the labels on exhibits. Several other studies made on young visitors (Gottfried, 1980; Herbert, 1981; Carlisle, 1985; Tuckey, 1992) also reach the conclusion that children on a field trip to a science centre, at first, exhibit diversive exploratory behaviour and gradually become orderly, attentive and interested in exhibits. On the basis of these many studies, it appears reasonable to conclude that visitors through their active involvement fulfil a necessary, though it alone may not be a sufficient, condition of learning.

During the visit, visitors see a number of miscellaneous, unique and splendid things, and participate in a number of activities in a short span of time. They often see or do something which rubs-off, sticks or 'sparks-off' (Wellington, 1989) something in their mind which may resurface later. Indeed, there are many, varied and scattered views about what actually visitors take away with them. Stevenson (1991) collected diversely scattered 'professional views' about visitors' assets and summarised them in six categories:

1. a set of experiences (or memories).
2. a set of effects.
3. a set of explanations.
4. a set of applications.
5. more understanding in a general sense.
6. a change in attitudes.

To make Stevenson's list further useful, on the basis of my behavioural studies I suggest to include two more categories:

7. a set of brain-storming questions (or mysteries).
8. a set of misconceptions.

For category 6, Stevenson says that it is generally hoped that a visitor may feel positively disposed after a visit to a science centre. In their independent studies, both, Stronck and Birney, conclude that highly structured organised school visits appear to result in greater cognitive learning and less structured, in producing more positive attitude (Stronck, 1983; Birney quoted in Falk and Dierking, 1992: 50).

6.2 Attitude change: theory and practice

As we have seen in Chapter 3 that one of the primary objectives of science centres all over the world is to shape people's attitude towards science, with a special emphasis on younger generations. From the above discussion, it is clear that all the three essential building blocks of a museum system, that is museum (container), exhibit (content) and visitors, strive for the same goal - development of new attitudes and consolidation of the existing attitudes. Attitudes are learned from experiences. If attitudes are learned, they can be shaped over time as a result of many influences including persuasive messages. Social psychologists see this understanding of attitude change quite problematic. If people's attitude could be changed, they argue, we would have a better world - one in which prejudices are lessened, social conflict is reduced and life styles are more healthful. 'Which is not really is the situation in real life,' their reasoning goes on.

In the above argument, social psychologists expect 'attitude' to behave like a magnetic needle which rests always in the north-south direction under the influence of the magnetic field. For that to happen, the attitude is a quite complex concept. But in real life setting also, one can see the influence of persuasion and training. For example one can easily notice the difference in attitude and behaviour of Karachi Police (in Pakistan), Bhagalpur Police (in India) and London Police (in Britain). In the 1970s, Bhagalpur Police burnt the eyes of several prisoners in their custody. Karachi cops are also well known for their corruption, savageness and cruelty. On the other hand, one rarely hears of the death of a person in police custody in London. To put the theory into practice, it can be assumed that we can attempt to shape the attitudes, and can succeed to some extent, but we cannot fully control the process.

In psychology, basically, theories of attitude change can be divided into two groups: 'Process' theories and 'Combinatorial' theories. The process theories provide an account of how beliefs and attitudes form and change when people receive relatively complex messages. The combinatorial theories focus on how information is integrated to affect attitudes when people gain information about attitude objects. While the combinatorial theories are virtually applicable to any settings in which people gain new information about attitudinal objects or ruminate about information they already possess, the process theories work best in persuasion setting in which messages consist an overall position that is advocated and one or more argument is designed to support that position. In general, both theories of attitude change draw from assumptions that certain cognitive, affective, or motivational processes mediate such changes.

Both theories may be useful to analyse events in museum settings, as they are complementary. For example, the process theories attempt to explain the mechanisms that influence people's tendencies to accept information to which they are exposed and the combinatorial theories do describe how people integrate information they have accepted.

McGuire (1968), in his Information-Processing Paradigm (Process theory), proposes that the persuasive impact of messages could be viewed as the multiplicative product of six information processing steps: presentation, attention, comprehension, yielding, retention, and behaviour (12 steps in his 1985 modified model). He argues that the failure of any of six information processing steps to occur causes the sequence of chain to be broken, with the consequence that subsequent steps do not occur. Any way, suppose that a few people succeed in processing some information. Now, in his Information Integration Theory (Combinatorial theory), Norman Anderson assumes that attitudes are formed and modified as people receive and interpret information and then integrate this information with their prior attitudes (Eagly and Chaiken, 1993: 109). If someone has rigid and permanent sorts of prior attitudes, it may well be a Herculean task to change them. Evidently, according to both theories, attitude change is found to be conditional and, therefore, cannot be taken for granted.

To answer the question whether science centres have been, and are, successful in their purpose of attitude development toward science, we have only some anecdotal evidence. Exceptional and illuminating experiences often act as a catalyst in the process of human development. For example, the sight of a huge electric arc as a child determined Sir Bernard Lovell's career as a scientist (quoted in his book *Astronomer by Chance*). Those scientists who had some contact with science museums as children usually maintain that the museums played a vital role in developing their interest in the pursuit of science (Oppenheimer, 1968b; Tressel, 1992). Besides, we have also got some evidence from general population. For example, Frank Oppenheimer talks about a woman who reported that visiting Exploratorium gave her confidence she needed to rewire a lamp (Oppenheimer, 1987). Similarly, a woman rectified a lock in her sister's house a week after visiting Launch Pad (Tulley and Lucas, 1991). Anecdotal evidence is important for the individuals concerned - nevertheless, as individual statements, they have limited applications. It is, therefore, always desirable to establish some generalised results.

A number of quantitative research have already been undertaken on the aspect of attitude change as a result of exposure in museum settings. "Do attitudes change after exposure to the U.S. Science Pavilion?" was one of the main queries of the study conducted in the US Science Pavilion at the Seattle World's Fair, 1962 (Taylor *et al.*, 1963). During their literature survey, the authors went through several constructed scales but noted that they were exploring no more than the strength of pro-or-con feelings about science (Taylor *et al.*, 1963: 19). On the basis of literature survey and free-response interviewing, Taylor and his colleagues selected four main attitude variables: stereotypes of scientists, stereotypes of science, the meaning of scientific endeavour, and the potentials of science. They prepared an attitude questionnaire consisted of 45 items, taking 15-20 minutes to complete.

Interviews were conducted at six different locations and it was intended to find out the attitude change occurring in response to different activities or displays: that is, in response to the film in Hall I, to the *Development of Science* exhibit in Hall II, to the simulated trip through space in Hall III, and so on. The majority of significant attitude change occurred in response to the *House of Science* film in Hall I. The slight observed changes that took place after exposure to Hall 2 (*Development of Science*) were speculated to have occurred not as a result to the exhibits placed there but as overspill from the changes induced by the *House of Science* film. In sum, the portions of pavilion produced changes in attitude, but the changes were of slight magnitude.

In the late 1960s, Harris Shettel evaluated an ambitious American exhibit *The Vision of Man* at the National Museum of History and Technology. The exhibit was designed to impart knowledge about the role of the federal government in science and technology and to develop a favourable attitude in young visitors toward this role. A maximum, minimum and control indices of effectiveness measure were established in order to determine changes occurring in three areas - knowledge, interests and attitudes. The results in the areas of interest and attitudes found to be difficult to interpret. While the findings in interest area were found to be unstable, the problem with attitude measure was of no difference at all. The findings here tend to show that attitude do not seem to be influenced in response to short term exposure to an exhibit and, therefore, are inconsistent with Shettel's own studies for the *Atoms in Action* exhibit (Shettel, 1973). In *Atoms in Action*, Shettel surveyed exhibit viewers and non-exhibit viewers and found that most viewers showed positive changes in attitude to the peaceful use of nuclear energy.

Borun (1977) used three sub-scales - that is, interest in science, science is good or bad and perception of impact of science - in order to measure attitudes toward science, technology and society. In her study, high pre-visit attitude became low post-visit attitude indicating that the museum experiences failed to sustain the initial level of interest and enthusiasm among visitors. The major weakness of this study is that the author did not attempt to define the concept of attitude and its underlying structure.

In 1981, Bob Peart (1984) conducted an evaluation of exhibits (using the post-test only control group design) in the *Living Land-Living Sea* gallery of the British Columbia Provincial Museum. A questionnaire was developed to measure knowledge gain and attitude change about the seabird colonies. No significant change in attitude was found among the control and five experimental groups (1. word exhibit, label only 2. picture exhibit, with label 3. object exhibit, without label 4. standard exhibit, with objects and label 5. sound exhibit, with object, label and sound) pooled as one. Seventy-one per cent of the control group visitors were found to be in favour of leaving seabird colonies undisturbed. For the experimental group, the corresponding figure was 78 per cent.

In 1984, Finson and Enochs (1987) conducted a study to determine if a visitation to the Kansas Cosmosphere and Discovery Center in Hutchinson can affect attitudes toward science-technology-society (STS). A previously developed Scientific Attitude Inventory (SAI), composed of 60 items in a statement format with a five-point Likert-type scale for responses, was employed (with slight modification) for this purpose. The items were divided into sub-scales focusing on intellectual and emotional attitudes. The authors found the building of more positive attitudes toward STS of students who visited the museum (Finson and Enochs, 1987).

In a recent survey study of teachers' reaction on the role of interactive science centres in fostering positive attitude toward science (Tuckey, 1992), respondents were asked to react to the statement, "My pupils have shown a more positive attitudes towards science as a result of their visit to Satrosphere." By using this type of statements, we may perhaps not reach the right conclusion because: first, the term 'attitude' may have different meanings to different teachers; second, teachers instead of paying critical attention to the question may respond in socially accepted terms; and final, it is an indirect study in the sense that teachers estimate the attitudes of their students and so may draw their conclusion on the basis of some bright students. The response to the above statement seems obvious (in positive terms) and so actually is the case. Sixty-eight per cent of the respondents agree strongly with the statement. In his conclusion, Tuckey (1992) also admits that changes in attitude are notoriously difficult to measure and further tries to supplement the findings by statements from children.

All the above discussed studies seems to bring no consensus over the issue of changes in attitudes toward subject matter as a result of a science museum visitation. The researchers reported all possibilities - an increase, a decrease and no change in post-visit attitudes. In general, researchers also did not attempt to define the concept of attitude. In some cases, the researchers, for example Peart (1984) and Tuckey (1992), attempted to measure attitudes by means of a single question. There is a substantial technology and associated mystique about attitude measurement. Central to this is a belief that it is not possible to evaluate something like attitude on the basis of a single statement. Unfortunately, most of the researchers who used several items in their questionnaires did not pay attention to the reliability and validity of their scales or questionnaires. Evidently, for reliable results, much has to be done in this area.

6.3 Aim and objectives of the study

It is always desirable to predict the outcome of a museum visit as precisely as possible. On the basis of our own experiences, we can say that the cognitive outcomes are highly specific and subjective in nature, while the affective ones possess some generality. This study assumes that if there is some generality in the affective outcomes then we should be able to detect and measure it.

Prediction about outcomes is obviously very difficult as a number of different variables interplay in the process. For example, there is no such thing as a standard visitor to museums. The second assumption of the study is that we can understand the outcome of a visit provided we eliminate as many variables as possible, and also succeed in controlling the remaining variables of interest. As a result, this study eliminates a number of variables by focussing on organised school groups. In the present study, I aim to find the impact of a science centre visit on attitudes of young visitors to science.

Attitude change is a constructive process. It is natural to think that junior students may have different impact on attitudes than senior ones due to their different educational level. Similarly, girls may also have different impact than boys due to their different genetic make-up, and also due to different cultural, social and psychological expectations from them. Gender is also a variable of great interest as girls have an entirely different 'pattern of participation' in Indian education system than that of boys (Chapter1). Attitudes also have temporal stability, that is they are enduring enough to be stable but transient enough to be changed (Miller and Colman, 1981). Hence, we have got here three interesting variables - that is, education level, gender, and time of data collection (before and after the visit) - which can be easily controlled in the study. My objective of the present study is also to throw light on the relationship of attitude with gender, time of data collection, and educational level of students.

Attitude is an abstract term to define in some concrete sense. Allport (1935) observed that attitudes could be measured more successfully than they were defined. For Dawes

(1972), this statement was also true in the 1970s. For the present study in the 1990s, it does not appear a good idea to accept these views as it is. Admittedly, it is quite difficult to define exactly what attitude is, but we can certainly define it in 'approximate' terms. For example, we do not yet know what exactly an electron is, but by defining it in approximate terms we now know about it to the extent that we can control it. Following this analogy using an equally abstract concept, the third assumption of the study is that the concept of attitude to be measured can be constructed in approximate terms. In what follows next, I shall discuss the construct of attitude concept and its appropriate measurement technique.

6.4 Construct of the attitude concept

Attitude is a very broad and inter-disciplinary term, meaning very different things to different people. At the turn of the eighteenth century, artists used 'attitude' to describe the posture of a stationary figure in space and later as the postures of live actors and dancers; it still holds this meaning for kinesiologists (experts of the movements of the body and their communicative functions) (William and Lissner, 1962: 6). Though Darwin moved 'attitude' from theatrical to real life in the mid-1800s by using the term to describe the emotional readiness of animals in a state of crisis and gave the first hint of attitude's evaluative character (Fleming, 1967), and almost at the same time Herbert Spencer and Alexander Bain cited it as a mental concept (Albretcht *et al.*, 1980) but the physical connotation of 'attitude' reigned till 1950s. Now-a-days, attitude increasingly refers to the psychological rather than immediately physical orientation of a person.

Traditionally, two opposing points of view seem to exist among researchers concerning the nature of attitudes. On the one hand, Symonds (1927), Hartshorne (1930) and Bogardus (1931) contended that attitudes are highly specific and are as numerous as the person, ideas, or objects to which people respond, while on the other hand, Faris (1931), Dewey (1922) and Likert (1932) viewed attitudes as a number of isolated dispositions which are general in nature. Eysenck (1944) bridged the gap and admitted the existence of both types of attitudes specific as well as generalised. Ferguson (1940) proposed that if there is any generality in attitudes, it will be possible to extract it from the responses to the specific items or scale.

The attitude is also a contentious concept. Some researchers, in psychology and social psychology, find it an efficient way to size up the world while others, a bogus method. Research interest in attitudes has seen its peaks and valleys. In the 1960s and 70s, a series of blows came to the potency of attitudes when researchers found that people's expressed attitude predicted little of the variation in their behaviours. In 1971, Wicker reviewed several dozen studies covering a wide variety of people, attitudes and behaviours, and concluded that it may be desirable to abandon the attitude concept. A brief re-visit of these studies reveals that such discrepancies occur only when respondents, somehow, come to know the researcher's mind or they know what are socially acceptable responses. Hence, this may well be a result of misappliance of technique, of inadequate measurement technology rather than inadequacy of the concept itself.

It can be seen in literature that from the very first stages of research in attitudes it was found difficult to restrict attitudes to one model or theory. Attitudes were considered in affective-cognitive (Cantril, 1932; Krech and Crutchfield, 1948: 152) and affective-behavioural terms (Guilford, 1954; Freeman, 1963). Myers (1993: 112) mentions of three dimensions - what he calls ABC's of attitudes - affect (feeling), behaviour (intention) and cognition (thoughts). However, recent theorists have questioned the utility of the three component view of the attitude (Zanna and Rempel, 1988; Fazio, 1990; Tesser and Sheffer, 1990). These theorists consider behaviour to be separate from attitude and propose that behaviour may be an attitudinal object. One may, for example, either like or dislike doing an experiment: that is, one can have an attitude about a behaviour. It is also a fact that only due to attitude-behaviour inconsistency this field has seen a trough in the 1970s. Hence, for our purpose, it appears appropriate to consider attitudes in cognitive-affective terms. Behavioural term can be added after a careful and thorough examination.

A simple encounter with an object does not necessarily lead a person to develop an attitude toward it. In museums, a visitor sees a whole range of objects and activities, many of which may call forth no attitude at all. Interest, knowledge (information associated with the object), and evaluation (judgement based on knowledge) constitute as essential pre-requisites for attitude acquisition. Two people may share the knowledge about an object but may differ sharply in their judgements. For example, in India, two people can view recycling positively, but one may consider it a rebate on newspaper subscriptions, where as the other's relevant knowledge may be concern about the ecological survival. Tetlock (1984) calls this phenomenon as 'integrative complexity' - the degree to which people have multi-dimensional views on an issue and integrate a variety of information in arriving at their judgement. Kristiansen and Zanna (1988), while assessing attitudes toward allowing nuclear weapons in Canada, found that people used to justify their attitudes. For example, respondents who favoured nuclear weapons rated national security and a comfortable life as more relevant, while anti-nuclear respondents selected wisdom, salvation, and true friendship. In the light of such studies it appears reasonable to consider people's knowledge structures representing attitudes as inconsistent, value plural and, therefore, multi-dimensional.

In experimental studies, various instruments have been constructed which contain two or more logically and psychologically distinct variables; the distinction either not perceived, or ignored for the sake of simplicity, and all the item responses are summed to yield a single score. The student opinion poll of Laughton and Wilkinson (1968) contains 70 items covering pupils' attitudes to various aspects, like practical work, science as subject, characteristics of scientific thinking, interest and enjoyment, and yielding a single score. Aiken and Aiken (1969) asserted that in further research it would be of particular importance to develop more precise measures of attitudes towards the various aspects of science. For the present study, it is, therefore, necessary to consider attitude as multi-dimensional, but the nature of underlying variables will be decided after factor analysis of the collected data.

Religion and culture play a central role in preliminary attitudes formation in society as they evolve meaning about some object or event what is understood by society. For example, in Bangladesh, natural disasters, such as floods, are considered Godly and, therefore, beyond human control. This, of course, is not true in American or British context. As a further example, people from different religious and cultural backgrounds have different attitudes toward birth control and abortion. Most Muslims have negative attitudes in the extreme toward contraception and abortion, but the same is not true for most Protestants. At the recent UN population summit, the Vatican-Muslim alliance against birth control and abortion was described as hypocritical during a sustained counter-offensive from the West, led by Norway.

Attitudes can be learned through direct reinforcement or acquired through imitation and social learning. Many attitudes are acquired from other people. The religious, cultural, political, and economic (career related) attitudes are acquired mainly from parents and other close family members. Attitudes toward music, clothing styles, hairstyles and many other things develop in the context of interaction with peers. Preliminary attitudes, however, can be influenced, and in many cases, changed through persuasion. In one study, Inuit children were exposed to television for the first time when they saw a series about other cultures and values. Children who watched this series underwent significant changes in their beliefs about other cultural groups (Caron, 1979).

A brief survey of major journals points to three major lines of research: attitude-behaviour consistency, cognitive dissonance, and persuasion. No domain of attitude research, perhaps, could be of more relevance for the purpose of the present study than the study of persuasion in multi-media setting. It continues to be dominated by the cognitive response approach. The approach postulates that attitude change processes can be best understood by taking into account the thoughts that arise in the stimulus situation. The development of valid measures of cognitive responses has been a source of controversy. Nevertheless, the successful construction of models of attitude change in this area to a large extent depends on whether the validity of such measurement can be firmly established.

In sum, attitudes are pervasive, encompassing a broad spectrum of topics and issues: they can be specific and generalised as well; they can be wilfully manipulated or misrepresented by the respondents; they are comprised of a number of different dimensions, they can have temporal stability; and they can be changed through persuasion and exposure. For the purpose of the present study, Cattell's definition (1947) of attitude is accepted as an extremely useful one:

> "an attitude is a vector, definable by direction as well as magnitude, and further by point of application (object) and stimulus situation."

According to Cattell, an attitude may emerge from innate propensities and may take a behavioural form. By "stimulus situation" Cattell refers to secondary or derived (learned) emotions patterned after social institutions. In presenting an overview of attitude construct, it can be assumed that attitudes affect the processing of related information and, therefore, mediate knowledge and to some extent behaviour in the learning process.

Evaluative quality is the central attribute to the attitude concept. The need of employing adequate methodology for measurement cannot be over-emphasised. Numerous scales to measure attitude change have been developed in the field of science education. These are comprised of attitudes toward science classes, science teachers, science as a potential career, and the perceived usefulness of information learned in the science programme. The museums environment is altogether different from that of a classroom one (Chapter 3). The existing scales, as such, cannot be used in the museum environment. Hence, it becomes essential to develop and validate a suitable attitude scale specially for those students who visit science centres.

6.5 Development of the scale

Scale development is both an art and a science. The art lies in the item writing and the science in the techniques used for the selection and rejection of items. In science education, psychology and marketing management, research studies frequently attempt to measure attitudes by a single evaluative statement, or 'item' (for example: do you want a nuclear power station to set up in your town?). Any single item typically contains nuisances of meaning and tone that may exert unintended influences on respondents. Multiple items can, however, compensate for the limitations inherent in most individual items.

Attitude scale can be constructed by following two statistical techniques: *Stimulus, then Person Scaling* (derivative of Psychophysical model) and *Person Scaling* (derivative of Psychometrics model). In the first technique, the respondents are positioned on the evaluative dimension in relation to the locations of the stimuli they endorse. For example:

Scale Value Item	1	2	3	4	5
Blood donation makes me feel	ill	bored	assured	useful	overjoyed

The locations of the stimuli are either determined as a first step (for example, in Thurstone scaling) or simultaneously with locating the person on the dimension (Guttman scaling). In the second technique, stimuli are classified *a priori* as either favourable or unfavourable toward the attitude object, and the locations of the respondents are determined by the number of stimuli with which they agree and the extent of their agreement (for example, Likert scaling and the semantic differential).

In Thurstone and Guttman scaling, it becomes increasingly difficult to choose right word which could represent stimuli. The scales also expect respondents to have a good vocabulary. On the other hand, the construction of Likert scale is considered simple and less time-consuming in compare to Thurstone or Guttman scale construction. For its simplicity, the Likert scaling technique is preferred in the present study. Also, in psychometric tests, the sum of the scores on a number of items provides a good indication of where the person stands on the attribute.

The development of a reliable and valid attitude scale is a process that consists of several distinct stages (Gardner, 1975; Koballa, 1984). The main stages of this process are:

1. Conceptualisation - the attitude dimensions to science.
2. Item formulation.
3. Statistical analysis of pilot study - construct validity and Cronbach's alpha reliability coefficient.
4. Content validation
5. Finalisation of the scale - pilot testing employing four different samples and factor analytical investigation and Cronbach's alpha coefficient of final questionnaire.

Stage 1: Conceptualisation

The first stage in the development of the scale was to identify various components of students' attitudes toward science which could be affected in a stimulating and experiential science centre's environment. A number of relevant research studies from many journals, including *Science Education, Studies in Science Education, Journal of Research in Science Teaching, International Journal of Science Education* and *School Science Review*, and text books in the field of museum studies, psychology, statistics and science education were consulted. The six dimensions which approach to the nearest to here constructed attitude to science concept were identified: the learning aspect, the environmental aspect, echo of the visit in school science classes, interest, enjoyment and satisfaction. But, it was decided that the final decision about the underlying dimensions would be taken on the basis of the results of factor analysis of the generated data.

Stage 2: Item formulation

To formulate individual items and the scale, following three points were considered as ground rules:

1. The scale should work at different levels, that is neither answer for specific item should be obvious nor it should be too complicated. Target population was from 8 to 12 graders (Aged 12 to 17) from government schools in Delhi and Guwahati in India.

2. The scale should work equally well for pre-visit and post-visit tests. It requires that each item should be closely related with the science centre visit - its content, activity or environment, and should fit in some dimensions of attitude and also simultaneously should be answered by common sense.

3. The scale should not take too much time of students.

Initially, thirty items were planned. In the scale, more and more aspects of learning in science were covered, for example, using laboratory apparatus, deriving science formulae, science specials on TV, science club, discussion with friends and out-of-school science experiences. Later in trial, it was found that students gave obvious answers to some of the items (For example, "I enjoy learning about science through play") which belonged to the enjoyment and satisfaction dimensions of attitude. Besides, students who had not visited science centre were found perplexed or confused and, therefore, were unable to attempt them. So, the enjoyment and satisfaction dimensions were discarded and the items were trimmed to 16.

Each item in the scale was retained for some definite purpose. For example, item 16, "I usually perform experiments several times to confirm results," was thought to predict the impact of intense activity in science centres on students' thinking or feeling or belief with regards to their laboratory performance. For each item, it was attempted to use simple and appropriate words. For example, in item 12 (Looking through a microscope is not interesting to me), the apparatus 'microscope' was preferred to any other apparatus because most students know about it. Some play with it in their childhood. Many use it in their school laboratories. We also find either microscopes or similar investigative experiences in science centres. The item points to the investigative tendency of students.

Each item was assessed on a five-point Likert-type scale (Strongly Agree/ Agree/ Undecided/ Disagree / Strongly Disagree). To avoid the problem of positive answering tendency among students, half of the items were presented in negative way (Table 6.2, section 3).

"I prefer to see all science specials on television."	Positive item
"Science films bore me to death"	Negative Item

Stage 3: Pilot study

In order to establish a Likert scale, it is advocated by most researchers to try the initial pool of items out on a group of respondents. The practice, commonly known as 'pilot study', is considered very useful to eliminate ambiguous and non-discriminating items and to remove any implicit discrepancies from the scale in the initial stages. The preferred contemporary procedure for assessing the quality of an item is to examine the *item-total score correlations* (r-value), each of which correlates the respondents' score on an item with their scores summed up over all the items. In general, higher correlations indicate better items and items with low or no correlation (r-value less than 0.3) with the total score are discarded.

The first pilot study was made at the Moat Community College, Leicester (UK) on GCSE students. Students were asked to write their feelings about any items in case they find they cannot express themselves merely ticking in a box. The item 1, "I really like science," was found not to be working at its best. A few students said that they like some topics of science but not science as a whole. The modified item, "I really like science (Please mention if you like particular subjects)," worked well and also generated a useful data about the science subject of one's interest.

The item-total correlation was found between 0.35 to 0.80 (Table 6.2, section 6.1). From the collected data, it was also found that students exhibit ambivalence in their knowledge structure which represent their attitudes, beliefs, and behaviours. In this context, it can be defined as the extent to which they hold both favourable and unfavourable affects about an attitudinal object. Some students, it was found, like as well as dislike science at the same time. At this stage, it was decided that the 'social dispositions of science' factor should also be included in the scale. As a result, the following three items were added to the scale:

1. Science has nothing to do with everyday problems.
2. Science is posing a serious threat to our environment.
3. Science is the greatest enemy of the world peace.

Stage 4: Content validation

Each item was considered time and again consulting Edwards' (1957) fourteen criteria for writing Likert statement. The following five experts were consulted to assess the quality of each item in the context of clarity, ambiguity, generality, and to validate the content of the questionnaire.

1. Gaynor Kavanagh, Lecturer, Department of Museum Studies, Leicester.
2. Simon Knell, Lecturer, Department of Museum Studies, Leicester.
3. Jannette Elwood, Lecturer, Department of Education, Leicester.
4. S. Dabas, Post Graduate Teacher, Government Co-Education Model Senior Secondary School, B-4, Paschim Vihar, New Delhi.
5. S. C. Gupta, Post Graduate Teacher, Government Co-Education Model Senior Secondary School, New Delhi.

Stage 5: Finalisation of the scale - construct validity and reliability

To make sure that the scale holds equally well for populations having different cultural background and education system, and ultimately, that the scale represents a wider population sample, the 19-item inventory was administered to four different samples, three in schools of Delhi and one in Guwahati, comprised of grade 8 to 12 students. For the sake of convenience of students, the questionnaire was also made available in Hindi. The *item-total correlations* (r-value) were again calculated (Table 6.2, section 6.2-6.5). Most items were found to hold equally well for different populations. No item was found working poorly in all pilot testing. For example, item 18 (Science is posing a serious threat to our environment) was not working at all with one population but worked well with rest (Table 6.2, section 6).

The validation of an attitude scale refers to the extent to which the scale truly measures the attitude it is intended to assess. In other words, we must be pretty sure that the concept we intend to measure looks like and behaves like the presumed attitude. In practice, the construct validity of a scale is gradually built up as more and more evidence accumulates about its properties. For example, a new scale designed as a measure of spatial ability should correlate with real world measures that are known to vary with differences in spatial ability, such as - navigation and hand-eye control tracking task. As a further example, a person who does not like science at all should not attain better attitude score on the valid scale.

Table 6.2 Data Generated by Likert Analysis on 19 Final Item

S N	Item	Neg/ Pos	Sub comp-onent	Frequency (In percentage)					Item-total Correlation					Final Scale
1	2	3	4	5					6.1	6.2	6.3	6.4	6.5	7
				SA	A	U	D	SD	n = 27 α=0.86	n=39 α=0.80	n=21 α=0.63	n=27 α=0.80	n=36 α=0.61	n=275 α=0.75
1	I really like science.	+	2	46	39.8	6.9	1.1	2.6	0.73	0.27	0.48	0.08	0.17	0.45
2	I feel that everybody should learn science.	+	3	33.5	48.0	8.7	7.3	2.2	0.49	0.45	0.39	0.37	0.12	0.26
3	Learning science facts is boring.	-	3	3.3	8.0	8.7	45.5	34.2	0.67	0.50	0.28	0.27	0.14	0.50
4	I hate to record observation in science experiments.	-	1	8.7	12.0	10.2	38.2	30.0	0.46	0.62	0.70	0.27	0.01	0.53
5	Science films bore me to death.	-	1	6.5	8.0	16.7	38.2	30.5	0.65	0.30	0.53	0.56	0.43	0.46
6	I wish science class should be allotted more time than any other subjects.	+	5	23.6	42.5	15.3	13.8	4.0	0.80	0.20	0.23	0.38	0.52	0.40
7	Working with laboratory apparatus make me feel important.	+	1	25.8	43.6	17.8	8.0	4.0	0.58	0.45	0.04	0.17	0.01	0.40
8	I would like to join science club.	+	2	32.4	43.6	14.9	5.8	2.9	0.68	0.52	0.49	0.49	0.65	0.42
9	I like talking about science with friends.	+	5	38.5	46.9	5.5	5.8	2.5	0.50	0.62	0.26	0.50	0.52	0.40
10	I don't enjoy deriving science formulae using mathematics.	-	1	10.2	16.0	13.8	36.7	21.8	0.41	0.51	0.22	0.34	0.09	0.44

Table 6.2 ......Continue

S N	Item	Neg/ Pos	Sub comp-onent	Frequency (In percentage)					Item-total Correlation					Final Scale
1	2	3	4	5					6.1	6.2	6.3	6.4	6.5	7
				SA	A	U	D	SD	n = 27 α=0.86	n=39 α=0.80	n=21 α=0.63	n=27 α=0.80	n=36 α=0.61	n=275 α=0.75
11	I prefer to see all science specials on television.	+	2	29.1	54.9	7.3	5.1	3.3	0.74	0.56	0.53	0.65	0.10	0.47
12	Looking through a microscope is not interesting to me.	-	1	9.5	7.3	6.2	34.5	41.8	0.35	0.43	0.51	0.71	0.37	0.50
13	I hate to study science outdoors.	-	3	5.1	8.4	9.5	38.9	37.1	0.36	0.41	0.52	0.63	0.26	0.55
14	Discussing science issues is very common event in my home.	+		10.9	42.2	18.2	19.6	8.4	0.60	0.44	0.19	0.55	0.32	0.33
15	I feel like day dreaming during science classes.	-	3	7.3	12.7	9.5	33.1	36.4	0.50	0.57	0.68	0.56	0.22	0.51
16	I usually perform experiment several times to confirm results.	+	2	18.2	42.5	21.1	10.2	5.5	0.44	0.61	0.25	0.66	0.85	0.47
17	Science has nothing to do with everyday problems.	-	5	5.8	9.1	8.4	35.6	39.6	-	0.40	0.33	0.68	0.62	0.51
18	Science is posing a serious threat to our environment.	-	4	16.7	37.1	18.9	14.5	11.6	-	0.03	0.35	0.42	0.61	0.24
19	Science is the greatest enemy of the world peace.	-	4	17.1	18.5	19.6	22.9	21.1	-	0.29	0.50	0.43	0.59	0.27

The reliability is concerned with whether an instrument - regardless of what it truly measures - yields scores that are consistently repeatable. In other words, the reliability of a scale is the extent to which it is free from *random error*. The reliability is assessed by determining how well scores on the scale correlate with themselves. Alpha (α) is the current standard statistics for the assessment of the reliability of a scale composed of multiple items. In the procedure, the scale is split into many parts, and each of the parts is intercorrelated with other parts. Because α considers the degree to which items on a scale intercorrelate with one another, it is often referred to as a measure of *internal consistency*. When the item variances are equal, Cronbach's α is given by the formula:

$$\alpha = \frac{N\, r_{ij}}{1 + (N-1)\, r_{ij}} \qquad (1)$$

Where N is the number of items and r_{ij} is the average correlation between the N items. For a given scale, internal consistency is influenced by two factors: the number of items in the scale, and the extent to which the items reflect a clearly defined unitary construct. The internal consistency of the scale is estimated 0.75 (for 275 cases; Table 6.2, section7). For individual reliabilities, values around 0.80 to 0.95 are desirable, however, for reliable information in groups (in multi-dimensional scales), a smaller value is acceptable. One could make the internal consistency very high by making all the constituent items nearly identical, but the scale would then have such a narrow approach that it would be of little value as a research instrument.

The factor analytic investigation confirmed the hypothesis that attitudes to science is not unidimensional but consists of several distinct (in the present case five) dimensions. The correlation matrix was factor analysed using Principal Factor Analysis with Varimax rotation. The number of factors was restricted to five covering 49 per cent variance. Loadings exceeding 0.4 were considered to identify the factors. The item14 (Discussing science issues is a very common event in my home) which had loading below 0.4 was omitted (Table 6.3). (The omission does not imply the inferior quality of item14. Rather, it only indicates that item 14 doesn't fit in any of the five attitude dimensions - in common words, odd man out)

Table 6.3 Factor Analysis (Varimax Rotation) - Attitudes toward Science (N =275)

Item	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
1		0.68			
2			0.62		
3			0.70		
4	0.74				
5	0.44				
6					0.60
7	0.64				
8		0.62			
9					0.65
10	0.58				
11		0.70			
12	0.41				
13			0.44		
14	0.31				
15			0.57		
16		0.44			
17					0.50
18				0.70	
19				0.75	
Variance	20%	8.5%	7.7%	6.8%	6.0%

Factor analysis determined slightly different arrangement of items in groups from the one that was planned theoretically. To appropriately name the factors has been found a complex and contentious event, as there may be varied views of different scholars - for example, Factor1 can be known as 'discovery learning' or 'unfamiliar learning'. Factor1 is comprised of all items that demand active participation and involvement - that is, doing, observing, watching and motor skills- from students. Using common sense, one can hardly think of grouping item 5 (Science films bore me to death) in factor1, but it shows better association here. Similarly, item16 (I usually perform experiments several times to confirm results) appears to be more fit with the items of factor1, but it shows more proximity with items of factor 2. As a further example, item 2 (I feel that everybody should learn science) was planned to be a member of the 'Perception of science' dimension, but, perhaps, students found more stress on the word 'learning' and considered it more in the sense of learning science facts. The detail of the factors are as follows:

Factor1 **DISCOVERY LEARNING** dimension

4. I hate to record observations in science experiments.
5 Science films bore me to death.
7. Working with laboratory apparatus makes me feel important.
10 I do not enjoy deriving science formulae using mathematics.
12 Looking through a microscope is not interesting to me.

Factor2 **INTEREST IN SCIENCE** dimension

1. I really like science (Please mention if you like some particular subjects)
8. I would like to join science club.
11. I prefer to see all science specials on television.
16. I usually perform experiments several times to confirm results.

Factor3 **LEARNING SCIENCE FACTS** dimension

2. I feel that everybody should learn science.
3. Learning science facts is boring.
13. I hate to study science outdoor.
15. I feel like day dreaming during science classes.

Factor4 **SOCIAL DISPOSITIONS OF SCIENCE** dimension

18. Science is posing a serious threat to our environment.
19 Science is the greatest enemy of the world peace.

Factor5 **SELF-PERCEPTION OF SCIENCE**

6. I wish science should be given more time than any other subjects.
9. I like talking about science with friends.
17. Science has nothing to do with everyday problems.

Correlation matrix of five factors presents all positive and moderate correlations, except for the fourth dimension (Table 6.4). Vary high correlation between any two factors implies that they represent the same sub-area within the attitude object. Vary low correlation between them suggests that the two factors almost do not have any relation and so may represent different attitude objects.

Table 6.4 Summary table for factor correlations

	Factor 1	**Factor 2**	**Factor 3**	**Factor 4**
Factor 2	0.39	-	-	-
Factor 3	0.39	0.40	-	-
Factor 4	0.10	0.05	0.05	-
Factor 5	0.33	0.32	0.35	0.21

Factors 1, 2, 3, and 5 have moderate correlation values (between 0.32 to 0.40) and factor 4 shows very low correlation with factor 1, 2 and 3, but moderately low (0.21) with factor 5. It suggests a model of our theoretical attitude construct in which factor 4 exists parallel to the other four factors (Figure 6.2). Figure 6.3 also highlights the point that factor 4 is quite different from rest of the four factors whose mean attitude scores lie almost at the same level.

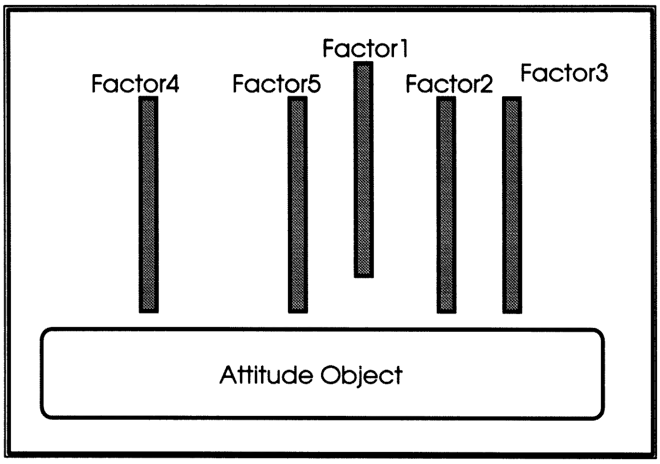

Figure 6.2 Graphical representation of the constructed attitude object.

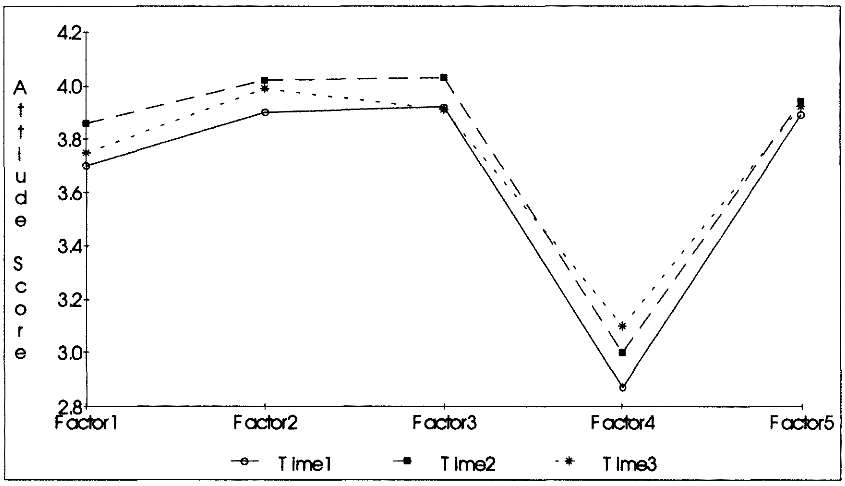

Figure 6.3 Mean attitude scores of five attitude factors of three different samples represented by time.

Qualitative data also reveals the ambivalence in students' knowledge structure representing attitudes towards science. Nearly 36 per cent students answered both questions "I like science most because ..." and "I dislike science most because ..." on the same page in the questionnaire. This finding further consolidates to our theoretical attitude model. Factor 4 can be regarded to lie in the affective element of the attitude construct which resists to change but can change drastically during natural or human-made disaster. Factor 1, 2, 3, and 5 can be regarded as 'cognitive' attitudes which are most susceptible to change in normal condition.

Table 6.5 shows the results of testing each dimension as a singly entity. The coefficient alphas of the dimensional scales are moderate considering the low number of items in each. In Hull scales for the measurement of attitudes to science, the alpha reliability was found between 0.64 to 0.81 (Ato and Wilkinson, 1982). In an another scale of five sub-components (Misiti, Shrigley and Hanson, 1991), for one factor alpha value was 0.04 and for the rest four factors was between 0.66 to 0.81.

Table 6.5 Summary data for five attitude dimensions

Dimensions of Attitude Scale	Number of items	Eigen Value	Coefficient
Discovery Learning	5	3.79	0.63
Interest in Science	4	1.62	0.53
Learning Science Facts	4	1.46	0.62
Social Disposition of Science	2	1.30	0.50
Self-Perception of Science	3	1.14	0.47

Evaluative quality

The evaluative quality of an item can be assessed by examining its frequency of responses across the five point Likert continuum. The generated data by items is distributed across Likert's continuum which points to the evaluative quality of the scale (Table 6.2, section5). Low neutral responses on the scale, range from 5% to 21%, also suggests the evaluative quality. The comparison was also made between the lower group and the higher group subjects. Kelley (1939) found that if the total scale scores are distributed normally, the selection of respondents from the upper and lower 27 per cent of the distribution provides optimal discrimination. Figure 6.4 and 6.5 graphically illustrate skewed and bipolar distribution of responses suggesting good discriminating power of items.

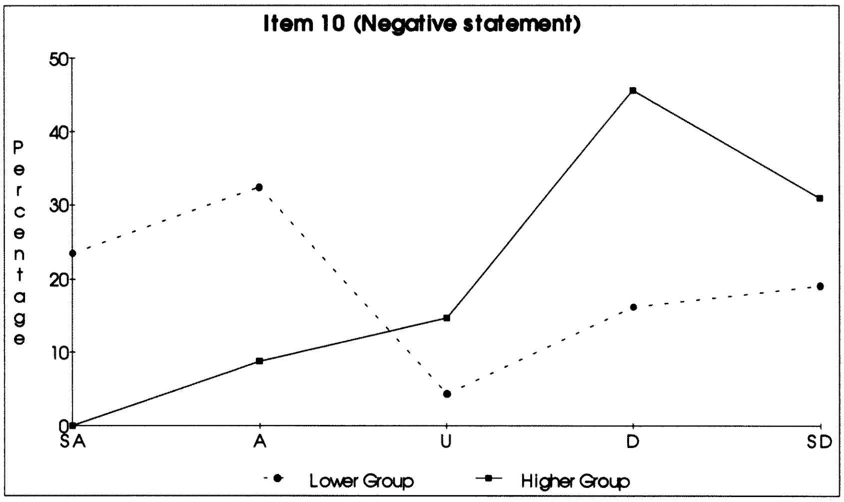

Figure 6.4 Distribution of responses of lower and higher group subjects over five Likert categories.

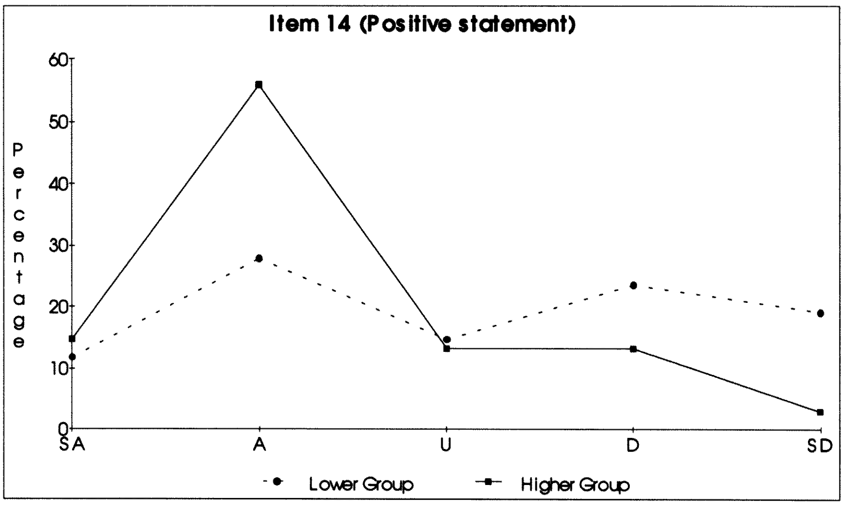

Figure 6.5 Distribution of responses of lower and higher group subjects over five Likert categories.

Conclusion

The science attitude scale for young students has passed several tests suggesting some degree of validity. Almost all subjects were able to attempt all the items on the questionnaire, suggesting acceptable reading level and clarity of items. High item-total correlations, low percentage of undecided responses, clarity, discriminating power of items - all suggest a valid scale which could be used to compare group means of pre- and post-visit tests.

The scale, however, has a weakness, as two of its sub-scales are composed of relatively low number of items. The social dispositions of science (Factor 4) is consisted of two items and the self-perception of science (Factor 5) is composed of three items. But we shall employ both of these sub-scales owing to their importance in our attitude construct. Although the social dispositions of science sub-scale is quite different from rest of the four but it is validated and supported by the ambivalence shown in the qualitative statements (about liking and disliking of science) of 36 per cent of the students.

It would be unwise to conclude this discussion without a recognition of the limitations of Likert-type of attitude scale. There is no basis for belief that the five ratings indicated on the scale are equally spaced. The interval between "agree" and "strongly agree" may not be equal to the interval between "undecided" and "agree". It is also unlikely that the items are of equal value in "agree-ness" and "disagree-ness". In these circumstances, several respondents with equal scores may not necessarily have equal attitude toward the given position. Ideally, this scale should not be used for assessing and comparing the attitude of individuals.

In the next chapter, we shall use the scale for determining the mean attitude score for a group of students. In order to measure the change in attitudes, different mean attitude scores will be compared using appropriate statistical techniques.

Chapter 7

Immediate and Long-Term Impact on Attitudes toward Science in Response to a Science Centre Visit

Introduction

In this chapter, the preliminary results of the study in which the constructed 'Attitudes toward Science' scale has been used are presented. The aim of this chapter is to find out the immediate and long-term impact (five to six months past the visit) of a science centre visit on various dimensional factors of attitude toward science. Specifically, four research questions have been addressed:

1 Are there differences in attitudes toward science amongst students as a result of their science centre visitation?

2 Are there differences in attitudes toward science between male and female students as a result of a science centre visit? If yes, then what is the pattern of the differences in long terms?

3 Are there differences in attitudes toward science between secondary and senior secondary students as a result of their science centre visitation? If yes, then what is the pattern of the differences in the longer term?

4 Are there differences in attitudes toward science between biology and physical science stream students in response to a science centre visit? If yes, then what is the pattern of the differences in long terms?

The present chapter is divided into two parts. In the first part, immediate impact and, in the second part, the long-term impact on students' attitudes toward science in response to a science centre visit will be discussed.

7.1 Participants and data collection

This investigation took place within a large school system in Delhi. Eight schools from the system's more than 500 government schools were selected and invited to participate. The sample represented geographically a vast area on Delhi State map. Principals were contacted with detailed plan of the study in which the same students were to be tested twice: *before the visit* and *after the visit*. They were pursued to send the school groups to visit the National Science Centre. The Principals of participant schools took great interest and made necessary arrangements (for example, financial arrangement, permission from parents, permission from the Directorate of Education and transportation) for organising educational trip. The sample in this report included secondary students, that is from eighth to tenth graders, and senior secondary students, eleventh and twelfth graders.

Plate 7.1 Students of Government Model Girls Senior Secondary School, Paschim Vihar, New Delhi, taking post-visit test in their own classroom.

The trips were conducted in their natural course and no special efforts were made to influence the outcome of visits. In order to avoid the effect of extraneous variables, such as anxiety or novelty, both tests (pre-visit and post-visit) were conducted in schools. Two hundred and seventy five students participated in the pre-visit test and 227 in the post-visit study. The post-visit test was conducted at best the following day of the visit and at worst within three days.

7.2 Analysis of quantitative data

Some students out of 275 who took the pre-visit test were found absent on the day of the visit. On the other hand, some students out of 227 who visited the science centre and took part in the post-visit study did not participate in the pre-visit test. In this part of the study only those 168 students were considered who participated in both, the pre-visit and post-visit, tests. This method is known as 'within-subjects' design and the sample, as 'paired or related sample'. As a result of a treatment, the means of paired samples are less likely to differ than the means of unrelated samples since the score comes from the same cases. The great strength of within-subject design is that by virtue of trying to hold other extraneous variables (such as, genetic make up, personal traits and experiences) constant and to vary only those factors which are of interest, it enables us to assert that the effects are observed largely due to the factors that have been manipulated.

The null hypothesis that the group means of total attitude score for pre-visit and post-visit populations are equal was formulated. To test the null hypothesis, the possibility of using a t-test was explored. The t-test for related samples determines whether the means of such samples differ. For each pair of cases, the difference in the responses is calculated. The statistics used to test the hypothesis is:

$$t = \frac{D_{av}}{S_d / \sqrt{N-1}}$$

where D_{av} is the observed difference between the two means, S_d is the standard deviation of the differences of the paired observations and N is the number of students.

For ordinal scales (Appendix 3), however, some authors advised against using a t-test (Stevens, 1946; Siegel, 1956). They argued that common statistical tests that require adding values should not be performed on scales that lack interval scale properties

(Appendix 3). Ordinal scales, they suggested, require non-parametric (Appendix 4) statistics such as median that do not make use of score values but only of their order. Critics of Steven's stance argued that parametric (Appendix 4) tests could also be used with ordinal variables since the test applies to numbers and not to what those number refers (Lord, 1953; Hays 1963). Their argument appears reasonable as far as the numbers are concerned.

Proponents of parametric tests argue that they are more *efficient* (in the sense that they will detect significant difference with a smaller sample size than the corresponding non-parametric test); that it is possible to carry out a greater range and variety of tests with them; and that they are *robust* (meaning that violations of the assumptions on which they are based, for instance about the normality of the distribution from which the data samples are drawn, have little or no effects on the results they produce) (Robson, 1993: 354). As in recent past, a few researchers have also employed the t-test to test the equality of group means (Orion and Hofstein, 1991; Breakwell and Beardsell, 1992), it is contented justified to use the t-test in the present study.

Before going further, I shall explain here a few statistical terms which will be used frequently in the text. In statistical procedures, a population value is estimated and compared with other such value, for example, attitudes to science of Delhi students can be compared with that of Guwahati students. This might be tested by measuring the attitude of all Delhi and Guwahati students. This, of course, does not appear a good idea and most researchers would opt for measuring the attitude of a random sample from these populations. Random sampling has much in common with gambling. For example, in market place sample, scientists may be way down the list of those who the public most trust to tell the truth, while in a science museum sample they may be placed at the top.

Clearly, the sample values are of limited reliability. The significance, expressed as a precise numerical probability value, tells us how reliable our sample values are. Five percent significance of a value in an experiment means that we accept that out of hundred times five times this value may come by accident. Lower values of significance give us much more confidence in accepting or rejecting the experimental hypothesis. In the present study, given a significant t-value, it can be asserted that the group mean difference is likely to represent a corresponding difference in their population means.

7.3 Presentation of findings

Data were analysed using independent and paired t-tests. In the pre-visit test, senior secondary students are found to have higher mean attitude score than the secondary students (Table 7.1). The significant difference is found in social dispositions of science and self-perception of science dimensions (Table 7.1). It can be explained as science is a compulsory subject up to secondary level and thereafter it is optional. Naturally, students who, in general, have real flair for science go for it at senior secondary level. Female students are found to have more positive attitude toward science than males (Table 7.2). The significant difference is observed in discovery learning, social dispositions of science, and self-perception of science dimensions.

The finding of females' superior attitudes to male students is also supported by over the years consistently better performance of girls over boys in the Central Board of Secondary Education examinations, as evident from the following newspaper reports:

> Girls continued to have an upper hand in the battle of sexes, beating their male counter parts throughout the country with a figure of 75.31 as against boys' 67.61. The trend was much the same in the capital too, girls outgunning boys 71.62 to 60.32 (*The Hindustan Times*, 30 May, 1995: Result of Class XII).
>
> Boys made history, for once piping the girls in the class X examination......the gender balance swung in favour of the males for the first time ever, though girls manage to have a leg up in the Delhi and Chandigarh regions (*The Hindustan Times*, 3 June, 1995).

Several explanations arise for this finding: because of cultural restrictions on their movements and out-of-home leisure activities, female students have more time to devote to their study at home; female students tend to take homework more seriously than boys; and their superiority in language, writing, spelling and other verbal skills.

Table 7.1 t-Test - Comparison of Secondary and Senior Secondary Students (Pre - visit Test)

	Sec. n =	students 108	Sr. Sec. n =	students 60		
Scale	**M**	**SD**	**M**	**SD**	**t**	**ρ**
Discovery Learning	3.62	0.79	3.82	0.78	1.63	0.11
Interest in Science	3.87	0.74	3.96	0.69	0.78	0.44
Learning Science Facts	3.76	0.70	3.83	0.55	0.72	0.48
Social Dispositions of Science	2.77	1.10	3.13	1.09	2.07	0.04
Self-Perception of Science	3.79	0.79	4.11	0.75	2.57	0.01

Table 7.2 t-Test - Comparison of Male and Female Students (Pre-visit Test)

	Female n =	Students 75	Male n =	Students 93		
Scale	**M**	**SD**	**M**	**SD**	**t**	**ρ**
Discovery Learning	3.82	0.72	3.58	0.83	1.95	0.053
Interest in Science	3.85	0.70	3.94	0.74	0.81	0.420
Learning Science Facts	3.77	0.63	3.79	0.66	0.20	0.850
Social Dispositions of Science	3.10	1.03	2.74	1.14	2.14	0.034
Self-Perception of Science	4.09	0.71	3.76	0.82	2.77	0.006

Grade-based findings

In grade-based pre-and post-visit test comparison (Figure 7.1), an increase is observed in all of the attitude dimensions for secondary students. But, the significant mean attitude difference is observed in four dimensions, namely in discovery learning, interest in science, learning science facts, and social dispositions of science dimensions (Table 7.3). In the case of senior students, an increase is found in four of the attitude dimensions, namely discovery learning, interest in science , learning science facts, and social dispositions of science) and a decrease is noted in self-perception of science dimension (Table 7.4).

Analysis of senior secondary students' attitude in self-perception of science dimension.

		Pre-Visit		Post-Visit	
Item	**SELF-PERCEPTION OF SCIENCE**	**Mean**	**Std Dev**	**Mean**	**Std Dev**
6	I wish science should be given more time than any other subjects.	3.75	1.19	3.55	1.19
9	I like talking about science with friends.	4.23	0.96	3.98	0.93
17	Science has nothing to do with everyday problems.	4.35	0.97	4.23	1.05

There appears no single and specific reason for the decrease in self-perception of science dimension of attitude. One thing appears patent that neither senior students see the relevance of the presented science (in the science centre) in every day life nor they want that science as a subject should be given more time in schools. The increase in interest in science dimension for senior student is also non-significant. The findings may also be partly attributed to the 'Ceiling effect', as pre-visit high attitude score of senior students may have only little scope to increase further.

All students appear to have gained in much the same way except in social dispositions of science and Self-perception of Science dimensions. The finding indicates that there are differences in the way each group follows to process the concept and, perhaps, in the way those concepts are structured in their minds.

Table 7.3 t-Test - Comparison of Pre - Post Attitudes Towards Science of Secondary Students (N = 108)

	Pre	test	Post	test		
Scale	**M**	**SD**	**M**	**SD**	**t**	**ρ**
Discovery Learning	3.61	0.79	3.82	0.61	2.60	0.011
Interest in Science	3.87	0.74	4.04	0.62	2.51	0.014
Learning Science Facts	3.76	0.70	4.03	0.66	3.58	0.001
Social Dispositions of Science	2.77	1.10	2.98	1.00	1.90	0.06
Self-Perception of Science	3.79	0.79	3.89	0.74	1.03	0.306

Table 7.4 t-Test - Comparison of Pre - Post Attitudes Towards Science of Senior Secondary Students (N = 60)

	Pre	test	Post	test		
Scale	**M**	**SD**	**M**	**SD**	**t**	**ρ**
Discovery Learning	3.82	0.78	4.01	0.62	2.12	0.038
Interest in Science	3.96	0.69	4.01	0.73	0.64	0.52
Learning Science Facts	3.83	0.55	4.16	0.65	3.89	0.001
Social Dispositions of Science	3.13	1.09	3.17	1.07	0.19	0.846
Self-Perception of Science	4.11	0.75	3.92	0.75	1.82	0.07

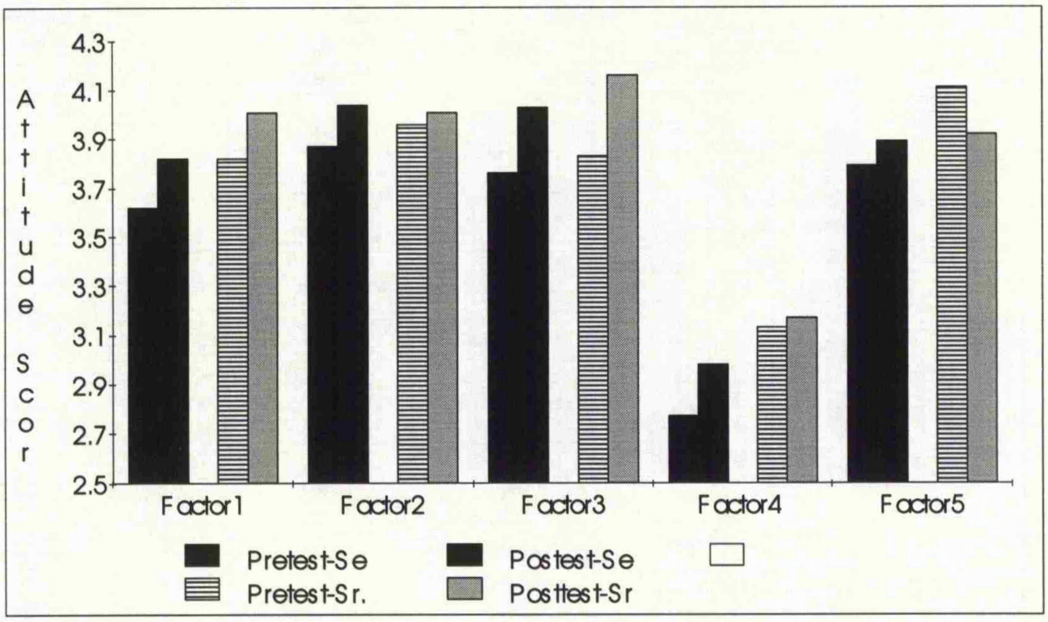

Figure 7.1 Graphical representation of changes in Mean Attitude Score in pre and post visit tests for secondary and senior secondary students.

Gender-based findings

In gender-based pre-and post-visit test comparison (Figure 7.2), a significant increase in mean attitude score for female students is observed in interest in science and learning science facts dimensions (Table 7.5) and for males, in discovery learning and learning science facts dimensions (Table 7.6). Male students appear to have gained much more than females by their active participation and physical involvement in activities.

In self-perception of science dimension, female students' attitude score decreased significantly and, on the other hand, male students' attitude score increased but insignificantly. The reported post-visit low scores is difficult to interpret. Female students do not want science as a subject should be allotted more time in schools. They also do not want to discuss science with friends any more than they used do before the visit. The lower value of standard deviation (for item 6 and 9) in the pre-visit test indicates the concentration of responses in the positive side of the attitude scale which may yield higher mean attitude score. The low post-visit mean attitude score may be attributed to the comparatively greater variation of the post-visit responses of students. A large proportion of the decrease in self-perception of science dimension may be due to the higher self-evaluation in the pre-visit test.

Analysis of female students' attitude in self-perception of science dimension.					
		Pre-Visit		**Post-Visit**	
Item	**SELF-PERCEPTION OF SCIENCE**	**Mean**	**Std Dev**	**Mean**	**Std Dev**
6	I wish science should be given more time than any other subjects.	4.08	0.85	3.64	0.97
9	I like talking about science with friends..	4.23	0.85	4.00	1.04
17	Science has nothing to do with everyday problems.	3.96	1.27	4.01	1.13

In social dispositions of science dimension, both groups gain insignificantly, but girls little more than boys.

Table 7.5 t-Test - Comparison of Pre - Post Attitudes Towards Science of Female Students (N = 75)

	Pre- Visit Test		**Post-Visit Test**			
Scale	**M**	**SD**	**M**	**SD**	**t**	**ρ**
Discovery Learning	3.82	0.72	3.84	0.58	0.24	0.815
Interest in Science	3.85	0.70	4.03	0.60	2.53	0.014
Learning Science Facts	3.77	0.63	4.03	0.61	3.19	0.002
Social Dispositions of Science	3.10	1.03	3.27	1.07	1.40	0.165
Self-Perception of Science	4.09	0.71	3.88	0.78	1.96	0.053

Table 7.6 t-Test - Comparison of Pre - Post Attitudes Towards Science of Male Students (N = 93)

	Pre- Visit Test		Pre- Visit Test			
Scale	M	SD	M	SD	t	ρ
Discovery Learning	3.58	0.83	3.94	0.65	4.06	0.001
Interest in Science	3.94	0.74	4.03	0.71	1.19	0.235
Learning Science Facts	3.79	0.66	4.10	0.69	3.99	0.001
Social Dispositions of Science	2.74	1.14	2.87	0.97	0.93	0.355
Self-Perception of Science	3.76	0.82	3.92	0.71	1.58	0.117

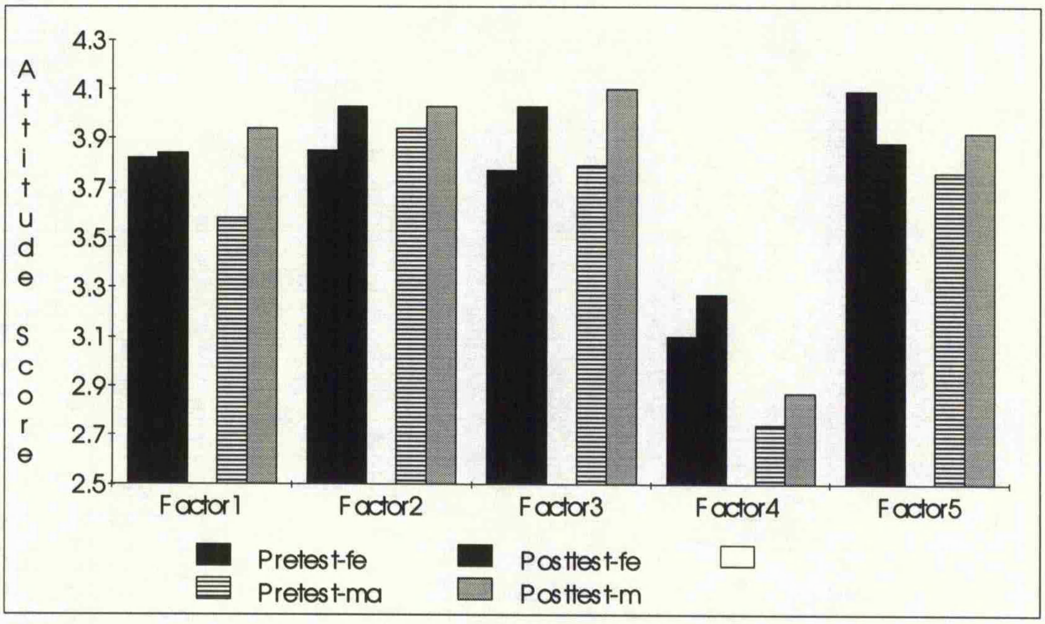

Figure 7.2 Graphical representation of changes in Mean Attitude Score in pre and post visit tests for male and female students.

The findings of male students' attitude gain due to their active participation and physical involvement is also supported by a number of other studies conducted in museums and other disciplines. According to Baker (1992), girls as a group have far fewer science- and maths-related experiences than boys both inside and outside the classroom. Kubota and Olstad (1991) suggest in their study that the scientific orientation of the playground may have acted as a deterrent to exploration and conceptual learning in girls. Kahle (1990) points out that boys do participate at large scale in physical activities, and gain background knowledge, interests, and attitudes *that will foster success in-school science* as a result of their out-of-school experience (my italics).

The findings here, however, do not support the Kahle (1990) and Kubota and Olstad (1991) and indicate that both groups adopt different learning strategies during their visit and attain equally good attitude changes in magnitude and direction. From the findings, it appears that the girls participate passively in the learning process and observe the exhibits and activities more seriously than boys. In our observation studies also, girls involvement (in the sense of time spent and engagement) in the *Fun Science* exhibit is found more than boys. The passive tendency of girls also have cultural roots:

> '....boys generally receive more subtle rewards for taking risks. Exclamations such as 'What a brave boy!' or 'isn't he strong!' rewards a boy for climbing trees and jumping into pools. A girl, on the other hand, is praised for 'being a little lady' and 'keeping her pretty dress clean' (Kahle, 1990: 55).

The supposed passivity among girls may also have roots in education system. Small differences in attitudes, interest, and behaviour between the sexes increase greatly through schools (Smail, 1984). Science education is stacked against woman, because by and large teachers tend to convey stereotypes of what people are going to be when they grow up (Tressel, 1992: 20).

It would be more appropriate to conclude from the results that both groups reap benefits as a result of their out-of-school experiences and these will be used in the classroom setting in an equally efficient way.

Subject-based findings

In subject-based pre- and post-visit test comparison (Figure 7.3), significant gains are not observed in any of the factors for students who do not like science (Table 7.7). The less number of participants in the group is an apparent shortcoming. In biology stream, students gain significantly in interest in science and learning science facts dimensions (Table 7.8). The pattern of gain for this group is much more similar to that found for girls. This is not surprising as a great majority among girls pursue their studies in science with special interest in biology. It, specially discovery learning, also points to the negligible provision for biology stream people in science centres. In science stream (excluding biology), students gain significantly in discovery learning and learning science facts dimensions (Table 7.9).

Table 7.7 t-Test - Comparison of Pre - Post Attitudes Towards Science of Students who do not like science (N = 4)

	Post-Visit Test		Post-Visit Test			
Scale	**M**	**SD**	**M**	**SD**	**t**	**ρ**
Discovery Learning	3.55	0.76	3.35	1.01	0.93	0.423
Interest in Science	2.88	0.43	3.06	0.38	0.48	0.661
Learning Science Facts	3.06	0.43	3.44	0.55	1.13	0.339
Social Dispositions of Science	1.75	0.87	2.13	0.85	0.68	0.547
Self-Perception of Science	3.17	0.84	3.17	1.04	0.00	1.000

Table 7.8 t-Test - Comparison of Pre - Post Attitudes Towards Science of Students who have special interest in biology stream (N = 65)

	Post-Visit Test		**Post-Visit Test**			
Scale	**M**	**SD**	**M**	**SD**	**t**	**ρ**
Discovery Learning	3.77	0.82	3.90	0.64	1.33	0.189
Interest in Science	3.88	0.77	4.05	0.59	1.71	0.091
Learning Science Facts	3.79	0.58	4.10	0.61	3.37	0.001
Social Dispositions of Science	3.00	1.06	3.23	1.05	1.47	0.146
Self-Perception of Science	3.98	0.69	3.96	0.71	0.30	0.769

Table 7.9 t-Test - Comparison of Pre - Post Attitudes Towards Science of Students who like science (N = 99)

	Post-Visit Test		**Post-Visit Test**			
Scale	M	SD	M	SD	t	ρ
Discovery Learning	3.64	0.77	3.91	0.59	3.32	0.001
Interest in Science	3.96	0.67	4.06	0.68	1.68	0.096
Learning Science Facts	3.81	0.68	4.08	0.68	3.68	0.001
Social Dispositions of Science	2.88	1.13	2.96	1.00	0.71	0.481
Self-Perception of Science	3.88	0.84	3.90	0.74	0.12	0.903

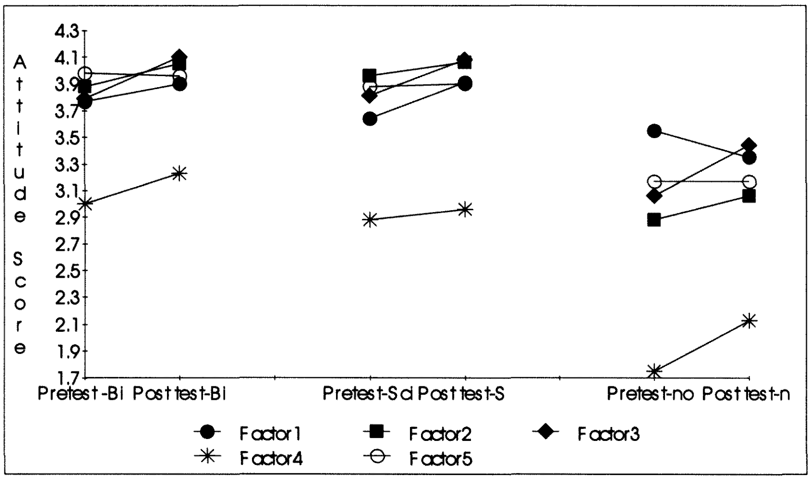

Figure 7.3 Graphical representation of changes in Mean Attitude Score in pre and post visit tests for biology students, science students and those who do not like science.

Summary

The significant gain in composite attitude score for the whole sample establishes the value of a science centre visit. Specifically, the over-all gain of secondary students, male students and physical science stream students are very significant (Table 7.10).

Table 7.10 t-Test - Comparison of Pre - Post Composite Attitude Toward Science.

	Pre-Visit Test		**Post-Visit Test**			
Category	**M**	**SD**	**M**	**SD**	**t**	**ρ**
Full Sample (168)	3.72	0.52	3.81	0.55	2.17	0.044
Female Students (75)	3.80	0.53	3.77	0.62	0.29	0.772
Male Students (93)	3.65	0.51	3.84	0.48	4.21	0.001
Junior Students (108)	3.63	0.50	3.81	0.42	3.96	0.001
Senior Students (60)	3.86	0.53	3.82	0.73	0.47	0.093
Life Science Stream (65)	3.76	0.49	3.81	0.65	0.57	0.57
Physical Science Stream (99)	3.71	0.53	3.85	0.46	2.65	0.009

The attitude dimension self-perception of Science does not gain significantly in any case. It implies that the visit does not make any magical impact. Students do not want suddenly after the visit that science should be given more time than any other subjects. They do not want to discuss science immediately after the visit any more than they used to discuss it before. Similarly, they do not visualise the utility of science in everyday life any more than they used to see it before. However, a considerable decrease for girls in the dimension is difficult to explain. It may be useful to see long-term effects of a science centre visit in the dimensions of social dispositions of science and self-perception of Science.

Part II

Long-Term effects of a Science Centre Visit on Attitudes to Science

7.4 Long-term objectives and impacts of a science centre visit

Science is an essential ingredient of modern times. It is inextricably related with the economic development. In his address, Charles Holster, Vice President of Research at Pennsylvania State, emphasised the need of humanpower trained in science and technology disciplines and expressed his apprehension:

> 'Without radical shifts of talent into science and engineering today, the generation of Americans could well find themselves in a less developed country' (quoted in Misiti *et al.*, 1991).

Governmental authorities, almost everywhere in the world, desire to develop long-term scientific attitudes among the masses. In many countries including India, science centres have been entrusted with a great responsibility in this respect.

Science centre professionals have hoped for the life-long educational objectives of the knowledge and experiences they produce (or construct). They, at least, aim to equip their young visitors with a set of tools, attitudes as well as skills, so that they can explore their natural surroundings successfully. Douglas A. Penny, first education director of the Ontario Science Centre, gave such indication in his following description of the 'arcade', the children section in the centre:

> The arcade does not attempt a logical exposition of science and technology, indeed its exhibits are sparsely captioned. We do not expect the young visitor here to realize he is learning. We do intend that he leaves with a host of unanswered questions and an aroused curiosity and we believe he will seek answers at other exhibits elsewhere (Young, 1970).

The children who visit science centres perform a number of activities in a short span of time. They may forget most things what they do or see. They may remember a few things. Not much has been explored for the estimation of long-term impacts of the visit. There may, well, be something in student's subconscious mind that may re-surface weeks, months and even years later. In his research study on the relationship between mood and memory, Gordon Bower, experimental psychologist, elaborates on how a person feels when some experience becomes an integral part of their memory of that experience. Evoking that feeling or mood at a later time may than trigger the details of a memory associated with it.

In his article, Jerry Wellington (1989) gives an interesting account of his son's experience to this effect. At Discovery Dome (a travelling exhibition), his son observed for some time the 'moving water patterns' (generated when water, after giving circular motion, is allowed to fall from the upper container to the lower bottle) inside two plastic bottles fixed at the open ends (mouth) by means of a small connector. About nine months after the visit he came dripping out of the bath water saying 'I have seen that thing again - you know those water patterns, going down the plug hole.' Such accounts indicate that in spite of interacting for a long time with the exhibits science centres may not necessarily and immediately multiply facts in the visitors' memories, and contribute directly to the deeper understanding, but their indirect effect must not be under-estimated.

Most of the evaluation studies conducted in museums to explore the area of long term impact of the visit focus on the issues related to memories such as what students remember or forget, and why?. For example, in an evaluation of visitors in Cincinnati Science Centre, Garvin (n.d.) has measured the level of recollection of the average fifth grader three weeks after the visit (quoted in Belcher, 1991).

John Stevenson also conducted a study on how people, in long terms, are changed in response to their visit in *Launch Pad*, Science Museum, London. He held in-depth interviews of 20 people as they left Launch Pad, sent questionnaires two weeks later and then interviewed the same people six months after the visit. On analysing interviews, he found visitors' experiences falling into three broad areas: *descriptions* of exhibits or of their experiences with exhibits; *feelings* of enjoyment, surprise, annoyance, for example; and *thoughts* (Stevenson, 1994). These studies indirectly tell us the possibilities of favourable and stable changes in people's attitudes toward science as a result of their visitation.

This part of the study examines whether there is indeed a generalizable long-term impact and, and if yes then, what is the pattern of this impact in respect to the chosen variables (gender, time of data collection and education level). In order to assess the impact, we shall apply Analysis of Variance (ANOVA) technique on the generated data.

7.5 Analysis of Variance (ANOVA): purpose of the procedure and statistics

The Analysis of Variance is used to test for significance between the means of separate groups. Unlike the t-test, the ANOVA is performed for more than two groups of respondents. For example, in the present study, there are three groups of students:

Time1	Pre-visit Group (275)	Data collected before the visit.
Time2	Post-visit Group (227)	Data collected after the visit.
TIme3	Later-visit Group (225)	Data collected five months after the visit.

Detail of the Sample in the Present Study

	Female	Male	Junior	Senior
Time1	110	165	177	98
Time2	94	133	144	83
Time3	128	97	178	47

From the collected data, it may be suspected that the average attitude of school students is greater after the visit than it was before the visit. On comparing observations, we may find that the average attitude score is indeed higher by a few units. The objection immediately arises that this difference may be true for small sample, but may not represent to the whole population of school students. At this stage, the analysis of variance comes to our rescue. We use ANOVA to obtain a statement of likelihood of making a mistake in our assessment.

There are two different analysis of variance procedures: One Way ANOVA and Simple Factorial ANOVA. One way analysis is used when only one variable is used to classify subjects into the different groups. Subjects are assigned to groups, for example, on the basis of sex. The Simple Factorial ANOVA procedure is used when two or more variables are used to form groups. For, example, respondents can be divided into groups on the basis of three independent variables (IV), such as sex, time and grade. The basic idea of the factorial ANOVA is to determine whether there is an effect of various independent variables such as IV1, IV2, IV3....etc. and whether there are significant interactions between these independent variables.

Analysis of variance procedures require the following assumptions:

- Each of the groups is an independent random sample from a normal population.
- In the population, the variances of the groups are equal.

To check on these assumptions, the data is explored and the tests for variability are calculated. In analysis of variance, the observed variability in the sample can be divided into two parts: variability of the observations within a group (that is, variability of observations around their group mean) and the variability among group means. Using these two variability, a F-ratio is calculated:

$$F = \frac{\text{Between -group estimated variance}}{\text{Within-group estimated variance}}$$

$$= \frac{\text{Mean Square (MS) between groups}}{\text{Mean Square (MS) within groups}}$$

The general form of Mean Square is:

$$MS = \frac{\text{Sum Squares (SS)}}{\text{Degree of freedom}}$$

The degree of freedom for between group is calculated by subtracting 1 from the number of groups. For within groups, it is calculated by subtracting the number of cases (or observations) in all groups combined.

A significant F value tells only that the population means are probably not all equal. It does not tell which pair of groups appear to have different means. To determine which means are significantly different from each other, *multiple comparison procedures* are used. By adjusting for the number of comparisons (if suppose we have five groups and compare all pairs of means then we need to make 10 comparisons), multiple comparison procedures protect us from declaring too many differences significant. Many multiple comparison procedures are available. They differ in how they adjust the observed significance level. The Scheffe test is used in this study.

The General Linear Model

ANOVA is based on a model of an individual's score which assumes that the score is a sum of components. The components are the population mean, the effect of the various independent variables, the interactions of the independent variables, and an error term.

For a one way design, the model would be conceived as:

$$X = \mu + \alpha + \varepsilon$$

Where:
X = Student's score (dependent variable)
μ = the population mean
α = the effect of the independent variable
ε = error

For a two-way design, the model would be:

$$X = \mu + \alpha + \beta + \alpha\beta + \varepsilon$$

Where:
X = Student's score (dependent variable)
μ = the population mean
α = the effect of the first independent variable (IV1)
β = the effect of the second independent variable (IV2)
$\alpha\beta$ = the interaction of "IV1" and "IV2"
ε = error

Similarly, for a three way ANOVA, the model will be :

$$X = \mu + \alpha + \beta + \gamma + \alpha\beta + \alpha\gamma + \beta\gamma + \alpha\beta\gamma + \varepsilon$$

Where:
X = Student's score (dependent variable)
μ = the population mean
α = the effect of the first independent variable (IV1)
β = the effect of the second independent variable (IV2)
γ = the effect of the third independent variable (IV3)
$\alpha\beta$ = the interaction of "IV1" and "IV2"
$\alpha\gamma$ = the interaction of "IV1" and "IV3"
$\beta\gamma$ = the interaction of "IV2" and "IV3"
$\alpha\beta\gamma$ = the interaction of "IV1," "IV2"and "IV3"
ε = error

7.6 Presentation of ANOVA results

Effect of Time

The results of effect of time in three way design are summarised in Table 7.11. From the table we find significant F value on discovery learning and social dispositions of science dimensions of attitude. It infers that there is significant differences in the mean scores of pre-test, post-test and later-test. For discovery learning dimension, according to Scheffe test, mean scores of the pre-test and post-test are significantly different at the 0.05 level. While for social dispositions of science, mean scores of pre-test and later-test are found significantly different at the 0.05 level. The mean score is recorded considerable higher on each dimension of attitude in the post-visit test than the pre-visit test (Figure 7.4). In the later-visit test, the mean score of post-visit test in each dimension, except in social dispositions of science, is decreased and rested near the pre-visit mean score (Table 7.12). This tells the fading away impact of the visit with time.

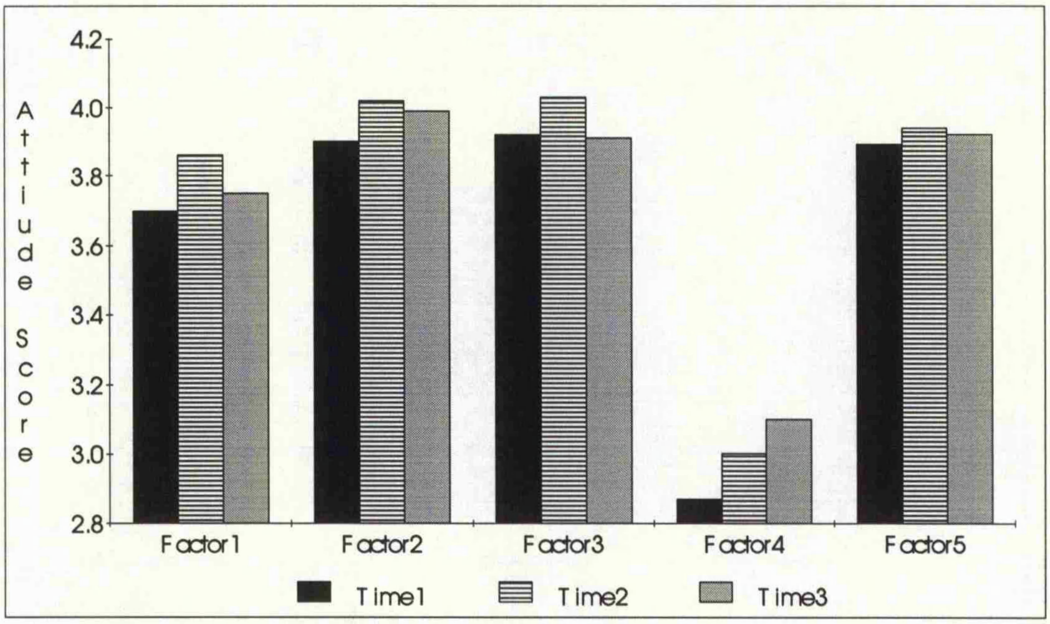

Figure 7.4 Graphical representation of changes in Mean Attitude Score in pre-, post- and later- visit tests.

The social dispositions of science dimension infers that students consider science less-harmful after the science centre visit and their this feeling appears to consolidate with time. There may be two contributing factors to this finding: one may be the celebratory approach of science centres (contribution of science centre) and the other may be the (overspill) effect of the increase in rest of the four dimensions (contribution from visitors' judgement).

Gender and Time interaction

For discovery learning dimension, the F value associated with the gender and time interaction is 2.748 at significant level 0.065 (Significant at 0.001 in two-way ANOVA design). For learning science facts dimension, the F value associated with the gender and time interaction is 5.193 at significant level 0.001. For social dispositions of science dimension, the F value associated with the gender and time interaction is 2.193 at significant level 0.1 (Significant at 0.01 in two-way ANOVA design). For self-perception of science dimension, the F value associated with the gender and time interaction is 3.389 at significant level 0.034 (Significant at 0.001 in two-way ANOVA design) (Table 7.11; Figure 7.5.1 and 7.5.2).

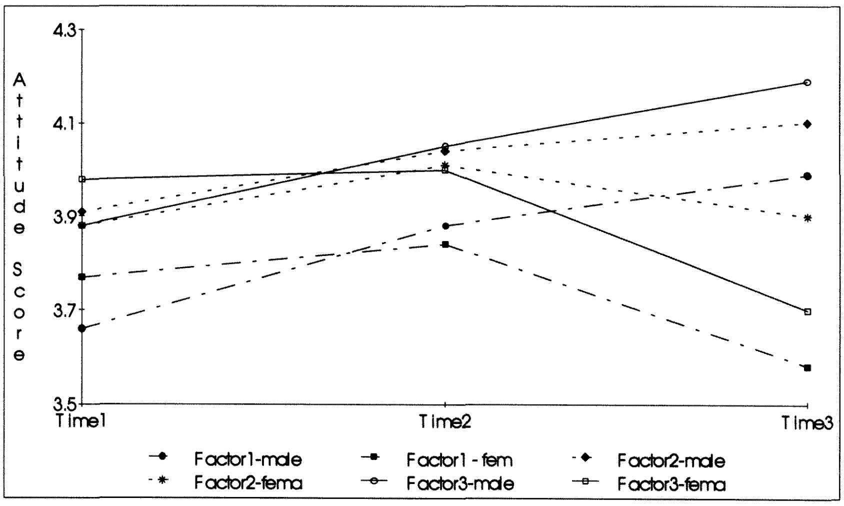

Figure 7.5.1 Graphical representation of changes in Mean Attitude Score in pre-, post-, and later- visit tests for male and female students.

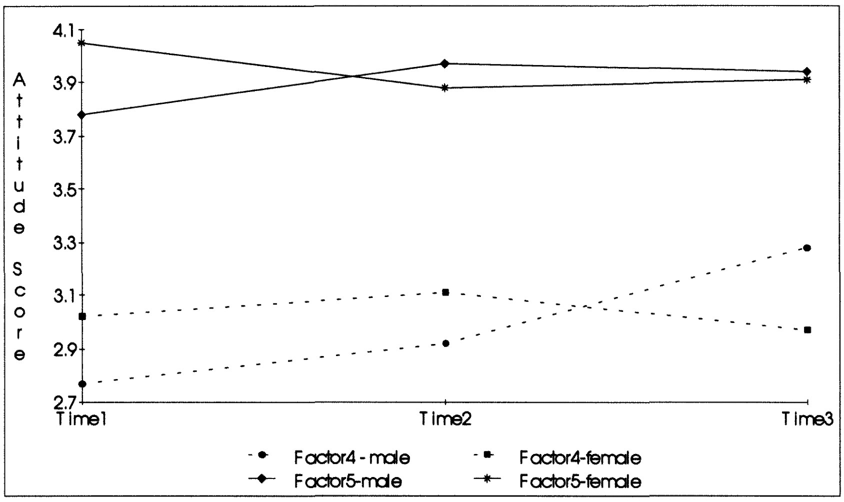

Figure 7.5.2 Graphical representation of changes in Mean Attitude Score in pre-, post- and later- visit tests for male and female students.

For all these four dimensions, the statistics indicates that there is a significant gender and time interaction. In general, both groups, boys as well as girls, gained two to six per cent in the post-visit mean attitude score over the pre-visit one. The group mean score for girls has decreased sharply in the later-test. In contrast, for boys this score has increased with time. The gain in later-test mean score is estimated between five to ten percent over the pre-visit one. It implies that either boys, during the test, have recalled their experiences of the visit more successfully than the girls, or there happens really a 'long-term gain' due to their exploratory learning style.

For interest in science dimension, the interaction between gender and time was found insignificant. But the trend was found the same as for rest dimensions. The group mean score for girls was observed to be decreased considerably in the later-test. In contrast, for boys this score increased with time (Figure 7.5.1).

Grade and Time Interaction

For discovery learning dimension, the F value associated with the grade and time interaction is 3.491 at significant level 0.03. Similarly, for interest in science dimension, the F value associated with the grade and time interaction is 2.778 at significant level 0.063. (Table 7.11; Figure7.6.1) For both dimensions, the statistics indicates that there is an significant grade and time interaction. In discovery learning and interest in science dimensions, although all students have shown gain in the post-visit test over the pre-visit test, but the senior secondary students maintained their growth in the later test. In contrast, the secondary students have attained scores just like pre-visit ones.

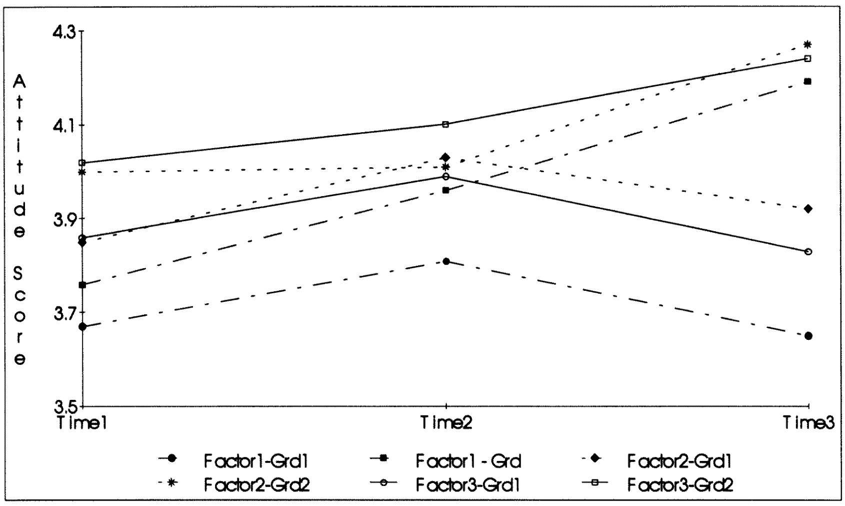

Figure 7.6.1 Graphical representation of changes in Mean Attitude Score in pre-, post-, and later- visit tests for secondary (Grade1) and senior secondary students (Grade2).

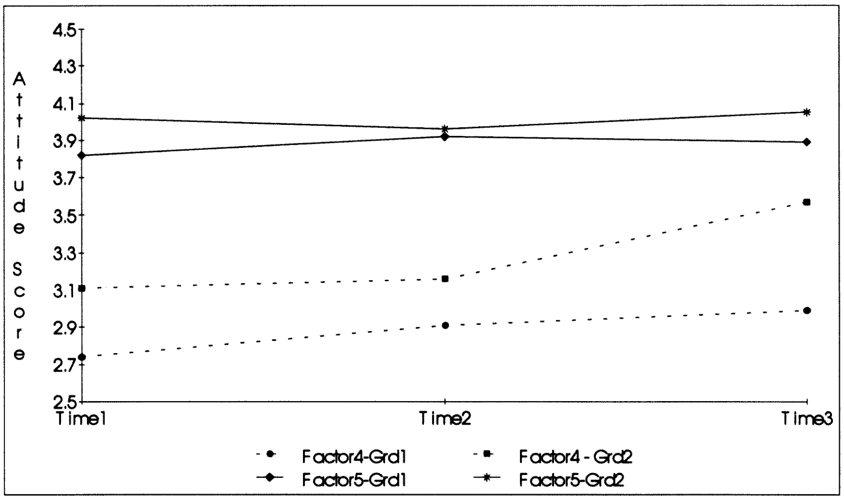

Figure 7.6.2 Graphical representation of changes in Mean Attitude Score in pre-, post-, and later- visit tests for secondary (Grade1) and senior secondary students (Grade2).

For learning science facts, social disposition of science and self-perception of science dimensions, the interaction between grade and time was found non-significant (Table 7.11). Similar trend (with respect to the direction of attitude score) as noted in discovery learning dimension was observed in learning science facts dimension. But the Grade and Time interaction was observed significant. All students showed a positive gain in social dispositions of science dimension. The scores for perception of science dimension were found almost same in all the three tests (Figure 7.6.2).

Significant three variables interaction (Time*Grade* Gender) effect is not observed in any of the attitude dimensions (Table 7.11). A considerably strong Grade and Gender interaction effect was found in discovery learning ($F = 11.3$; $p = 0.001$) and learning science facts dimensions ($F = 8.5$; $p < 0.01$). The data also shows that, as a single contributor, the effect of Grade is much stronger than that of the Time or Gender.

Table 7.11 Analysis of variance of major variables (Three-way Design)

Subscale	Discovery learning		Interest in science		Learning science facts		Social dispositions of science		Self-perception about science	
Source of Variation	**F Ratio**	**F Prob.**	**F Ratio**	**F Prob**	**F Ratio**	**F Prob**	**F Ratio**	**F Prob**	**F Ratio**	**F Prob**
Time	3.580	0.028	2.219	0.109	2.249	0.106	2.855	0.058	0.291	0.747
Grade	15.862	0.001	6.403	0.012	13.476	0.001	18.262	0.001	5.491	0.019
Gender	2.641	0.105	2.208	0.138	5.363	0.210	0.810	0.368	1.678	0.196
Time * Grade	3.491	0.031	2.778	0.063	0.538	0.584	0.487	0.615	0.580	0.560
Time * Gender	2.748	0.065	0.049	0.952	5.193	0.006	2.139	0.119	3.389	0.034
Grade * Gender	11.309	0.001	3.021	0.082	8.506	0.004	0.579	0.447	2.045	0.153
Time*Grade* Gender	0.019	0.981	0.130	0.878	1.955	0.142	1.092	0.336	0.457	0.633

Table 7.12 Analysis of variance of major variables.

Subscale	Discovery learning		Interest		Learning science facts		Social dispositions of science		Perception about science	
Source of Variation	**Mean**	**Sign. level**	**Mean**	**Sign. level**	**Mean**	**Sign. level**	**Mean**	**Sign. level**	**Mean**	**Sign. level**
Time1	3.70		3.90		3.92		2.87		3.89	
Time2	3.86	0.05	4.02	NS	4.03	NS	3.00	0.05	3.94	NS
Time3	3.75		3.99		3.91		3.10		3.92	
Time1 - Female	3.77		3.88		3.98		3.02		4.05	
Time1 - Male	3.66		3.91		3.88		2.77		3.78	
Time2 - Female	3.84	0.001	4.01	NS	4.00	0.001	3.11	0.01	3.88	0.001
TIme2 - Male	3.88		4.04		4.05		2.92		3.97	
Time3 - Female	3.58		3.90		3.70		2.97		3.91	
Time3 - Male	3.99		4.10		4.19		3.28		3.94	
Time1 - Grade1	3.67		3.85		3.86		2.74		3.82	
Time1 - Grade2	3.76		4.00		4.02		3.11		4.02	
Time2 - Grade1	3.81	0.01	4.03	0.05	3.99	NS	2.91	NS	3.92	NS
Time2 - Grade2	3.96		4.01		4.10		3.16		3.96	
Time3 - Grade1	3.65		3.92		3.83		2.99		3.89	
Time3 - Grade2	4.19		4.27		4.24		3.57		4.05	

Discussion

Large scale surveys (Kelly, 1978; Heuftle *et al.*, 1983; Kahle and Lakes, 1983; Johnson and Murphy, 1986) consistently find that boys participate more than girls in out-of-school science related activities, particularly in activities which are associated with physical sciences. The results in this study are consistent with these earlier studies. As a result of the visit, girls gain in their attitudes toward science significantly in the post-visit tests and the gain is found to decay quickly with time. Thus, female students appear to have short-term benefits. In contrast, male students appear to consolidate their attitudes with time.

There can be said two causes responsible for this finding: first, the genetical make-up of girls for attitude framework may be much more sensitive to persuasion or exposure than that of boys (A metaphor might perhaps better explain this, for example mercury is more sensitive to heat than water. Under the influence of heat, mercury in a thermometer goes up fast and comes back, too, equally rapidly); second, the consolidation of attitudes of boys with time may be due to their active participation in science related out-of-school and in-school activities. In this case, it supports the assumption that real learning and long lasting changes in perception takes place through activity and involvement.

As a result of the visit, although all students gain in their attitudes toward science, it seems that junior students take it more as fun or a sort of leisure outing. In contrast, senior students appear to take the visit quite seriously and consolidate their attitudes with time. Senior and male students appear to have significant long-term effect. In three-way analysis of variance, a very significant grade*gender interaction in discovery learning and learning science facts dimensions also indicates, and supports, to this inference. The findings here appear to hold consistency with other research studies in science education and psychology.

Cognitive scientists see knowledge structures as active and constructive. Learners use the information and organisational schemes currently available to them. In a case study (Chi *et al.*, 1981), beginners and advanced physics students were asked to sort problems from a physics text into groups. The beginners, it was found, take relatively superficial approach, for example they put together problems on the basis of similar looking diagram or structure, while the advanced students classify the problems on the basis of physics principles. The students of both groups have studied the laws and equations, but the beginners have not used them in the same way as the advanced students. In their work, Chi and Glaser identified several novice-expert differences within the knowledge structure - a network of concepts and relations - in the domain of elementary physics.

As a further example, in her study of children's acquisition of biological knowledge, Carey (1985) found that young children view the characteristic and behaviour of people and other animals almost exclusively in social and psychological terms while the older children, in biological term.

In the light of the findings of Chi and colleagues (1981) and Carey (1985) and the findings in this study, it is reasonable to conclude that during the visit senior students appear to be more systematic, attentive and subject oriented, while junior students take it more as a game or a day of freedom and enjoyment.

Summary of the findings

Male and female students adopt different learning styles during their science related out-of-school activities. Male students physically appear to participate in the environment more than girls. Boys show a long-term gain in their attitudes. The consolidation of their attitudes with time may be due to their active participation in science related out-of-school and in-school activities. The finding here supports the assumption that real learning and long lasting changes in perception takes place through activity and involvement.

There has been an interminable controversy on the issue of relationship between 'science related attitudes' and 'achievement in science'. Some studies show a high correlation between these two factors (Johnson and Murphy, 1986), while others observe a low correlation (Wilson, 1983). If achievement is measured with the annual examinations conducted by the Central Board of Secondary Examination, Delhi State, then this study also appears to support the stance of low correlation between 'science related attitudes' and 'achievement in science'.

It has been found that female students get short-term benefits out of the visit (in spite of spending more time in the *Fun Science* gallery) and, on the other hand, males have upper hand in the long-term impacts. This finding points to the fact that less opportunities are available for girls to accumulate rich, palatable, memorable science related experiences in science centres, due to perhaps science centre's orientation in physical sciences. In several studies, girls are found to be more inclined toward the animate aspect of science, nature study and applied life; while boys prefer the inanimate aspect, such as properties of matter and cosmology (Zerega *et al.*, 1986). Like elsewhere, most Indian girls take special interest in natural sciences. To some extent, the finding also points to the more sensitive genetical make-up of knowledge structure that represent attitude of girls in compare to that of boys.

Junior and senior students have different expectations from the science centre visit and different perception of the out-of-school visits. Junior students take the visit more as a day of freedom and enjoyment, while senior students consider it more seriously in terms of learning something useful. The pattern of gain in affective component of the attitude is found similar for both groups.

The attitude dimension self-perception of Science does not gain significantly in any case. It implies that the visit does not make any magical impact. Students do not want suddenly after the visit that science should be given more time than any other subjects. They do not want to discuss science immediately after the visit any more than they used to discuss it before. Similarly, they do not visualise the utility of science in everyday life any more than they used to see it before.

A number of studies (such as, Bitgood, 1987) suggest that people's attitude toward museums also changes as a result of their science museum/centre visit. For example after the visit, they perceive science museums as more child-oriented, spicy and funny places than they did as non-visitors. In the next chapter, we shall explore the change in student's attitudes toward science museums as a result of their visit.

Chapter 8

Construction of 'Attitudes to Science Field Trip' Scale for Organised School Groups in Science Centres

Introduction

As has been said in Chapter 3, the 'attitudes toward science centre' is an extremely important educational objective in its own right. According to Middleton (1991), the strongest single determinant of the future demand for museums is the attitude which visitors have towards what museums provide. True, the image of a museum (or, in fact, of any place) is one of the key factors which makes up our mind whether to go there or not. Children do not usually visit museums, but they often form their opinion about them from stories, comics or experiences of their parents and grandparents. The negative image of museums is deeply rooted in the soil of our language and culture (Department of Education and Science, 1971) and can be understood in terms of its pessimistic associations in real world.

> Life is not something one associates with museums. One thinks more of death. No matter how bright and lively museums become (as many now have) the image in the public's mind remains one of the dust, silence and sepulchral gloom (Spalding, 1991).

In a nationwide survey carried out in 1985 of 1500 people, 25 per cent of visitors and 46 per cent of non-visitors saw museums as being most like a monument to the dead (Merrimen, 1989). In an another survey, Prince and Schadla-Hall (1985) found that over 90 per cent of non-visitors still hold the view that museums are glorious depositories of a nation's heritage. Similar results were observed in an another study conducted by the London Museums Consultative Committee. Museums were seen by non-users as boring, musty, gloomy and stuffy (*Museum Development*, March 1991: 25). In general, people are not much aware of the recent developments in museums. For a student who has to visit a science centre for the first time, the event would mean no more than a school-day-out or a trip to a local industry. Usually, students have no specific image of science centres, but most of them certainly have an idea about a field trip or a school-day-out experience. In this chapter, the term 'attitudes to field trip' will be used in place of 'attitudes to science centre' in order to avoid any possible confusion which may arise in the mind of students (during pre-visit test).

In this chapter, I shall first attempt to draw together a range of ideas about field trips and practices of past decades in global and Indian context. I shall then briefly discuss some of the previous studies conducted on 'attitude toward museums'. This discussion will point to the need of defining 'attitude' concept and also to the need of developing a reliable and valid scale in order to measure the attitude and attitude change as a result of a science centre visit. The developed scale will be used to generate data and, subsequently, the results will be presented in the next chapter.

8.1 Attitudes toward field trips

The field trip is regarded by most educationists and teachers as an unrivalled teaching aid. In America, for nearly a century, it is claimed, no school year has been over without at least one field trip to a museum, zoo, nature centre, or other learning centre (Falk and Balling, 1980). Similarly, the practice of field trips in schools can be seen more or less all over the world. The historical significance of field trips, particularly in science and technology, can be judged from the statement of Mallinson (1957) when he says that bibliography of papers from science journals extolling the virtues of science field trips might be as long as dozen of arms placed end to end.

In the first half of this century, it appears that field trips were taken more or less on face value, as not much has been attempted to explore their outcomes and experiences. Although there are a few exceptions. For example, in the late 1930s, Aldo Leopold started to develop an education philosophy that was critical of the sterility of classroom science and laboratory experiences. In his lecture titled 'Natural History, The Forgotten Science' delivered at the University of Missouri, he suggested that it was necessary to make connections between critical field observations, what had been read and what had been told (Carter, 1993).

Since the 1950s, the outcomes of field trips, as several studies suggests, have been increasingly examined and recognised in the academic world. For example, in a report from the Department of Education and Science (1971), Her Majesty Inspectors became greatly impressed with the educational potential of museums and emphasised the need for utilising it more efficiently in the school curriculum and practices. In Gottfried's (1980) study, interviewee teachers reported that 'turned-off' kids or poorly motivated students were often found to be involved whole-heartedly in science related classroom activities as a result of their science centre visit. As an another example, according to Borun and colleagues (1983), a large proportion of teachers stated that a visit to the Franklin Institute Science Museum fulfilled their expectations and reached anticipated goals. Today, millions of children worldwide attend to a great variety of field trips ranging from cemeteries to highly specialised science centres.

But, in the Indian context (and this may also be applicable to many other countries), the use made of the enormous resources of museums is still uneven and disorganised. Too few teachers take regular interest in activities of museums and too many students complete their education without using the educational resources of museums. For example, out of 8 randomly chosen schools (scattered in the territory of Delhi and included in the present study) six had never visited the National Science Centre Delhi. The situation may have universal character, as may be learnt from official documents of different countries, for example from the reports of the Department of Education and Science (1971) in the UK. Also, the students of Moat Community College where I conducted the pilot study in January 1994 had up to that time not visited the Snibston Discovery Park in Leicestershire.

It appears paradoxical that, while on the one hand, the field trip is one of the education's oldest and most popular teaching aids, on the other hand, it is one of the least understood. In the past four decades, a growing number of research studies have been conducted on various aspects of field trips, but these altogether constitute an insignificant research body if compared to the number of the organised field trips every year. For example, Mason (1983) succeeded in locating only 43 references in his annotated bibliography of field trip research. This suggests that most teachers, in general, may not have stopped to analyse why do, precisely, they organise field trips? In this sense, the area of field trips can be said to exist in its infancy, having a lot to be explored and answered. For example, to date there is woefully little consensus on the extent and quality of benefits of field trips to students and to teachers.

A child, even when very young, has ideas about things. Often, these ideas can be volatile and can be changed, perhaps into more sensible ideas, each time the child interacts within her environment. In support, Bruner (1961) says that a child who finds things for herself not only gains deeper understanding of the principles involved but is more satisfied and motivated than a child who is taught didactically. Many researchers have incorporated discovery learning as an integral part of their theory. Piaget (1970b) identifies "hands-on experiences" as very helpful aids for the transition from a concrete to a more abstract level of cognition. Similarly, while applying Ausubel's (1968) learning theory in biology education, Novak (1976) points out the need for concrete experiences as a transitional learning stage from primary concepts to secondary concepts. There can be no disputing the assumption that during field trips, specifically in science centres and hand-on settings, students have enough scope to accumulate concrete experiences. Thus, in general, the value of a field trip can be regarded as beyond doubt. However, there can be contentions about the degree of the effectiveness of a field trip as not much work has been attempted on the correlation of the theoretical goals and experimental outcomes of a typical field trip. In other words, we do not, yet, know much about learning during a field trip. For example, does learning always occur in them? If so, what type of learning occurs and under what conditions?

The outcome of a field trip can be assumed as a function of the nature of the field trip and the knowledge and background of the potential learner. For example, a visit to an ornamental garden may be an engaging one for a botanist but may not interest a physics student at all. In all possibilities, there are chances that for some students experiences during the field trip may be awful or unexciting and if this is the case they may not enter that museum or institution again. In fact, the literature provides convincing evidence that there are people who have visited museums only once in their life time. On the other hand, for many, the museum experience may be a very exciting one. In this case, they share their experiences with their friends and family members. In no time, these people develop positive attitudes towards that particular environment and may pay multiple visits thereafter. In the existing literature, we find evidence that there are people who visit museums more than four times a year (for example, 17 per cent people visited 3 -10 times a year; Merriman, 1989).

Plausibly enough, 'attitudes toward field trip' is an important educational outcome as significant learning is a matter of opportunity and of continual, concentrated effort. If one finds one's visit to a science centre a stimulating and uplifting experience then he or she would like to visit there again and that time with some specific intentions or goals. In her study, Borun (1977) observes a decrease in 'attitude toward museum' and also in 'attitude toward science, technology and scientists' of people as a result of their visitation to the Franklin Institute Science Museum. With this observation, it can easily be speculated that attitudes toward museum may influence attitudes toward the subject-matter presented in it. People leaving the door with better images of museum in their mind are the people who are more likely to pay return visits. And in this context, researchers have found that repeated exposures are helpful in learning concepts and in making deep understanding of the presented information (Martin *et al.*, 1981; Kubota and Olstald, 1991). Hence, in the light of the above discussed studies, the significance of the 'attitudes toward field trip' as a research parameter gains further weight.

If it be granted that attitude to a field trip is nearly as important as suggested here, it is surprising that so little research has been done in this area. Though the issue related to attitudes toward field trip are touched on from time to time but seldom has there been a systematic and prolonged focus on this potentially significant outcome. For a variety of reasons, including students' ever declining interest in science subjects, the recent concern of politicians and educators for the adolescence problem (briefly discussed in Chapter 10), the increasing need of remedial strategy, and the renewed faith in attitudinal research, the time seems ripe to make study on it. This study mainly aims at: first, to investigate the significance of 'attitude toward field trip' in Indian context; and second, to measure possible changes in students' attitudes toward science centre as a result of their visit.

8.2 Science field trips in the Indian context: an outline of features

Science centres in India are growing at an impressive rate. While there were only four science museums/centres in 1973 (the year when the Planning Commission of India reviewed the over all situation of literacy), today there are 22. But, if we take the whole population and the vastness of the country into our account, the ostensibly powerful science centre movement is still insignificant. Science museums are still out of the reach of most students. For example, there is no science museum in the northern territory comprised of Jammu and Kashmir, Himachal Pradesh, Haryana and Punjab.

The situation cannot be said to be very optimistic in cities where science centres are located. For example, in Delhi around 60,000 students (estimated figure) visit National Science Centre (NSCD) every year out of a total 900,000 school-going population in the age group 6 to 17. While most of the prestigious public schools make it a point to send their students to visit NSCD at least once-a-year, this cannot be said for most government schools. For them, the organisation of such field trips depends on many factors, including the availability of funds (mainly on account of transportation), enthusiasm of principals and teachers.

In general, schools face acute shortage of funds and resources. While some schools do not have science laboratories, others do not have apparatus in them, and still others do not have accurate equipments. Students do often complete the formalities of performing a certain number of experiments. Quantity takes over from quality. Students often show the skills of extracting remarkably accurate results using inaccurate experimental apparatus. In these circumstances arguably, a visit to science centre should be mandatory, as it could prove useful beyond imagination for students and teachers as well.

The data of teachers' interview in this study reveals that teachers in Delhi mainly organise science centre visits for two reasons; first, to motivate their students to take classroom lessons more seriously; and second, to show their students working exhibits so that they can have idea or direction needed to develop their own models to participate in Delhi state level science fair. The science fair is an annual event which is organised by the Science Branch of the Directorate of Education. In this competitive event, participant schools are required to present science models conceptualised and fabricated by their students. On the face of it, there remains remote possibilities if a teacher organises a visit as part of a specific science lesson.

Unlike the United Kingdom where education is centralised and museums are de-centralised, in India, science museums are 'highly' centralised and education is de-centralised. In science museums, largely all major decisions are taken in the head-quarters (that is, Calcutta) and percolated down to museum in-charges at various places to implement. Most members of local programming committee participate in meetings as outsiders and simply endorse the decisions. In education sector, mostly decisions are made by the state authorities. Consequently, there can be found a limited association between science presented in the galleries and science curriculum in schools. Nevertheless, popular science galleries, populated with physics related exhibits, cover the science topics mentioned in the syllabus to some extent, and thus cater to the need of students. Beside, students have a lot more opportunities to learn through their involvement in a range of educational activities.

Booking at the NSCD is optional for organised school groups. While some schools inform the museum about their excursion, most arrive without prior intimation. At times, specially when four or five schools arrive at the same time, it becomes really tough to cater to all visitors. Many schools, specially government schools, send 150 to 300 students at the same time. They think in terms of getting full value of time and money and so plan to visit maximum possible number of places on the same day. For example, in December 1993, a government school of Janakpuri, included in the present study, sent around 300 female students with five or six teachers and they visited three places in a day, namely Nehru Planetarium, National Museum of Natural History and National Science Centre. Obviously, sometimes there can be found only five visitors in a huge gallery and other times five visitors at an exhibit. Such bimodal feature of visitors' density creates problems in administration and planning.

To date, there is no volunteer culture in Indian museums as is found in American and some European museums. For interpretation and other education related services, museums have to depend on their permanent staff. There is perennial shortage of education staff. On average, one staff member is made responsible for one gallery. Moreover, education staff remain busy in the organisation of educational activities. Naturally, they do not have time, and perhaps energy and enthusiasm, to explain exhibits to visitors. This feature can also be observed in many science centres all over the world. For example, about 20 volunteers work everyday in the Experimentarium, in Copenhagen. But, almost all of them remain busy in the organisation of a range of educational activities.

There is one another aspect: the problem of accessories. The accessories, like steel balls, magnets, strikers and so forth, are often stolen or misplaced by visitors. Stolen accessories are not often replaced regularly. Moreover, exhibits in India are much more fragile compared to exhibits housed in the Launch Pad, London or in the Experimentarium, Copenhagen. As most exhibits in the permanent galleries are fitted in a readily available frame made up of extruded aluminium sections, they are not very strong and do not withstand constant use (Plate 8.1).

Plausibly enough, during the course of a visit one may encounter a number of either incomplete (without accessories) or out-of-order exhibits. These exhibits will certainly not survive in France or in the Netherlands where every child has a right to express itself in whatever way it pleases (*Museums Journal*, December 1993: 16). One can jump over foot pumps or mercilessly punch on key boards, for example. In India, if a student behaves in some negative way, both the teacher and the security guard on duty in the gallery can be seen at the same time instructing them not to do so.

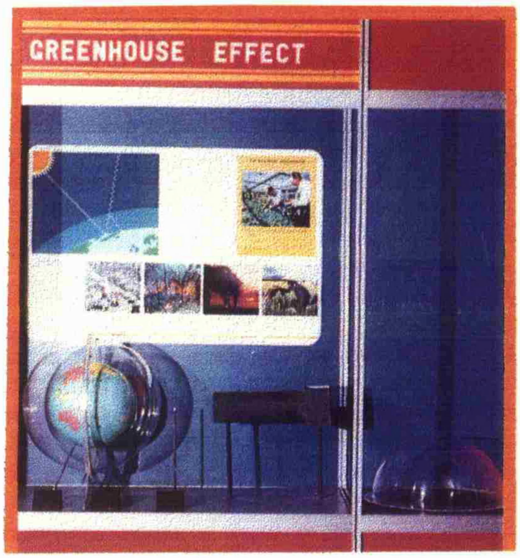

Plate 8.1 An exhibit demonstrating the greenhouse effect housed in a structure made up of readily available extruded aluminium sections and laminated ply sheets.

At the outset of the visit, elements of novelty take over and students show an extensive exploratory behaviour. In the reception lobby, school teachers can be observed instructing their students about the time of return. Unlike museums in Prague and Utretch, where having propelled their students through the door of the museum, teachers disappear during the visit (*Museums Journal*, December 1993: 16), teachers in India remain with students throughout the visit. But, very few instances of interaction between teacher and students can be seen. Considering the deplorably low teacher-students ratio, roughly one teacher for 50 students, the teacher's problem appears genuine. Mainly, students explore things on their own.

The gallery tour, thus, can be characterised as less-structured as, in general, there is no gallery staff to demonstrate, and accompanied school teachers with the student group have their own limitations. Many teachers also admit that they do not know much about exhibits. Consequently, it would be fair to say that students can explore a lot of scientific principles and latent processes on their own during the course of the visit.

In these circumstances, affective outcomes can be expected more than cognitive ones. Of course, they can make much more sense of scientific experimentation. But, this is simply not possible in one visit. Research studies reveal that in second and subsequent visits the role of environmental novelty and anxiety reduces to minimum and significant learning may take place (Falk, 1983; Kubota and Olstad, 1991). Hence, in Indian context, 'attitudes toward field trip' is much more important educational outcome and worthy in its own right of research rather than of ignorance.

8.3 Literature review

Field trips exist in every geographic location and are administered by people of widely varied backgrounds, such as elementary school teachers, biologists, historians, resource managers and engineers. The field trip is a multi-disciplinary subject, involving natural sciences, life sciences, and humanities, and includes formal as well as informal education. Understandably, as there is no standardised definition of field trip education and no standardised knowledge of its competency, research on field trips appears to suffer badly.

Since the 1960s about 40 experimental studies in science education have assessed various aspects on out-of-school education (Orion, 1993). Indeed, the studies made in museum context are much less in number. The existing field trip studies can be divided into four broad categories on the basis of their intended aims and objectives: the first category deals with the usefulness of a field trip; the second body assesses the question of cognitive goals (content learning and retention); the third body deals with the affective outcomes (attitude toward the subject-matter and towards the field trip); and the fourth body deals with multifarious aspects of planning a successful visit.

A review of research on field trips in the museum context (Table 8.1) reveals about the diversity of field trips. There are a great number of variables. For example, while some studies involve single exhibit, others are carried out in thematic exhibitions. Highly specific techniques have been used for developing questionnaires and also there has been observed no standard method for validating the questionnaire. Patently, comparison across studies is difficult and fraught with danger.

The research into the affective domain is a rare phenomenon, as most studies are concerned with the aspect of cognitive or content based learning. And the study on 'attitudes toward museum' is still rare. Only three studies (Borun, 1977; Stronck, 1983; Bitgood, 1987) have been found which look into the attitudes toward museum. Borun (1977) has, however, included in her study school groups as well as family groups. In this sense, it is not exclusively field trip study. This review exposes the real dearth of studies made to measure the potentially critical outcome 'attitudes toward field trip'.

Table 8.1 Review of research on field trips in the context of museums

	Reference	No. of particip a-nts	Grade	Place / Context	Subject matter	Study Design	Questio-nnaire	Validity of quest-ionnire	Aim and Objectives	Remarks
1	Delaney (1967)	180	7th	Brookhaven National Laboratory	Physical Science	Control-experimental group design	Composed (25 items) Multiple-choice		Effects of teachers' instruction on factual Knowledge	Enhanced for average and below students No difference for superior students
2	Eason and Linn (1976)	750	5th, 6th and 7th	Lawrence Hall of Science	Optics	Control-experimental group design	Composed Interview	Pilot study	Cognitive gains	Enhanced
3	Lambert (1978)		4th	Cincinnati Museum of Natural History	Prehistoric Indians	Multiple choice test	Composed		Cognitive gains	Enhanced
4	Borun (1977)		7th 9th high-school	Franklin Institute of Science Museum		Pre-test/post-test design	Composed	Pilot study	Cognitive gains Affective gains	 Decreased
5	Sneider *et al.* (1979)	138	6th to 12th	Lawrence hall of Science	Astronomy	Post-test only design	Composed	Pilot study	Effect of prior experience Cognitive gains Attitude toward astronomy material Interest	No difference between boys and girls Increased Decreased No difference

Table 8.1 ....continue (Review of research on field trips in the context of museums)

	Reference	No. of particip a-nts	Grade	Place / Context	Subject matter	Study Design	Questio-nnaire	Validity of quest-ionnire	Aim and Objectives	Remarks
6	Wright (1980)	13	6th	Kansas Health Museum	Human biology	Pre-post nonequivalent control group design	Composed	Jury and item analysis validity	Cognitive learning	Enhanced
7	Gottfried (1980)	400	-	Lawerence Hall of Science	Biolab	Pre-test/post-test design	Composed	Compare with obse-rvation studies	Cognitive gains Retention Interest	Enhanced Positive Enhanced
8	Gennaro (1981)	105	8th	Science Museum of Minnesota	Omnitheatre	Pre-test/post-test design	Composed 94 items	Jury validity	Cognitive learning (Effect of previsit instruction)	Positive outcome
9	Borun *et al.* (1983)	432	5th & 6th	Franklin Institute of Science Museum	Mechanics	4 (treatment) X 2 (test) factorial design	Composed highly structured objective test	Jury KR reliability	Cognitive goals Affective goals Psychomotor goal	Performance test proved sensitive measure of exhibit-based learning.
10	Borun *et al.* (1983)	535	6th & 7th	Boston Museum of Science	Planets moons	4 (treatment) X 2 (test) factorial design	Composed open-ended		Cognitive goals Affective goals Performance test	Sparse Positive Positive

Table 8.1 ....continue (Review of research on field trips in the context of museums)

	Reference	**No. of particip a-nts**	**Grade**	**Place / Context**	**Subject matter**	**Study Design**	**Questio-nnaire**	**Validity of quest-ionnire**	**Aim and Objectives**	**Remarks**
11	Stronck (1983)	306 216 262	5th 6th 7th	British Columbia Provincial Museum	Natural History	Pre-test/post-test control group design	Composed	Jury Validity	Cognitive goals Attitude toward museum	Positive for more structured tours Positive for less structured tours
12	Finson and Enochs (1987)	194	6th, 7th & 8th	Kansas Cosmosphere Discovery Centre	Space Technology and OMNIMAX	Pre-test/post-test design	Scientific Attitude Inventory		Attitude toward Science-Technology-Society	Positive after visiting KCDC
13	Bitgood (1987)	160	under-grad. & grad.	Anniston Museum of Natural History	Natural History	Pre-test/post-test	used Shettlel's scale		Attitude toward museum	Dramatic change (favourable)
14	Javlekar (1989)	190	7th	Nehru Science Centre Bombay	Physical Sciences	Pre-test/post-test control group design	Composed	Jury Validity and Pilot study	Cognitive goals	Strongly positive results (41% increase over the pre-visit score)
15	Kubota and Olstad (1991)	64	6th	Pacific Science Centre	Physical Science	Post-test only control group design	Composed	Jury Validity	learning & behaviour Learning & novelty Novelty & behaviour	Overall low correlation
16	Tuckey (1992)	153	3rd & 6th	Satrosphere	Physical Science	Recall exercise			Students' reaction to their visit	Positive

8.4 Purpose of the study

In school science education, some students do science related activities in schools but exhibit disruptive behaviour in science classes. In classrooms, they get the message that either they are too dumb to understand science or that science has nothing to do with everyday life. It is often said that these students may be really 'switched on' to science and get personal satisfaction in it, instead of withdrawal, if they are given 'the little extra bits' over and above the basic syllabus.

Often, the field trip is prescribed by educators as unique medicine. It is usually assumed that the main role of the field trip in the learning process is the direct experience with real objects and processes. Moreover, in science centres, these experiences are tailored according to the need of the users. The uniqueness of the science centre visit is not in the concrete experiences themselves but in the variety and quality of experiences. Theoretically, a science centre visit may motivate students to come again and gradually to form positive attitudes to field trips, and thus, can be like magic in shaping their careers.

In broad terms, the purpose of this study is to know the immediate and long-term impact of a science centre visit on 'attitudes toward science centre'. As discussed in introductory chapter, there are three variables - that is, education level, gender, and time of data collection (before and after the visit) - of our interest. The objective of the present study is to throw light on the relationships of attitude with gender, time of data collection, and educational level students.

8.5 Measurement of attitudes toward field trips

It is a well documented proposition in literature that the measurement of attitude is a notoriously difficult task. The measurement of attitude toward field trip is much more difficult as not much work has been attempted in this area. Usually, in an exit survey, visitors are asked questions like how do they feel about their time in the museum? or whether they would like to come again to visit the museum, and the collected data is presented as their attitudes toward the museum. As can be seen from the literature review, only three studies, that is Borun (1977), Stronck (1983) and Bitgood (1987) attempted to measure attitudes to the museum. In her study, Borun (1977) used face tests (in which the visitor has to make a choice from five faces ranging from a very sad frowning face to a very happy smiling face) and asked visitors: how do you feel about your visit to the museum today?

Stronck (1983) attempted to measure attitudes toward the museum in some details at the British Columbia Provincial Museum. The questionnaire for this study was prepared by Stronck in collaboration with Richard Kool, education specialist at the British Columbia Provincial Museum. Ten items of the questionnaire consisted of semantical differentials on a scale of five alternatives. The first two items presented a scale of five faces ranging from a very sad frowning face to a very happy smiling face. The first item, for example, began with the statement:

> Which face shows how you feel about going to visit the new Natural History Gallery, Living Land, Living Sea?

The rest eight of the items were designed to evaluated against a scale of five alternatives with opposite words at the extreme. For example:

(A) very happy	(B) happy	(C) neither	(D) sad	(E) very sad

In his study, Bitgood (1987) employed a 27-item, bipolar adjectives, 7-point rating scale (originally devised by Harris Shettel). The students were asked to rate their experience in the museum on different dimensions, more "child-oriented" or "adult-oriented", such as.

Colorful	-	-	-	-	-	-	-	Drab
Bland	-	-	-	-	-	-	-	Spicy
Children	-	-	-	-	-	-	-	Adults
Dead	-	-	-	-	-	-	-	Live

There are certain weaknesses of the above discussed studies. In all studies, the attitude has been measured at superficial level. None of the studies defines the concept of attitude. The studies also do not attempt to describe how the items in the questionnaire point to or relate to the attitudinal object.

Evaluative quality is the central attribute to the attitude concept. The need of employing adequate methodology for measurement cannot be over-emphasised. There is real scarcity of developed scales to measure students attitude toward scientific field trip. In a thorough literature survey, only one study, namely Orion and Hofstein (1991), has been found which developed a useful scale for assessing a science field trip in a natural environment. Obviously, this scale, as such, cannot be used in the museum environment. Hence, it becomes essential to develop and validate a suitable scientific field trip attitude scale specially for those students who visit science centres.

The concept of attitude is same for the purpose of this study as it is defined with regards to 'attitudes toward science' (Chapter 6). But to continue forward, it appears a wise idea to summarise the important features of the attitude construct. Attitudes are pervasive, encompassing a broad spectrum of topics and issues: they can be specific and generalised as well, they can be learnt, they can be wilfully manipulated or misrepresented by the respondents, they are comprised of a number of different dimensions, they can have temporal stability, and they can be changed through persuasion and exposure.

8.6 Development of the 'attitudes toward science field trips' scale

In Chapter 6, we have developed a scale for measuring 'attitudes toward science'. We shall follow the same procedure here. The development of a reliable and valid attitude scale is a process that consists of several distinct stages (Gardner, 1975; Koballa, 1984). The main stages of this process are:

1. Conceptualisation - the attitude dimensions to field trip.
2. Item formulation.
3. Content validation
4. Finalisation of the scale - pilot testing employing four different samples, factor analytical investigation, and Cronbach's alpha coefficient of final questionnaire.

Stage 1: Conceptualisation

The first stage in the development of the scale was to identify various components of students' attitude to field trip. Following four sub-scales of attitude were conceptualised provisionally on the basis of our construct of attitude: learning in the field trip setting; uniqueness of the field trip; self-perception about the field trip; and echo of the field trip learning in the classroom. Like 'attitudes toward science' scale, Likert technique of constructing scale was preferred to other techniques for the purpose of this study for its simplicity (discussed in detail in Chapter 6). It was also decided to present the items in the questionnaire in random order and also to present some items in negative way. The final grouping of items was left to decide after performing factor analysis on the generated data.

Stage 2: Item formulation

To formulate individual items and the scale, following three points were considered as ground rules:

1. The scale should work at different levels, that is neither answer for specific item should be obvious nor it should be too complicated. Target population was from 8 to 12 graders (Aged 12 to 17) from government schools in Delhi and Guwahati in India.

2. The scale should work equally well for pre-visit and post-visit tests. It requires that each item should be closely related with the science centre visit - its content, activity or environment, and should fit in some dimensions of our attitude construct and also simultaneously should be answered by those who have some sort of image in their mind about science museums on the basis of their previous field trip experiences, but do not necessarily have direct experience of the science centre visit.

3. The scale should not take too much time of students.

In the pre-visit questionnaire, students were first asked to furnish details if they ever had been to some field trips. The purpose of this question was two fold: first, to inform students that the field trip is basically means an educational visit to any out-of-school places, such as historical sites, a zoo, a botanical garden, an industry, a laboratory, a science museum, and a natural history museum; and second, to know from them about the places they had visited previously. From the responses, it was found that most students were having a fairly well idea about field trips. Although, some students had been to historical sites or to industry with their parents.

To formulate items, an experience-oriented approach was adopted. The criterion of the approach was that one should be able to answer all items on the basis of ones previous field trip related experiences. For example, item 3: *The field trip is a waste of time,* could be answered on the basis of ones previous field trip related experiences. The problem was envisaged about a few items. As for an example, item 12 which reads: *I would rather go to cinema than a science museum.* Naturally, such questions might not be straightforward to answer specially for those who do not have some idea about science museums. Provisionally, such items were included in the scale subject to passing the criterion of the pilot study.

Of course, to formulate items a number of different studies were consulted, but the study of Orion and Hofstein (1991) was very helpful. Three items in the present scale were taken from the scale developed by Orion and Hofstein (1991) (two items were included in slightly modified form)

1. The field trip helps in understanding of concepts learned in class (modified)
5. I would like to have more field trips, since they help in building class spirit.

13. Working alone during a field trip is important for understanding material (modified).

Each item was assessed on a five-point Likert-type scale (Strongly Agree/ Agree/ Undecided/ Disagree / Strongly Disagree). To avoid the problem of positive answering tendency among students six items were presented in negative way (Table 8.2, section3). For example:

"Field trips inspire me to search additional information in textbooks." Positive item

"I hate field trips because my teacher scolds me for silly reasons." Negative Item

Stage 3: Content validation

Each item was considered time and again consulting Edwards' (1957) fourteen criteria for writing Likert statements. Following five experts were consulted to assess the quality of each item in the context of clarity, ambiguity, generality, and to validate the content of the questionnaire.

1. Gaynor Kavanagh, Lecturer, Department of Museum Studies, Leicester.
2. Simon Knell, Lecturer, Department of Museum Studies, Leicester.
3. Jannette Elwood, Lecturer, Department of Education, Leicester.
4. S. Dabas, Post Graduate Teacher, Government Co-Education Model Senior Secondary School, B-4, Paschim Vihar, New Delhi.
5. S. C. Gupta, Post Graduate Teacher, Government Co-Education Model Senior Secondary School, New Delhi.

Stage 4: Finalisation of the scale - construct validity and reliability

To make sure that the scale holds equally well for populations having different cultural backgrounds and education systems, and ultimately, that the scale represents a wider population sample, the 16-item inventory was administered to four different samples, three in schools of Delhi and one in Guwahati, comprised of grade 8 to 12 students. For the sake of convenience of students, the questionnaire was also made available in Hindi. The *item-total correlations* (r-value) were found reasonably high ranging from 0.10 to 0.86 (Table 8.2, section 6.1-6.4). Most items were found to hold equally good for different populations. No item was found working poorly in all the pilot tests. For example, item 3 (*The field trip is a waste of time*) was not working well with one population but worked well with rest of the three (Table 8.2, section 6). The internal consistency of the scale is estimated 0.82 (for 275 cases; Table 8.2, section 7).

Table 8.2 Data generated by Likert analysis on 16 final items

SN	Item	Pos/Neg	Sub compo-nent	Frequency (In percentage)					Item-total Correlation				Final Scale
1	2.0	3.0	4.0	5.0					6.1	6.2	6.3	6.4	7.0
				SA	A	U	D	SD	n=39 α=0.80	n=21 α=0.74	n=27 α=0.85	n=36 α=0.72	n=275 α=0.82
1	The field trip helps in understanding of concepts learned in class.	+	1	39.6	49.5	6.2	1.8	1.8	0.53	0.24	0.48	0.52	0.56
2	I like field trips which involve a lot of adventure.	+	1	48.0	40.7	6.2	1.8	1.8	0.64	0.29	0.53	0.69	0.54
3	The field trip is a waste of time.	-	1	1.1	2.2	6.5	44.0	45.5	0.67	0.10	0.53	0.61	0.64
4	What I like best in field trips is the discussion with friends.	+	4	21.1	48.0	14.9	10.2	4.7	0.34	0.43	0.16	0.40	0.42
5	I would like to have more field trips since they help in building class spirit.	+	4	28.4	45.5	16.4	5.1	3.6	0.60	0.42	0.47	0.52	0.57
6	Field trips do not increase my interest in learning.	-	1	4.0	7.6	8.4	43.6	35.6	0.75	0.35	0.61	0.56	0.61
7	field trips inspire me to search additional information from textbooks	+	1	38.2	45.8	8.7	4.4	2.2	0.32	0.20	0.56	0.56	0.59
8	I hate field trips because my teacher scolds me for silly reasons.	-	1	2.9	9.8	19.6	38.2	28.4	0.51	0.15	0.57	0.47	0.47

Table 8.2 ....continue (Data Generated by Likert Analysis on 16 Final Items)

S N	Item	Pos/ Neg	Sub compo -nent	Frequency (In percentage)					Item-total Correlation				Final Scale
1	2.0	3.0	4.0	5.0					6.1	6.2	6.3	6.4	7.0
				SA	A	U	D	SD	n=39 α=0.80	n=21 α=0.74	n=27 α=0.85	n=36 α=0.72	n=275 α=0.82
9	The field trip is an enjoyable way to learn.	+	1	52.0	37.5	5.5	2.9	1.5	0.40	0.53	0.63	0.34	0.61
10	In field trips I feel exhausted.	-	2	4.0	16.0	15.6	42.2	20.4	0.65	0.69	0.75	0.58	0.49
11	I return from field trips with new experiences.	+	3	46.2	45.5	3.6	2.5	0.4	0.49	0.81	0.86	0.46	0.68
12	I would rather go to cinema than a science museum.	-	2	5.8	8.0	15.6	36.0	32.4	0.55	0.45	0.61	0.62	0.51
13	Working alone during a field trip is important for understanding material.	+	3	26.5	40.0	15.6	10.9	4.4	0.48	0.74	0.37	0.40	0.41
14	I love field trips because teacher encourages me to learn.	+	3	37.1	45.7	9.1	4.4	2.9	0.45	0.78	0.80	0.42	0.60
15	I would go to Appu Ghar rather than a science museum.	-	2	5.8	8.7	13.5	44.0	26.5	0.60	0.40	0.68	0.34	0.54
16	I like field trips because I enjoy more freedom than that in the classroom.	+	4	20.0	29.8	16.7	21.8	9.8	0.43	0.58	0.39	0.13	0.28

The factor analytic investigation confirmed the hypothesis that the attitude to scientific field trip is not uni-dimensional but consists of four dimensions, designated as 'group' hereafter. The correlation matrix was factor analysed using Principal Factor Analysis with Varimax rotation. Four groups covered 50 per cent of the total variance (Table 8.3). Loadings exceeding 0.4 were considered to identify the factors.

Table 8.3 Factor Analysis (Varimax Rotation) - Attitudes to Field Trips (N =275)

Item	Group 1	Group 2	Group 3	Group 4
1	0.60			
2	0.47		0.45	
3	0.59			
4				0.76
5				0.64
6	0.53			
7	0.47		0.49	
8	0.71			
9	0.49		0.47	
10		0.56		
11			0.65	
12		0.80		
13			0.71	
14			0.61	
15		0.80		
16				0.62
Variance	29.9%	9.8%	7.6%	6.7%

Factor analysis determined a different arrangement of items in groups from the one that was planned theoretically. Items related to the *learning aspect of the field trip* and *echo of the field trip learning in classroom* were observed segregated in different way: personalised learning and generalised learning.

According to the new arrangement, group 1 is comprised of all items which can be seen related to personalised learning. Group 2 contains items wherein students could give rating to science field trip against popular leisure institutions like cinema and Appu Ghar (Amusement Park, located very near to the national science centre). In group 3, all items point to the character of the field trip as learning tool. Enjoyment, adventure, inspiration, new experiences, working alone and teacher's encouragement are observed as important elements which make field trips precious. Three items, that is item 2, item 7 and item 9, are found common in two groups, that is group1 and group 3. All items in group 4 project the field trip as unique environment distinct from the classroom environment. For example, there is a limit to freedom that can be enjoyed in the classroom. The grouping of the items is noted as follows:

Group1 **Personalised Learning** dimension

1. The field trip helps in understanding of concepts learned in class.
2. I like field trips which involve a lot of adventure.
3. The field trip is a waste of time.
6. Field trips do not increase my interest in learning.
7. Field trips inspire me to search additional information from text books.
8. I hate field trips because my teacher scolds me for silly reasons.
9. The field trip is an enjoyable way to learn.

Group2 **Self-perception of the field trip** dimension

10. In field trips, I feel exhausted.
12. I would rather go to cinema than a science museum.
15. I would go to Appu Ghar rather than a science museum.

Group3 **Field trip as learning tool** dimension

2. I like field trips which involve a lot of adventure.
7. Field trips inspire me to search additional information in text books.
9. The field trip is an enjoyable way to learn.
11. I return from field trips with new experiences.
13. Working alone during a field trip is important for understanding material.
14. I love field trips because teacher encourages me to learn.

Group 4 **Uniqueness of the field trip** dimension

4. What I like best in field trips is the discussion with friends.
5. I would like to have more field trips since they help in building class spirit.
16. I like field trips because I enjoy more freedom than that in the classroom.

Correlation matrix of four groups presents all positive and moderate correlations (Table 8.4). Very high correlation between any two groups implies that they represent the same subarea within the attitude object. In contrast, very low correlation between them suggests that the two factors almost do not have any relation and so may represent different attitude objects. Correlation between groups 1, 2, 3, and 4 have moderate values (between 0.38 to 0.76) and except between group 2 and group 4 (0.10). The correlation r-values reveal a moderate connectedness between sub-scales, suggesting a group of items that represent a single attitude object. At the same time, r-values suggest an element of interdependence, an important feature to draw conclusions from all corners of an attitude object. Figure 8.1 represents a model of our theoretical attitude construct. Group1 and group3 define relatively cognitive core and group2 and group 4 characterise affective core of our attitude construct.

Table 8.4 Summary table for factor correlations

	Group 1	**Group 2**	**Group 3**
Group 2	0.45	-	-
Group 3	0.76	0.41	-
Group 4	0.38	0.10	0.38

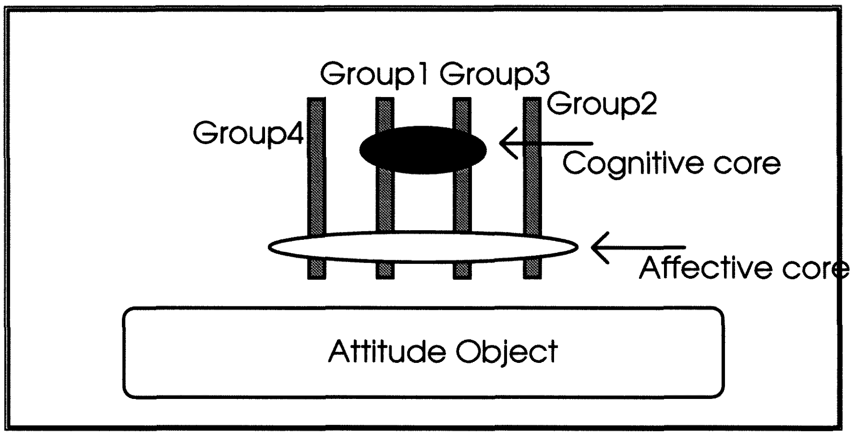

Figure 8.1. Graphical representation of the constructed attitude object.

Table 8.5 shows the results of testing each dimension as a single entity. The coefficient alphas of the dimensional scales are moderate considering the low number of items in each (0.50 to 0.77). For comparison, in Hull scales for the measurement of attitudes to science, the alpha reliability was found between 0.64 to 0.81 (Ato and Wilkinson, 1984). In an another scale comprised of five sub-scales (Misiti, Shrigley and Hanson, 1991), for one sub-scale alpha value was 0.04 and for the rest four sub-scales was between 0.66 to 0.81.

Table 8.5 Summary data for four dimensions

Dimensions of Attitude Scale	**Number of items**	**Eigen Value**	**Coefficient**
Personalised Learning	7	4.78	0.77
Self-perception of the field trip	3	1.56	0.65
Field trip as learning tool	6	1.21	0.74
Uniqueness of the field trip	3	1.07	0.50

Evaluative Quality

The evaluative quality of an item can be assessed by examining its frequency of responses across the five point Likert continuum. The generated data by items is distributed across Likert's continuum which points to the evaluative quality of the scale (Table 8.2, section 5). Low neutral responses on the scale, range from 3.6% to 19.6%, also suggests the evaluative quality. The comparison is also made between lower group and higher group subjects. Kelley (1939) found that if the total scale scores are distributed normally, the selection of respondents from the upper and lower 27 per cent of the distribution provides optimal discrimination. Figure 8.2 and 8.3 graphically illustrate skewed and bipolar distribution of responses suggesting good discriminating power of items. The two items presented here are selected on the basis of their mean attitude scores. Both items represent a sort of contrast as item 9 secures maximum mean score (4.8) and item 16 minimum (3.6).

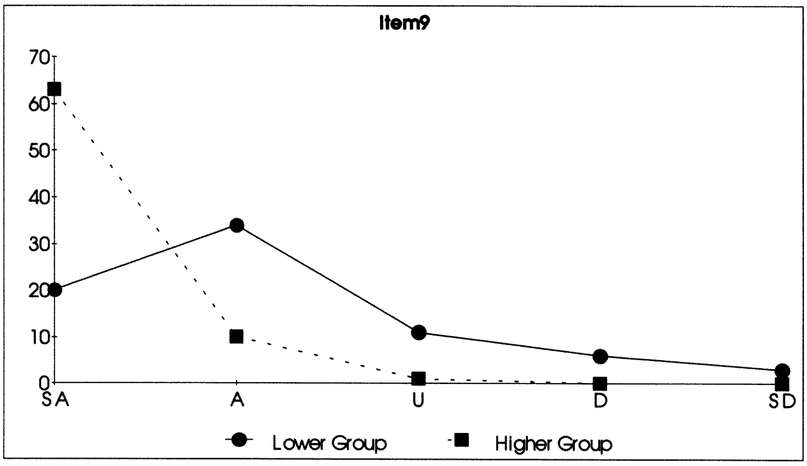

Figure 8.2 Distribution of responses of lower and higher group subjects over five Likert categories.

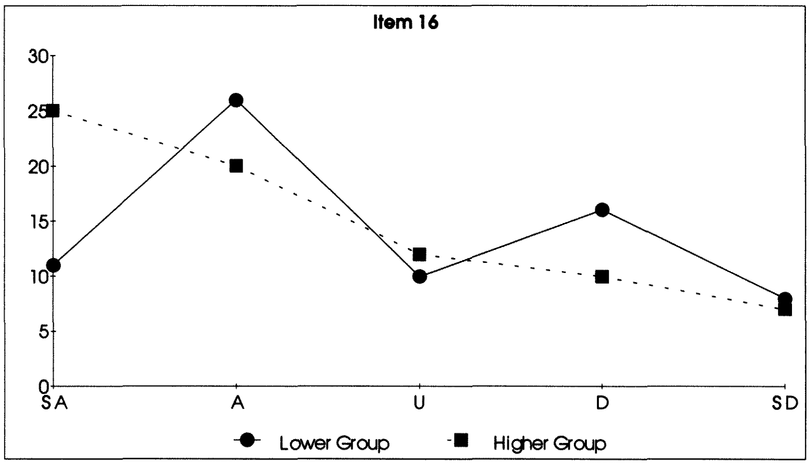

Figure 8.3 Distribution of responses of lower and higher group subjects over five Likert categories.

Conclusion

The science field trip attitude scale for young students has passed several tests suggesting some degree of validity. Almost all subjects were able to attempt full questionnaire suggesting accepted reading level and clarity of items. High item-total correlations, clarity, evaluative character of items, suggests a valid scale which could be used to compare group means of pre- and post- visit tests.

The scale, however, has a weakness, as two of its sub-scales namely, the self-perception of the field trip (group 2) and the uniqueness of the field trip (group 4) are composed of relatively low number of items (3 items in each sub-scale).

In the next chapter, we shall use the scale for determining the mean attitude score for a group of students. In order to measure the change in attitudes, different mean attitude scores will be compared using appropriate statistical techniques.

Chapter 9

Immediate and Long-Term Impact on Attitudes toward Science Museums in Response to a Science Centre Visit

Introduction

In this chapter, the preliminary results of the study in which the constructed 'attitudes toward field trip' scale has been employed are presented. The aim of this section is to find out the immediate and long-term impact of a science centre visit on various dimensional groups of attitudes toward science museums. Specifically, four research questions have been addressed:

1 Are there differences in attitudes toward science museums amongst students as a result of their science centre visitation?

2 Are there differences in attitudes toward science museums between male and female students as a result of a science centre visit? If yes, then what is the pattern of the differences in long terms?

3 Are there differences in attitudes toward science museums between secondary and senior secondary students as a result of their science centre visitation? If yes, then what is the pattern of the differences in the longer terms?

4 Are there differences in attitudes toward science museums between biology and physical science stream students in response to a science centre visit? If yes, then what is the pattern of the differences in long terms?

The present chapter is divided into two parts. In the first part, immediate impact and, in the second part, long term impact on students' attitudes toward science museums in response to a science centre visit will be discussed.

9.1 Participants and data collection

This investigation took place within a large school system in Delhi. Eight schools from the system's more than 500 government schools were selected and invited to participate. The sample represented a geographically vast area on Delhi State map. Principals were contacted with detailed plan of the study in which the same students were to be tested twice: *before the visit* and *after the visit.* They were pursued to send the school groups to visit the National Science Centre. Principals of participant schools took great interest and made necessary arrangements for organising educational trip (for example, financial arrangement, permission from parents, permission from the Directorate of Education and transportation). The sample in this report included secondary students, that is from eighth to tenth graders, and senior secondary students, eleventh and twelfth graders.

The trips were conducted in their natural course. In other words, no special effort, such as special orientation programme, was made to influence the outcome of the visits. In order to avoid the effects of extraneous variables, such as anxiety or novelty, tests, both pre- and post-visit, were conducted in schools. Two hundred and seventy five students participated in the pre-visit test and 235 in the post-visit test. The post visit test was conducted at best the next day and at worst within three days of the visit.

9.2 Experimental design

In this part of the study, in order to compare the impact of the science centre visit, only those 168 students were considered who participated in both, the pre-visit and post-visit, tests. This method is known as 'within-subjects' design and the sample, as 'paired or related sample'. As a result of a treatment, the means of paired samples are less likely to differ than the means of unrelated samples since the score comes from the same cases. The great strength of within-subject design is that by virtue of trying to hold other extraneous variables (such as, genetic make-up, personal traits and experiences) constant and to vary only those factors which are of interest, it enables us to determine with more certainty whether the effects we observe are due to the factors that have been manipulated.

9.3 Presentation of findings and discussion

Data are analysed using independent and paired t-tests. In the pre-visit test, senior secondary students are found to have higher mean attitude score than the secondary (junior) students but the difference is statistically insignificant in all dimensions except in self-perception of the field trip (Table 9.1). Girls secure higher mean score, though statistically insignificant, than boys in self-perception of the field trip dimension and in rest of the three dimensions the score is recorded nearly equal (Table 9.2). On average, senior students have higher (but insignificant) composite attitude score than junior students.

Table 9.1 t-test - Comparison of secondary and senior secondary school students (Pre-visit Test)

	Sec. students n = 108		Sr. Sec. students n = 60			
Scale	M	SD	M	SD	t	ρ
Personalised Learning	3.99	0.685	4.15	0.702	1.39	0.167
Self-perception of the field trip	3.52	0.993	3.79	0.919	1.79	0.075
Field trip as learning tool	4.03	0.722	4.09	0.766	0.49	0.626
Uniqueness of the field trip	3.46	0.868	3.54	0.819	0.58	0.564
Composite attitude score	3.80	0.588	3.93	0.642	1.40	0.163

In the light of these findings, it seems that all students in the age group of 13 to 17 have more or less similar perceptions about field trips with only contradiction in self-perception of the field trip dimension. According to the analysis of responses of students given below, comparatively more junior students find the field trip tiresome than senior students. Similarly, more junior students want to go to Appu Ghar (entertainment park in Delhi) or a cinema than senior students. The findings here suggest that junior students, in general, have a dull and passive image of a field trip, so they tend to underestimate field trips in comparison with other popular leisure institutions.

	Analysis of <u>self-perception of the field trip</u> dimension				
Item 10	**In field trips, I feel exhausted**				
	Agree	(-) ←	Undecided	→ (+)	Disagree
Junior	26%		13%		59%
Senior	10%		15%		72%
Item 12	**I would rather go to cinema than a science museum**				
	Agree	(-) ←	Undecided	→ (+)	Disagree
Junior	18%		14%		66%
Senior	15 %		18%		65%
Item 15	**I would go to Appu Ghar rather than a science museum**				
	Agree	(-) ←	Undecided	→ (+)	Disagree
Junior	20%		12%		66%
Senior	12%		13%		73%

Table 9.2 t-Test - Comparison of female and male Students (Pre-visit Test)

	Female Students n = 75		**Male Students n = 93**			
Scale	**M**	**SD**	**M**	**SD**	**t**	**ρ**
Personalised Learning	4.04	0.697	4.04	0.694	0.04	0.972
Self-perception of the field trip	3.71	0.994	3.54	0.955	1.10	0.275
Field trip as learning tool	4.07	0.738	4.04	0.738	0.31	0.758
Uniqueness of the field trip	3.48	0.862	3.49	0.841	0.05	0.960
Composite attitude score	3.87	0.610	3.82	0.611	0.49	0.626

The result also reveals that girls rate field trips slightly better than boys. Higher scores of female students in self-perception of the field trip dimension in comparison to males can be understood in terms of their less freedom. While, in general, boys can go out with their friends, there are cultural restrictions on girls' movement. While for boys the participation in the science centre trip may be an event, for girls it is an opportunity.

Grade-based findings

In grade-based pre- and post-visit test comparison (Figure 9.1), all students, junior as well as senior, have gained higher scores in all dimensions of attitude as a result of their science centre visit. Significant increase in mean attitude score is observed: in self-perception of the field trip (Table 9.3) for junior students and in personalised learning and uniqueness of the field trip dimensions for senior students (Table 9.4). For junior students, almost no difference is observed in uniqueness of the field trip dimension.

The analysis of responses in self-perception of the field trip indicates that more junior students join the undecided category. But, as a result of their experience more students tend to place the science centre at the top of cinema or Appu Ghar in their list of preference.

Analysis	**of self-perception of the field trip dimension for junior students**					
Item 10	**In field trips, I feel exhausted**					
	Agree	(-) ←	Undecided	→	(+)	Disagree
Pre-visit	26%		13%			59%
Post-visit	27%		25%			47%
Item 12	**I would rather go to cinema than a science museum**					
	Agree	(-) ←	Undecided	→	(+)	Disagree
Pre-visit	18%		14%			66%
Post-visit	3%		14%			82%
Item 15	**I would go to Appu Ghar rather than a science museum**					
	Agree	(-) ←	Undecided	→	(+)	Disagree
Pre-visit	20%		12%			66%
Post-visit	8%		22%			69%

Table 9.3 t-Test - Comparison of pre- and post- visit Attitudes Towards Field Trips of secondary students (N = 108)

	Pre-Visit Test		**Post-Visit Test**			
Scale	**M**	**SD**	**M**	**SD**	**t**	**ρ**
Personalised Learning	3.99	0.685	4.09	0.703	1.22	0.224
Self-perception of the field trip	3.52	0.993	3.79	0.759	2.43	0.017
Field trip as learning tool	4.03	0.722	4.15	0.752	1.26	0.212
Uniqueness of the field trip	3.46	0.868	3.47	0.854	0.12	0.907
Composite attitude score	3.80	0.59	3.93	0.61	1.67	0.098

Table 9.4 t-test - Comparison of pre- and post-visit Attitudes Toward Field Trips of senior secondary students (N = 60)

	Pre-Visit Test		**Post-Visit Test**			
Scale	**M**	**SD**	**M**	**SD**	**t**	**ρ**
Personalised Learning	4.15	0.702	4.36	0.447	2.64	0.01
Self-perception of the field trip	3.79	0.919	3.87	0.808	0.73	0.47
Field trip as learning tool	4.09	0.766	4.21	0.450	1.41	0.164
Uniqueness of the field trip	3.54	0.814	3.87	0.576	3.54	0.001
Composite attitude score	3.93	0.614	4.11	0.384	2.70	0.001

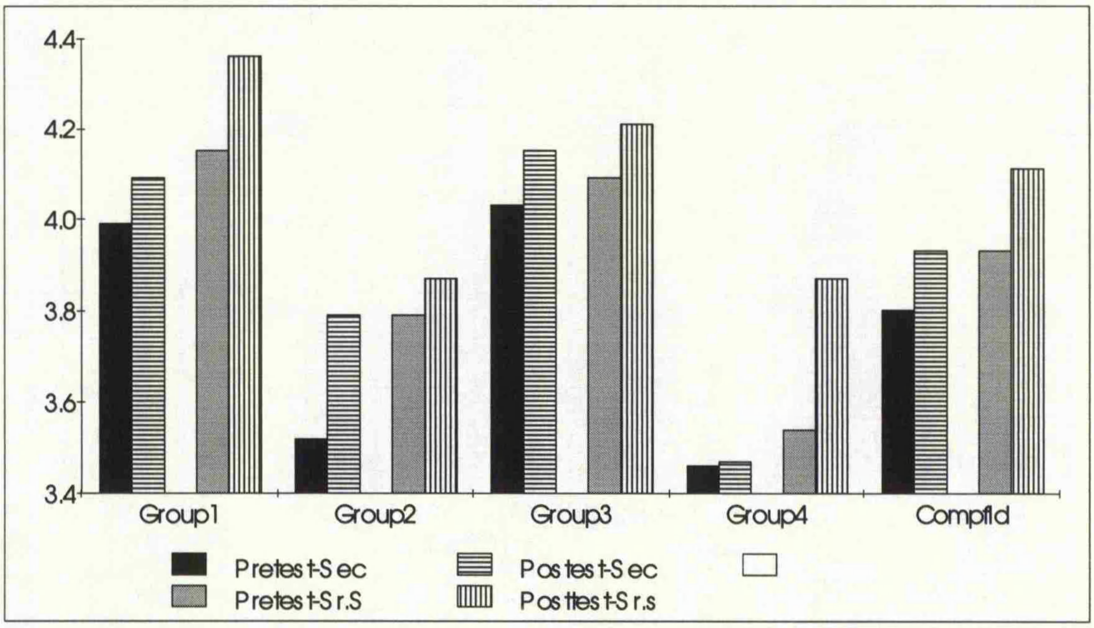

Figure 9.1 Graphical representation of changes in Mean Attitude to Field Trip Score in pre- and post- visit tests for secondary and senior secondary students.

Senior students have also gained significantly in *composite attitude score* (sum of all 16 items) and junior students insignificantly. The gain of junior students in <u>self-perception of the field trip</u> dimension indicates that they perhaps enjoy the science centre visit. Now, they find themselves in position to compare the science centre visit with other leisure institutions. Furthermore, on comparing the scores in other dimensions, it appears that as a result of their visit to the science centre, junior students appear to gain affectively while senior students cognitively. This finding supports the view based on earlier findings that field trip should be organised in the early years of education.

Gender-based findings

In gender-based pre- and post-visit test comparison (Figure 9.2), although girls have gained in mean attitude score in all the attitude dimensions but none of these gain is statistically significant (Table 9.5). On the other hand, increase in boys mean attitude score is slightly better than girls and also found statistically significant in <u>self-perception of the field trip</u> dimension (Table 9.6). Increase in *composite attitude score* is also recorded statistically significant in case of boys and statistically insignificant in case of girls.

Table 9.5 t-Test - Comparison of pre- and post-visit Attitudes Towards Science Field Trip of female students (N = 75)

	Pre-Visit Test		Post-Visit Test			
Scale	M	SD	M	SD	t	ρ
Personalised Learning	4.04	0.697	4.19	0.596	1.63	0.107
Self-perception of the field trip	3.71	0.994	3.78	0.643	0.62	0.539
Field trip as learning tool	4.07	0.738	4.16	0.516	0.99	0.325
Uniqueness of the field trip	3.48	0.862	3.56	0.721	0.68	0.497
Composite attitude score	3.87	0.610	3.97	0.434	1.23	0.224

Table 9.6 t-Test - Comparison of pre- and post-visit Attitudes Towards Science Field Trip of male students (N = 93)

	Pre-Visit Test		Post-Visit Test			
Scale	M	SD	M	SD	t	ρ
Personalised Learning	4.05	0.694	4.19	0.670	1.69	0.095
Self-perception of the field trip	3.54	0.955	3.85	0.870	2.83	0.006
Field trip as learning tool	4.04	0.738	4.18	0.758	1.44	0.153
Uniqueness of the field trip	3.49	0.841	3.66	0.839	1.56	0.122
Composite attitude score	3.82	0.611	4.00	0.618	2.44	0.016

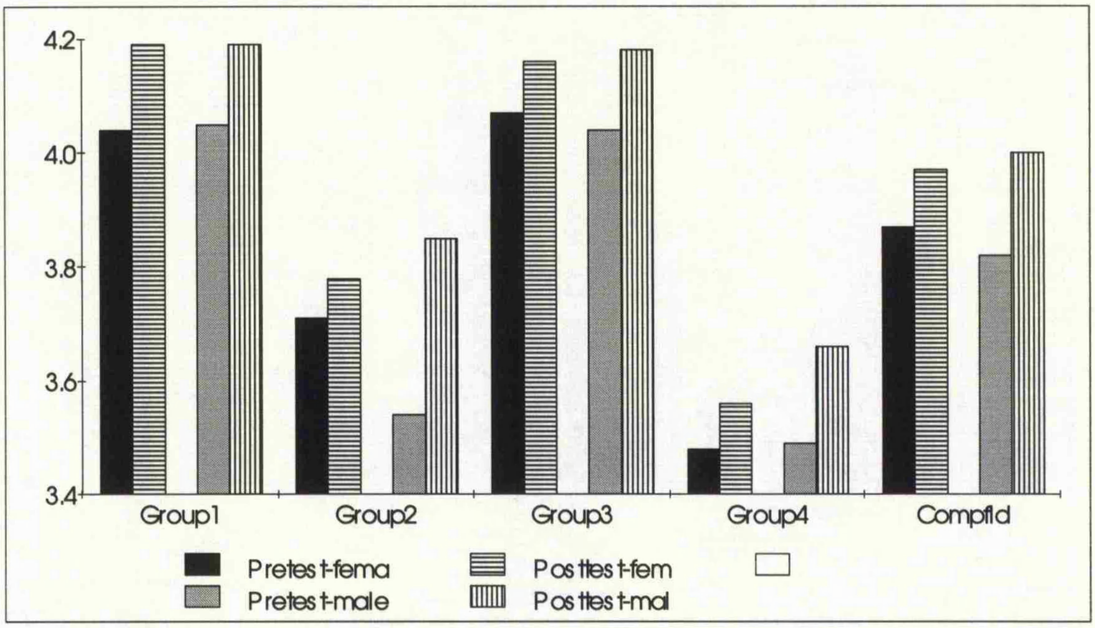

Figure 9.2 Graphical representation of changes in Mean Attitude toward Science Field Trip Score in pre and post visit tests for male and female students.

One conspicuous thing is that the mean attitude scores in the post-visit tests are similar for both boys and girls but the boys have gained in self-perception of the field trip and uniqueness of the field trip dimensions. In participant observation studies, boys have been found to be more actively involved with exhibits than girls. Naturally, they accumulate a rich variety of experiences. In post-visit test, the gain of boys can be attributed to the fact that now they were able to compare their science centre experiences with other out-of-school experiences.

Subject-based findings

In subject-based pre- and post-visit test comparison (Figure 9.3), significant gains are not found in any of the dimensions for students who do not like science (Table 9.7). However, the less number of participant in this case study is an apparent shortcoming. For students interested in biology, there is found an increase in all attitude dimensions but the increase is significant in personalised learning and uniqueness of field trip dimensions (Table 9.8). As a result of their visitation, these students have also gained significantly in their *composite attitude score*. Again, for science stream students, increase in mean attitude score is recorded in all attitude dimension. However, the gain is not found significant in any dimensions including *composite attitude score*.

Table 9.7 t-Test - Comparison of pre- and post-visit Attitudes Towards Field Trip of students who do not like science (N = 4)

	Pre-Visit Test		Post-Visit Test			
Scale	**M**	**SD**	**M**	**SD**	**t**	**ρ**
Personalised Learning	3.53	0.513	3.50	0.644	0.08	0.940
Self-perception of the field trip	3.17	0.430	3.33	0.609	1.00	0.391
Field trip as learning tool	3.42	0.319	3.76	0.491	0.77	0.495
Uniqueness of the field trip	3.50	0.694	3.83	0.192	0.77	0.495

Table 9.8 t-Test - Comparison of pre- and post-visit Attitudes Towards Field Trip of students who have special interest in biology stream (N = 65)

	Pre-Visit Test		Post-Visit Test			
Scale	**M**	**SD**	**M**	**SD**	**t**	**ρ**
Personalised Learning	4.13	0.499	4.29	0.421	2.52	0.014
Self-perception of the field trip	3.74	0.772	3.92	0.621	1.76	0.083
Field trip as learning tool	4.17	0.497	4.26	0.501	1.20	0.235
Uniqueness of the field trip	3.47	0.709	3.67	0.561	2.01	0.049
Composite attitude score	3.92	0.393	4.08	0.337	2.92	0.005

Table 9.9 t-Test - Comparison of pre- and post-visit Attitudes Towards Field Trip of students who like science (N = 99)

	Pre-Visit Test		Post-Visit Test			
Scale	**M**	**SD**	**M**	**SD**	**t**	**ρ**
Personalised Learning	4.01	0.795	4.15	0.730	1.48	0.142
Self-perception of the field trip	3.55	1.094	3.77	0.862	1.83	0.071
Field trip as learning tool	4.00	0.854	4.14	0.744	1.30	0.197
Uniqueness of the field trip	3.50	0.938	3.57	0.919	0.61	0.545
Composite attitude score	3.81	0.720	3.95	0.641	1.62	0.108

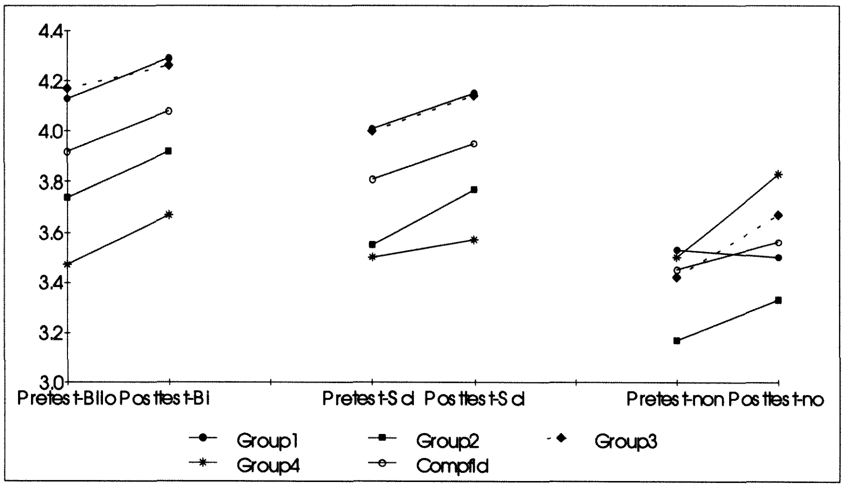

Figure 9.3. Graphical representation of changes in Mean Attitude to Field Trip Score in pre and post visit tests for biology students, science students and those who do not like science.

In a physical science dominated environment, a significant gain in personalised learning and *composite attitude score* dimensions of biology group students is really noteworthy. It is usually observed that biology group students do not like physics and mathematics. But in Indian science education system, one has to study physics almost compulsory up to senior secondary level. Here, it seems that these students really appreciated some of the concepts, principles or processes of physics which were perhaps incomprehensible for them before the visit.

Part II

Long-Term effects of a Science Centre Visit on Attitudes toward Science Field Trips

9.4 Long-term objectives and effects

Several survey studies made on demographic aspects of visitors in museums reveal the dominance of two age groups: 3 to 11 years (children) and 26 to 35 years (parents). Surprisingly, we do not find children with their grandparents in museums, but we see them enjoying in community parks. This may be due to the speculation that most of today's grandparents had formulated in their childhood negative image of museums, as mainly adult-oriented serious experiences, and they had never been to museums since then. There is evidence that since the beginning of the present century, at least, museum professionals has been aware of the problem. For example, E.E. Lowe, Curator of Leicester Museum, said:

> ...museums are misunderstood, and if we show the rising generation that the museum is interesting and instructive, a place of delight, then they will have a different feeling for us and our delights (Museums Journal, 1914: 288).

We also find a similar concern mentioned in the Board of Education Pamphlet *Museums and Schools* (1931) and again raised in the report of the Department of Education and Science:

> It might be suggested, in conclusion, that the word "museum" is perhaps in part responsible for the unsatisfactory state of affairs. Does it not suggest a depressing decaying institution, the last resting place of travellers' mementos and of fossils which have undeservedly survived from ages long

> ago? The existing prejudice is deeply rooted in the tough soil of our language and in the popular mind, but it would surely be overcome if a generation of our children were given systematic opportunities of enjoying the treasures of modern museums (Department of Education and Science, 1971: 49).

The absence of grandparents in todays museums patently tells that, in general, Curator Lowe at that time could not show the rising generation that the museum was a place of delight. But, we do not want to fail now. We want to build among the young people positive and long-lasting attitudes toward science museums and centres and we want them to come again, and also with their grandchildren. This is what is the objective of the present investigation. The aim of this section is to find out the long-term impact of a science centre visit on various dimensional groups of attitude to science centre visit.

9.5 Participants and data collection

This investigation took place within a large school system in Delhi. Thirteen schools from the system's more than 500 government schools were selected and invited to participate. The sample represented a geographically vast area on the Delhi State map.

In this part of the study, in order to compare the impact of the science centre visit, it was decided to collect data from different groups of participants (unlike the previous section where the same students took the pre- and post-visit tests). This method is known as 'between-subjects' design and the sample, as 'unrelated sample'. All 275 students (out of which 168 students visited the science centre and have been included in the first part of the study) forms the pre-visit sample (Time1). All 227 students (out of which 168 students took the pre-visit test and have been included in the first part of the study) constitutes the post-visit sample (Time 2). The post-visit test was conducted within three days after the visit. In the later-visit sample (Time 3), 225 students from five schools are included who visited the science centre five to six months ago (that is, during December 1993 and the first week of January 1994).

Detail of the Sample

	Female	Male	Junior	Senior
Time1	110	165	177	98
Time2	94	133	144	83
Time3	128	97	178	47

9.6 Analysis of Variance (ANOVA): purpose of the procedure and statistics

The Analysis of Variance is used to test for significance between the means of separate groups. Unlike the t-test, the ANOVA is performed for more than two groups of respondents. For example, in the present study, there are three groups of students:

Time1	Pre-visit Group (N=275)	Data collected before the visit.
Time2	Post-visit Group (N=227)	Data collected after the visit.
TIme3	Later-visit Group (N= 225)	Data collected five months after the visit.

From the collected data, it may be suspected that the average attitude of school students is greater after the visit than it was before the visit. On comparing observations, we may find that the average attitude score is indeed higher by a few units. The objection immediately arises that this difference may be true for small sample, but may not represent to the whole population of school students. At this stage, the analysis of variance comes to our rescue. The ANOVA is used to obtain a statement of likelihood of making a mistake in our assessment.

There are two different analysis of variance procedures: One Way ANOVA and Simple Factorial ANOVA. One way analysis is used when only one variable is used to classify subjects into the different groups. Subjects are assigned to groups, for example, on the basis of sex. The Simple Factorial ANOVA procedure is used when two or more variables are used to form groups. For, example, respondents can be divided into groups on the basis of three independent variables (IV), such as sex, time and grade. The basic idea of the factorial ANOVA is to determine whether there is an effect of various independent variables such as IV1, IV2, IV3....etc. and whether there are significant interactions between these independent variables. In the present study, both One Way ANOVA and Simple Factorial ANOVA procedures have been employed to analyse the results.

9.7 Presentation of ANOVA Results

Effect of Time (One-Way Design)

While the mean attitude score of the post-test is increased in all attitude dimensions, it is found to be declined in the later-test in personalised learning (F=4.5; Fprob. =0.05), self-perception of the field trip (F=15.5; Fprob.=0.001), and field trip as learning tool dimensions (F=1.6; Fprob.=NS). According to Scheffe multiple range test, the decrease in post- and later-test is found significant, at 0.05 level, in personalised learning and self-perception of the field trip dimensions. On the contrary, the mean attitude score of uniqueness of the field trip dimension is recorded increased in the later-test but not statistically significantly (F=2.4; F prob. = NS) (Table 9.10; Table 9.12; Figure 9.4).

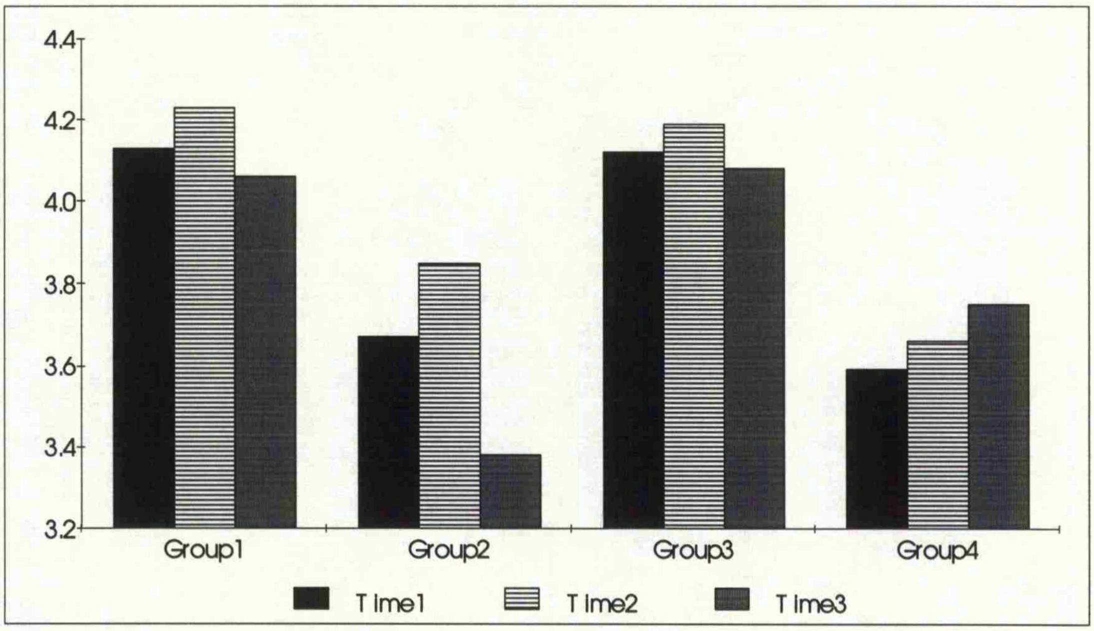

Figure 9.4 Graphical representation of changes in Mean Attitude to Field Trip Score in pre-, post- and later-visit tests.

The composite attitude score is found to be increased in the post-test and decreased in the later-test ((F=5.5; F prob. =0.005). According to Scheffe multiple range test, the composite attitude scores between post- and later-test is found to be decreased significantly at 0.05 level.

Gender and Time interaction (Two-Way Design)

For both boys and girls the mean attitude score is found to be reduced in the later-test in personalised learning (F=1.77; Fprob.= NS) and self-perception of the field trip (F=4.36; Fprob.= 0.01) dimensions, but the decrease is more steep in the case of girls, notably in self-perception of the field trip dimension (Figure 9.5.1; Table 9.12).

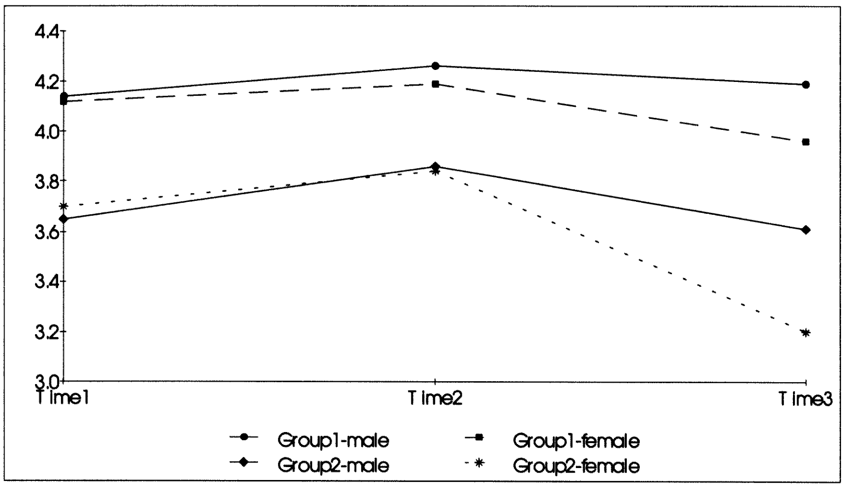

Figure 9.5.1 Graphical representation of changes in Mean Attitude to Field Trip Score in pre-, post-, and later- visit tests for male and female students.

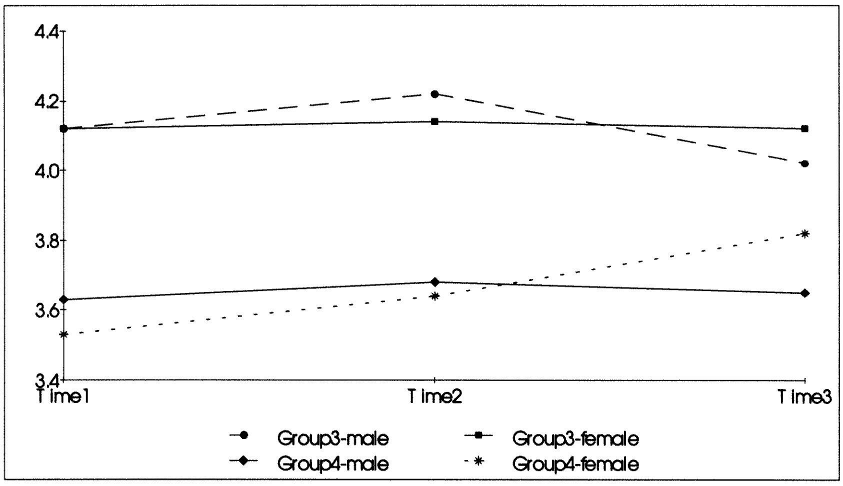

Figure 9.5.2 Graphical representation of changes in Mean Attitude to Field Trip Score in pre-, post- and later- visit tests for male and female students.

In field trip as learning tool dimension, girls' curve is horizontal throughout and boys mean attitude score is increased in the post-test and decreased in the later-test (F=1.06; Fprob.= NS). In uniqueness of the field trip dimension, boys' mean attitude score remain the same throughout, and on the contrary girls' score is recorded increased in post-as well as later-test (F=1.97; Fprob.= NS) (Figure 9.5.2; Table 9.12).

Grade and Time Interaction (Two-Way Design)

For both senior and junior students, the mean attitude score is found reduced in the later-test in personalised learning dimension (F=1.21; Fprob.= NS). In self-perception of the field trip dimension, both junior as well as senior students gain in the post-test and lose in the later-test, but the declining curve is more steep in case of junior students (F=1.06; Fprob.= NS) (Figure 9.6.1; Table 17).

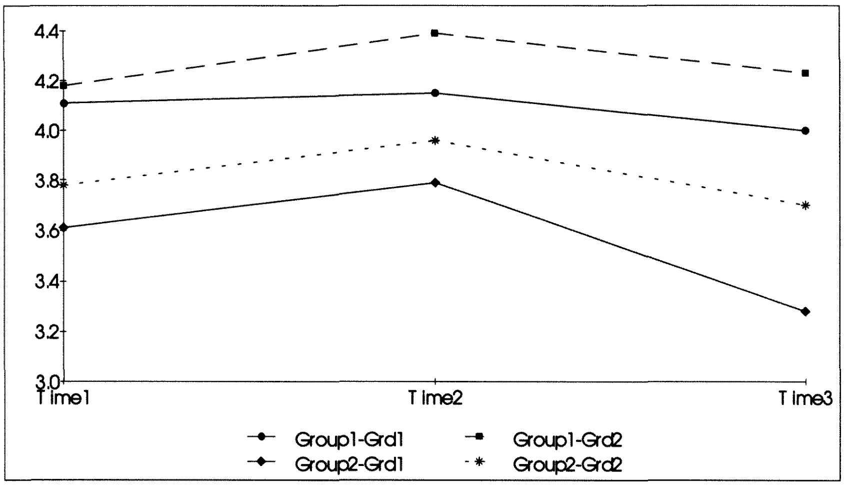

Figure 9.6.1 Graphical representation of changes in Mean Attitude to Field Trip Score in pre-, post-, and later-visit tests for secondary (Grade1) and senior secondary students (Grade2).

In field trip as learning tool dimension, the trend is same for junior and senior student, as they gain insignificantly in the post-test and lose in the later-test (F=0.012; Fprob.= NS). In uniqueness of the field trip dimension, the trend is surprising. While in post-test, the mean attitude score of junior students decreases and of senior students increases, the opposite is observed in the later-test (F=3.32; Fprob.= 0.05). In the later-test, while the mean score of senior students decreases, it increases significantly for junior students (Figure 9.6.2; Table 9.12).

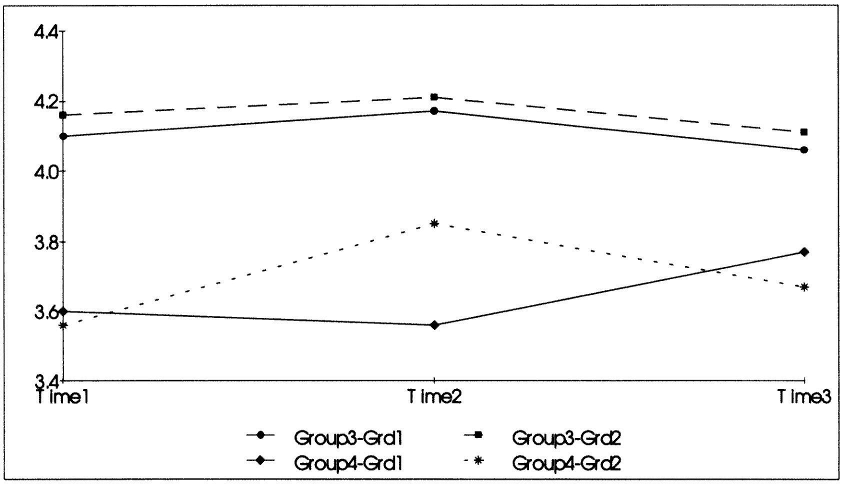

Figure 9.6.2 Graphical representation of changes in Mean Attitude to Field Trip Score in pre-, post-, and later- visit tests for secondary (Grade1) and senior secondary students (Grade2).

Table 9.10 Analysis of variance of major variables.(Two-way Design)

Subscale	Personalised learning		Self-perception of the field trip		Field trip as a learning tool		Uniqueness of the field trip	
Source of Variation	**F Ratio**	**F Prob.**	**F Ratio**	**F Prob**	**F Ratio**	**F Prob**	**F Ratio**	**F Prob**
Time (One-way design)	4.5	0.01	15.5	0.001	1.6	NS	2.4	NS
Time * Grade (Two-way Design)	1.21	0.276	1.06	0.345	0.012	0.988	3.316	0.037
Time * Sex (Two-way Design)	1.77	0.17	4.36	0.01	1.06	0.35	1.97	0.141

Table 9.11 Analysis of variance of major variables (Three-way Design)

Subscale	Personalised learning		Self-perception of the field trip		Field trip as a learning tool		Uniqueness of the field trip		Composite attitude score	
Source of Variation	**F Ratio**	**F Prob.**	**F Ratio**	**F Prob**	**F Ratio**	**F Prob**	**F Ratio**	**F Prob**	**F Ratio**	**F Prob**
Time	3.86	0.21	13.514	0.001	1.6	0.203	2.655	0.532	4.790	0.009
Grade	14.29	0.001	15.103	0.001	1.392	0.238	0.391	0.071	10.232	0.001
Sex	3.274	0.071	2.160	0.142	0.057	0.811	0.008	0.931	1.016	0.374
Time * Grade	1.26	.283	0.372	0.689	0.189	0.828	2.581	0.71	0.690	0.502
Time * Sex	0.063	.939	1.393	0.249	1.981	0.139	1.819	0.163	0.267	0.766
Grade * Sex	15.868	0.001	4.091	0.043	0.557	0.456	0.320	0.572	7.024	0.008
Time * Grade * Sex	0.843	0.431	1.6	0.203	0.302	0.739	0.757	0.469	0.461	0.631

Table 9.12. Summary of variation of attitude mean score for various populations

Subscale	Personalised learning		Self-perception of the field trip		Field trip as a learning tool		Uniqueness of the field trip		Composite attitude score	
Source of Variation	**Mean**	**Sign. level**	**Mean**	**Sign. level**	**Mean**	**Sign. level**	**Mean**	**Sign. level**	**Mean**	**Sign. level**
Time1	4.13		3.67		4.12		3.59		3.92	
Time2	4.23	0.01	3.85	0.001	4.19	NS	3.66	NS	4.03	NS
Time3	4.06		3.38		4.08		3.75		3.85	
Time1 - Female	4.12		3.70		4.12		3.53		3.91	
Time1 - Male	4.14		3.65		4.12		3.63		3.92	
Time2 - Female	4.19	NS	3.84	0.01	4.14	NS	3.64	NS	3.99	NS
TIme2 - Male	4.26		3.86		4.22		3.68		4.05	
Time3 - Female	3.96		3.20		4.12		3.82		3.82	
Time3 - Male	4.19		3.61		4.02		3.65		3.89	
Time1 - Grade1	4.11		3.61		4.10		3.60		3.93	
Time1 - Grade2	4.18		3.78		4.16		3.56		3.90	
Time2 - Grade1	4.15		3.79		4.17		3.56		4.01	
Time2 - Grade2	4.39	NS	3.96	NS	4.21	NS	3.85	0.05	4.11	NS
Time3 - Grade1	4.00		3.28		4.06		3.77		3.89	
Time3 - Grade2	4.23		3.70		4.11		3.67		3.90	

9.8 Discussion and conclusion

In some of the cases, the mean attitude score in the later-test has been found to be lower than that of the pre-visit test, which is really difficult to explain. This may be due to the different constitution of samples, for example more junior student in the sample than senior students. Hence, the direction of change should be much more useful for us here than the magnitude.

The 'fading away' effect (a decrease in attitude over time) of the field trip is evident from the results. The increase in uniqueness of the field trip dimension presents some hope. It would be difficult to draw some concrete conclusions from the increase, but it can be said that students, specially girls and junior students, remember their visit as an event. The finding here suggests that even after five months students recall and appreciate the facts like whom they were with, whom they were talking to, how they reached the science centre and how they were moving amid exhibits in the galleries.

The fading away effects are noticeable, more prominently in case of girls and junior students, in dimensions which form cognitive core of our attitude construct (Figure 8.1). Cognitively, the echo of field trips in the classrooms cannot be predicted with these results. On the contrary, the results suggests that neither teachers nor students make connections between their classroom lessons and science centre exhibits. Obviously, there is an increasing need to take seriously the advise of Aldo Leopold to extract the fullest benefit of a field trip.

Summary of the findings

Virtually, there is found no significant difference in different groups of students' attitudes to field trip, for example, girls versus boys and junior versus senior, in the pre-visit test. Though, female students and senior students have slightly better attitudes than male students and junior students respectively. The findings, however, suggest that junior students, in general, have a dull and passive image of a field trip, so they tend to under-estimate field trips in comparison with other popular leisure institutions.

All students appear to gain in attitudes toward science centre as a result of their visit, but immediate gains in attitudes are found to be more prominent for males, seniors and biology-stream students (Table 9.13).

Table 9.13 t-Test - Comparison of Pre - Post Composite Attitude Towards Science Field Trip

	Pre	test	Post	test		
Category	**M**	**SD**	**M**	**SD**	**t**	**ρ**
Female Students (75)	3.87	0.610	3.97	0.434	1.23	0.224
Male Students (93)	3.82	0.611	4.00	0.618	2.44	0.016
Junior Students (108)	3.80	0.588	3.93	0.605	1.67	0.098
Senior Students (60)	3.93	0.614	4.11	0.385	2.70	0.001
Life Science Stream (65)	3.92	0.393	4.08	0.337	2.92	0.005
Physical Science Stream (99)	3.81	0.720	3.95	0.641	1.62	0.108

As a result of their visitation, junior students appears to gain in affective terms while senior students, in cognitive. The analysis of responses in self-perception of the field trip indicates that more junior students join the undecided category. But, as a result of their experience comparatively more students tend to place the science centre before a cinema or a visit to Appu Ghar in their list of preference.

The fading away effects with time are noticeable in all the cases, but more prominently in case of girls and junior students. Both, female as well as junior students build their attitudes in uniqueness of the field trip dimension.

In long-terms, male and senior students appear to gain cognitively. But, junior and girls students appear to have gained long lasting effects in affective terms.

The finding suggests that field trips should be organised in the early years of elementary education; for cognitive goals, more efforts are required on the part of teachers in the classrooms; and for more impact, there should be organised more than one visit in the same academic year.

Chapter10

Construction of 'Continuing Motivation in Science' Scale for Organised School Groups in Science Centres

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10.1 Introduction

In our early and formative years, learning seems to remain almost everywhere - at homes, in schools, and in outdoor visits - at the helm of affairs. But, in our later years, most educators and parents somehow develop over-rationalised and over-intellectualised, and yet the over-simplified view of the learning process. As a result, in their early years, most children get the message that 'learning is a passive process, something that someone else (parents or teachers) does to them, instead of something they do for themselves'. They are taught that only explicit, certain, examinable knowledge is worth having: 'to be wrong, uncertain, confused is a crime' (Holt, 1971: 24-25). The process of learning is considered over-simplified as most of the learning theories (such as Stimulus-Response, Hull-Spence, Tolman's Expectancy and cognitive learning theories) readily assume that the learner is always willing to be involved in it. But, in practice, the matter is not so straightforward.

> This homework is driving me up a wall - I am just sick of it. It is boring and useless and I wish I could do something else - anything else! I hate homework, especially when my sister doesn't have any (A fourteen year old female, quoted in Csikezentmihalyi and Larson, 1984: 101).

Clearly, the above quote is a problem which all of us experience at one time or another. Learning is largely understood to be concerned with intellect. The role of play, curiosity, noise, excitement and confidence in the learning process is often down-graded. But, in reality, learning to occur involves the personality as a whole - that is, the senses, the desire, the longing, the feeling and the motivation as well (Csikszentmihalyi, 1988).

Not everybody feels comfortable in schools. The general estimate is that 27 per cent of students do not adjust to traditional schools (Hodgkinson, 1985). The figure could even be higher in the Indian context, as can be reckoned from the incredibly high school drop-out rate. The "early school leavers" are understood to have low motivation. As a remedial measure, many researchers have called upon to raise the academic standards of schools. Walberg and other researchers (Walberg, 1984, 1986, 1989; Fraser *et al.*, 1978) analysed large scale U.S. and international educational surveys and suggested five factors necessary for enhancing educational standards in schools. These included ability or prior achievement, development (indexed by the stage of maturation), quantity and quality of instruction, and motivation. Without at least a small amount of each, they argued, students can learn little. Large amount of relevant instruction, for example, may count for little if students are not motivated. In his study, Caprio (1993) also described the importance of the psychological factors of motivation in learning at the community college level. In the similar vein, Woolnough strongly advocated the value of motivation in the learning process in the following words:

> No matter how good our curriculum, how cognitively correct our teaching methods, unless we are able to motivate our students to enthuse about their science and make a commitment in it, we will have given them little of lasting importance (Woolnough, 1994: 25).

A large and growing body of research on the effects of in-school and out-of-school science related activities is evolving, but it focuses mainly on the cognitive gain as a desired educational outcome. Researchers attempt to assess teachers', parents', and students' discourses and activities as objective indicators of a learning environment. While it is not proper to argue against the primacy of knowledge gain as a criterion in research on the effects of learning and teaching environments, the importance of considering 'motivation' as an equally desirable educational outcome cannot be over-emphasised. Despite its potential significance, surprisingly little research has been attempted, in both classroom and out-of-school contexts, on factors that may foster or inhibit motivation.

The analysis of motivation is a challenging task because: first, the concept of motivation is not a well defined, static entity. On the contrary, at least since last forty years within each decade, the concept of motivation has been changing radically (Table 10.1); second, motivation, unlike behaviour, cannot be observed directly; third, people, often, remain unaware of their own motivations; fourth, as motivation is a multifaceted concept there is no standard technique or method for measuring it. For example, while on the one hand, 'changes in attitude', 'beliefs' and 'performance' are considered as indicators of motivation, on the other hand, motivation is said to be a function of 'contextual/environmental factors' and 'pubertal changes'. All these factors, combined with our over-simplified view of learning, discourage researchers from making an ambitious plan to explore the field of motivation.

However, in the past decade, concern with the quality of education in today's schools has impelled educational researchers to look into the role of motivation in students' achievement. As a result, there can now be seen convincing evidence that researchers are increasingly overcoming inhibitions and accepting motivation as an important educational outcome in classrooms. In 1980, American Educational Research Group founded the Motivation in Education Special Interest Group. In parallel developments, R. Ames and C. Ames (1984, 1985 and 1989) edited a three volume set on motivation in education. For the first time in nearly 20 years, *Nebraksa Symposium* volume in 1990 was exclusively devoted to motivation. In the USA, Christopher Cross, Assistant Secretary for Educational Research and Improvement, outlined four priorities for educational researchers: assessment, collaboration, dissemination, and motivation. As a matter of policy, motivation was targeted as a priority research area.

> Because motivation is a multifaceted issue touching many dimensions of education, we want each center to address it. We want more scholars - both inside and outside the federal education research system - to explore it (Cross, 1990).

The future for motivational research in the context of classroom looks promising, but it hardly appears so in the context of museums. It appears that museum evaluators still have to overcome their inhibitions about motivational processes.

It is commonly believed that one can really do little in the learning process except create a stimulating and favourable environment, and provide individuals opportunities for interaction and involvement. Such impressions are much more germane for an informal learning environment such as science centres. The most common objective why teachers bring their pupils (and parents their children) to a science centre, explicitly and implicitly, concerns motivation. In these circumstances, it becomes mandatory to look into the motivational patterns in hands-on science centre environments.

In the present chapter, I shall first review the literature to know more about how the concept of motivation has been changing in the present century. Next, I shall define the theoretical motivational construct. In the third stage, I shall develop a valid and reliable scale to measure the impact on students motivation as a result of their science centre visit. And in the following chapter, the scale will be employed and subsequenly results will be presented.

10.2 Review of motivation literature

Motivation is an abstract and 'cast-iron' concept. Just as some piece of cast iron can be moulded into different shapes, motivation has been, and can be, used differently in different contexts or situations by psychologists, managers, educators and other researchers. In schools, teachers speak of motivation in a way that assumes that it is something students either have or do not have, and some have more than others.

A somewhat related notion is that motivation can be increased by positive exhortation from a powerful leader. In ancient times, Kings used to motivate their soldiers just before the fight by addressing them in battle-fields. One of the finest examples of motivation to this effect in the world history is the inspirational speech of Alexander the Great (356-323 BC), King of Macedonia and conquerer of the large Persian empire. He addressed to his soldiers when they refused to adventure farther in India after facing a ferocious fight with King Porus in the far North-West region near the river Jhelum. The words of Alexander injected among the soldiers the needed spirit and prepared them to march forward. Usually, the athletic coaches motivate players just before the match to fight against their rival team using all their might and skills.

In the past, some biologists and physiologists, for example William James (1842-1910), William McDougall (1871-1938), Sigmund Freud (1865-1939), designated the survival activities - such as hunger, thirst and sex - as motivations. Most of these early theories assumed that people were motivated by drives to meet basic biological needs. In these theories, the primary source of motivation was personal and keyed to the idea of satisfying needs related to one's self image.

Immediately after World War II, an increasingly attention was paid to the contribution of human resources to an organisation's success. The motivational theories in management were, and are being, applied in attempts to instilling into workers a consciousness of the identity of their interest with those of their employers. The achievement motivation has proved a potentially useful tool for improving economic conditions in underdeveloped countries or even in specific ethnic groups. For example, McClelland and Winter (1971) trained businessmen in Hyderabad, India, to think, talk, and act like people high in need for achievement. After the training in the follow-up period, the trained business were found more active than those untrained ones. The trained business had invested, it was found, more money and also had employed over twice as many new employees during the follow up period than had untrained group. A strategic approach to motivational policies in organisational context begins with effort, proceeds through performance, and culminates in reward to the individual employee.

The success of achievement training in industry became a model to follow for educationists. During the early 1960s, achievement motivation was used synonymously to refer to motivation. The feedback-loop analogy of biological needs for food and water was employed widely to describe a variety of personal and social needs such as the needs for achievement, affiliation, wealth or power. Still in classrooms, motivation is largely conceived as a measure of inferred mediating variables such as achievement, self-esteem, self-efficacy and so forth.

More current research on motivation has produced a new concept of what would be called a "higher" self, already actualised self as a source of intrinsic motivation. This higher self has been described as being the formulator and director of thinking, of consciousness. In this paradigm, the self has nothing to do with external situations, circumstances, or personality. This self is more fundamental than what is thought of as personality and the self concept (Mills, 1991).

It is patently clear from the above discussion that the concept of 'motivation' has been constructed differently, but purposefully, based on the expertise and needs of various subject-domains. In other words, the notion of motivation has a greatly varied applicability. The theories which define laws of motivation include the biological theories, the psychoanalytical theories, the humanist theories, stimulus-response theories, optimal level theories, social learning theories, field theories, the theory of achievement motivation, cognitive-consistency theories and theories of causal attribution. A review of issues in motivation dealt in these theories will certainly be enlightening in our construct of motivation concept. Basically, there can be found four issues on which most theories of motivation vary.

10.2.1 Innate or learned origins

The first issue is about the origin of motivation. Most theories of human behaviour, whether psychoanalytic, humanistic, behavioural, or cognitive, deal with the issue of why we behave as we do. Each theory tends to align itself towards one side or the other of the perennial nature/nurture controversy, holding motivated behaviours to be either primarily innate or primarily learned.

The earliest theorists - William James (1842-1910), R. S. Woodworth (1869-1962), William McDougall (!871-1938), Sigmund Freud (1865-1939) and Clark Hull (1884-1952) - thought that motivation is innate; that it is an inherited characteristic of the species. Genetically motivated behaviours have been often analysed under the topic of 'instinct'. An instinct can be regarded as a genetically programmed bit of behaviour that occurs in appropriate circumstances and requires no conscious effort to learn the behaviour. McDougall was the one who believed that instincts were the unobservable motivational forces responsible for much of human behaviour. For example, an offensive behaviour of a person was to be explained in terms of aggressive instinct. He suggested gregariousness, pugnacity, acquisition, construction and reproduction as some of the most important human instincts. The use of instincts to explain behaviour soon mushroomed to a ridiculous degree. By 1924, over 14,000 instincts were used to explain virtually all possible behaviour (Atkinson, 1964: 7).

The early instinct theories were vague in that they had basically lebelled the observed behaviour rather than of understanding conditions what led to the behaviour. The demise of the instinct concept has left a conceptual vacuum that was neatly filled by the concept of 'drive'. The concept of drive was not a large departure from the instinct theory. Both theories were thought to be biological based. The concept of drive assumed that the motivation of behaviour depends on some readily identifiable physiological needs such as hunger. From a drive perspective, the feelings of "being hungry" could now be regarded as the hunger drive rather that of a food-seeking instinct.

Psychoanalytic (Freudian) theory conceived of individuals as caught in a never ending conflict between instinctual drives on the one hand, and the restraints demanded by the social world and by internalised ideals, on the other. Both Freud and Hull postulated that all human behaviour can be explained using a few innate drives. According to them, the whole range of human activities - for example skiing, paper shuffling, trigger pulling and attending music concert - could be reduced to a few primary drives.

Hull's early theory (1943) was primarily based on the idea of motivation as an internal expression of behaviour. By 1952, having realised the importance of goal on the performance of behaviour he introduced the concept of incentive motivation. While drives were tied to needs, incentives were to be learned.

Later motivation theorists became far more restrictive in the topics to be dealt with in the domain of motivation. For example, survival activities such as hunger or a sexual urge were removed from the jurisdiction of motivation. Social learning theories emphasised that the basis of motivation - the acquisition and processing of expectancies, reward values, vicarious experiences, and the like - is to be learned. The more recent cognitive theories deal with motivation in very circumscribed situations as they posit only one source of motivation - a non-biological one, such as a motive to achieve or a motive to be consistent.

The newly emerging concepts - such as the higher self, will, or reflective self-awareness - of motivation are looking at the problem from different perspective and suggest the primacy of nature role. According to these theories, motivation need not to be developed or instilled in humans nor supplied them - as if people are somehow deficient; rather the potential is already in place and need only be accessed and allowed expression.

10.2.2 Mechanistic or cognitive processes

The second issue pertains to the process of motivation: how does a person become suddenly interested and involved in some task or how does a behaviour become motivated? Here again, different theories offer different explanations. Some theories (like drive theories) emphasise a quasi-physiological mechanism - for example, the reduction of tension; others (cognitive consistency theory and attribution theory) give a more prominent role to thinking and cognition. In other words, people are thought to behave in a particular way either because of some internal mechanism is operating or because they want to.

Sigmund Freud was one of the first theorists to use the concept of *psychic energy,* which he never clearly defined, in his explanation of motivation. Sometimes he used the concept of psychic energy as an excitation of the nervous system and at the other times he likened it to a hydraulic system of storage or flow of energy. According to him, psychic energy builds up when "some" need exists. Particular need (for example the need to maintain proper blood sugar level) is satisfied by the channelling of psychic energy into behaviours (such as eating an orange) that reduce the need.

Woodworth first coined the term "drive" because he believed that all needs do not lead to behaviour. He suggested different drives for different motive state. Woodworth's development of the drive concept led to the behavioural theory of Clark Hull. Hull conceived drive as a general pool of energy that can activate either instinctive or learned behaviour.

While drive theory is classified as entirely mechanistic, attribution and humanistic theories are considered as cognitive. But, most theories contain both mechanistic and cognitive concepts. For example, psychoanalytic theory includes assumptions about energy, energy distribution and also conscious and unconscious thought processes. The role of cognition in motivation is restricted to unconscious, drive-related processes. Only those thoughts are considered to have motivational properties which possess some association with instinctual drives. Thus, conscious, drive-free thinking is considered as non-significant in motivation.

Optimal level, social learning, field, and achievement theories are all quasi-cognitive. These theories postulate that the individual uses cognition in selecting behaviour - for example, when evaluating his or her probability of succeeding on a particular task.

The early work of James (ideo-motor action: 1890), Tolman (purposiveness of behaviour; 1932) and Lewin (dynamic nature of behaviour due to cognitive motives; 1938) laid the ground work for the modern cognitive theories of motivation. Behaviouristic and humanistic psychologists appear less willing to accept the existence of unseen and unmeasurable processes. The humanistic theorists, specially Rogers and Maslow (1950-60), attribute a large role for conscious cognition but do not elaborate on the processes.

Cognitive consistency theory and attribution theory are the most cognitive oriented formulations. Cognitive consistency theories assume that the inconsistencies between attitudes, beliefs and behaviour lead to a state of tension that generates a motivation to reduce or eliminate the inconsistency. In essence, cognitive theorists increasingly believe that we are thinking, rational and decision making organisms. But, our judgements are largely context dependent. The presence of others may greatly influence our judgements.

10.2.3 The role of individual differences

The third issue deals with individual differences in motivation. Some theories are concerned about the differences in motivation that exist from person to person. They seek to classify people by personality, ability and so forth, as these groupings are related to motivation. Other theories do not attempt to distinguish between differing patterns of motivated behaviour.

In social learning theory and field theory, individual differences are purported to play a major role in the motivation of behaviour, but the theories provide no means of measuring and assessing the differences.

In Freudian, humanistic, and achievement theories, the motivational consequences of various types of personalities are specified to some degree. For example, according to Carl Rogers, an individual strives constantly for enhancement and growth. Similarly, Abraham Maslow proposes that certain deficiency needs first be met before an individual can become all that it is capable of becoming. While not stated explicitly, these theories seem to imply that the fully functioning person is both competent and in control of his or her world.

In cognitive consistency theory and attribution theory, research indicates that personality variables, such as self-esteem, can influence the selection of behaviour. In humans, then the need to be competent, self determining, in control, fully functioning and self actualising is apparently an importation of behaviour. While the terminology differs from theorist to theorist, the basic commonality is that people need to believe that they have an effect on the world around them.

10.2.4 The role of non-motivational causes

The fourth issue is whether all behaviour is motivated. Is all behaviour purposive? Is all behaviour caused by the person? What role does the environment play? Again, the theories differ in the extent to which they take such non-motivational factors into account.

In general, the theorists whose motivational constructs are instinctual tend to minimise the role of other causes. For them, causes, such as happenings in the environment, are accidental. The humanist theorists have a similar view.

The humanist researchers described the persistent motive within individuals to become competent in dealing with the environment. Rogers describes this motive state as an attempt to grow and reach fulfilment. According to him, fully functioning individuals are open to experience. Maslow described the process as a movement towards self-actualization, an attempt to become all that one can possibly become. For Maslow, the environment is merely a source for the satisfaction or thwarting of the basic needs.

At the other extreme, field theory and attribution theory are quite cognizant of the environment. According to cognitive theorists, thinking can not take place in vacuum. In fact, one constantly need inputs from ones physical world. While for most cognitive scientists the modest prediction of actual adult accomplishments from early childhood experiences is strongly suggestive, for some it is nearly definitive.

Table 10.1 Review of research in motivational aspects.

Time	Prominent psychologists and authors	Author (concept)	Theories	Prominent elements	Remarks
1890-1930	James, W. McDougall, W. Kuo, Z.Y. (1921) Tolman, E.C. (1923)	James (instinct) James (ideo-motor action) McDougall (instinct) Kuo (criticised instinct) Tolman (criticised instinct)	Instinct theories	Taxonomies of instincts Basic need states	For James, instinct is basically reflexive. For McDougall, instinct is more than just disposition to react in a particular way. (Instinct = cognitive+affective+conative) For Freud, instinct uses psychic energy to satisfy some need (instinct=pressure+aim+objective +source)
1930-1950	Freud, S. Hull, C. Spence, K. Tolman, E.C. Young, P. Kurt, L.	Freud (psychic energy and need) Tolman (Purposive behaviour; 1932)	Psychoanalytical theory (important for its generative aspect) Lewin's Force Field theory	Dynamics of sub-human behaviour	Human behaviour was considered too complex to examine. Motivation examined the use, but not development, of knowledge.

Table 10.1......continue (Review of research in motivational aspects)

Time	Prominent psychologists and authors	Author (concept)	Theories	Prominent elements	Remarks
1930-1950	Woodworth, R.S. Hull, C. Spence, K.	Woodworth (Drive) Spence (incentive)	Drive theories (Drive theory is important in making apparent that a single theory may not explain all motivated behaviour)	Drive, habit, drive reduction	For Woodworth, drive is necessary for all behaviour to occur (Drive=intensity +direction + persistence) For Hull, derive is singular and non-specifit to which several different motivating conditions can contribute.
1950-1960	Tolman, E.C. Klinger, E.	Tolman and Klinger (cognitive expectations and meaningfulness of incentives)	Drive theory (In 1951 & 52, Hull included incentive in his drive theory) Achievement theory	Relation to learning, incentive, inhibition and frustration	Reduce internal stimulation (drive stimuli)

Table 10.1......continue (Review of research in motivational aspects)

Time	Prominent psychologists and authors	Author (concept)	Theories	Prominent elements	Remarks
1960-1970	Atkinson, J.W. McClelland, D.C. Maslow, A. Roger, C. Hunt, J. Heider, F.	Maslow (self-actualisation) Rogers (growth motivation) Hunt (intrinsic motivation;1965)	Achievement theory Humanisitic Theory Cognitive theory	Relation to learning, perception and memory	Increase positive and decrease negative emotional states. Self enhance
1970-1980	Kelly, W. Deci, E. Maehr, M. Rotter, J.B. Bandura, A. (1977)	Deci (intrinsic motivation; 1975) Maher (continuing motivation; 1976) Bandura (self-efficacy; 1977))	Attribution Theory Social Learning theory	Locus of control, stability, and level of control Importance of perception of competence and control	Motivation became almost synonymous with achievement motivation. Shift from mechanism toward cognition (gain information). Satisfy need

Table 10.1......continue (Review of research in motivational aspects)

Time	Prominent psychologists and authors	Author (concept)	Theories	Prominent elements	Remarks
1980-1990	Ames, R. Covington, M.V. Nicholls, J.		Goal Theory	Achievement striving at the centre Individual differences and environmental determinents	Application of successful industrial experiments in classroom
1990-2000			Integrating theories and research	Integration of attributions such as: self-concept, self-reinforcement and competitive rewards	Total Quality Management in Classrooms

10.3 Motivation Construct

The word 'motivation' finds its origins in the Latin word, 'motivus'. Motivus means 'motion' or 'movement'. When applied to human beings, motivation connotes to what really 'makes us tick' and essentially it concerns our own accomplishments.

According to earlier theories such as instinct theories, motivation appears to have some generality in nature. In others words, it has some predictable patterns. For example, genetically endowed persons will naturally have more motivation than those who are genetically deprived of it. But cognitive theories label motivation highly specific and personal. Rennie (1990) demonstrated (in the classroom context) that students with similar engagement profiles had quite different levels of achievement and different types of motivation to learn. While some students were found to be motivated to learn with understanding because of an intrinsic drive, others were driven to succeed with minimum possible effort, and still others were motivated by a need to sustain their ego and self-concept. Evidently in specific situations, students engage themselves purposefully in tasks, find them meaningful and worthwhile, and try to get the intended benefit from them. So, it appears plausible to consider motivation having both generality and specificity.

Every human being is believed to have a distinctive motivational pattern. Cultural diversity that exists not only across but also within each society makes the distinction in motivational patterns more prominent. For some students the study of science in schools may largely be a matter of their preference, but it is also true that in a majority of cases their parents and wider society often have great influence. In India, most people motivate their sons to study science and often discourage girls doing the same. In an another example, the disparity of academic outcomes among various social and cultural groups indicates a serious problem. Minority, backward and low caste children all too often pass out from schools and colleges without being able to read, write or do simple mathematics. They have low motivation to learn. Instead of providing deprived children opportunities of improving their performance and building their self-esteem, the authorities have taken an ostensibly judicious step to provide equal opportunities to all - that is, to set criteria required for entry in careers low for these social groups (positive discrimination). Such cultural differential approaches pose a significant problem and create barriers for some members from participating effectively in the wider society.

Motivation can be both quantitative and qualitative. As a quantitative entity, motivation is equated with a conceptualisation of activity which involves energy and persistence. Often, teachers complain that some of their pupils lack motivation. Such statements imply that some of the students receive a small quantity of it when the rations were distributed. From a qualitative perspective, activity involves specific cognitive processes. For example, as described by Carno and Mandinach (1983), two students may be equally motivated to learn but may differ in how they think about themselves, how they think about the goal and how they think about the task.

Human motivation is hierarchical. Peterson (1992: 40) describes three levels of motivation in a motivation depth gauge. The three levels are: reaction level, incentive level, and deep level. While as a result of a certain activity the impact of motivation at reaction level may have short term effect, deep motivation might never cease for a given person. In formal educational settings, we mostly rely on extrinsic motivators, that is - the stick (punishment) and the carrot (reward). In general, the impact of extrinsic motivators are found of short term type. In an informal environment, one involves in an activity apparently not for something external but for everything arcane and internal. One does things because one is willing to. In such circumstances, the motivation has to be of intrinsic type.

For the purpose of the present study of motivation in science centre, I propose an 'oscillator model of motivation' (Figure10.1). In this model, motivation as a cultural concept is more qualitative than quantitative - that is, it is reflected in how students think (or made to think) about themselves, the task and their performance. It is very similar to what Berlyne (1960) calls curiosity (a kind of intrinsic motivation) and Hunt (1965) and Deci (1975) call 'intrinsic motivation'. From Hunt's perspective, motivation (inherent in the information processing of the organism) exists whenever an incongruity occurs between past experience and new experience. While a small amount of incongruity, such as novel situations, were thought to be attractive and encouraging, large incongruities could lead to withdrawal from the situation. According to Deci, intrinsic motivation generates behaviour that cause a person to feel competent and self-determining. Given the optimal level of incongruity in a setting where a person feel competent and self-director, intrinsic motivation could lead to what Maehr (1976) calls 'continuing motivation'. Continuing motivation sustains the real pioneers of a given field of endeavour.

The motivational processes in the model can be understood by following the example of an oscillator. An oscillator is a device which, *once started or given input*, gives output infinitely without any further external input. The oscillator sustains its oscillations by giving some feedback from the output.

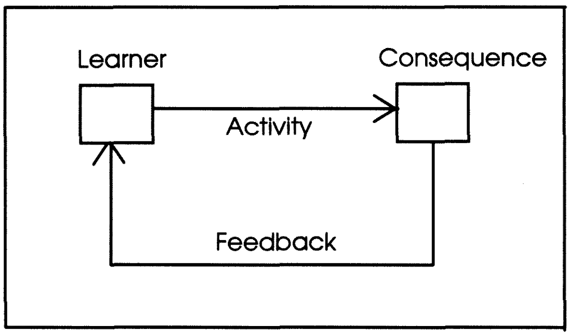

Figure 10.1 Oscillator model of motivation

Our construct of motivation follows the lead from the newly emerging motivational concepts - such as the higher self, will, or reflective self-awareness. According to these concepts, motivation need not to be developed or instilled in humans nor supplied them - as if they are somehow deficient; rather the potential is already in place and need only be accessed and allowed expression. Both 'inherent patterns' and 'initiation' are the two important considerations in the motivational process.

Motivational properties can be seen everywhere in natural as well as human-made environments. In general, all sensory inputs do not appeal to everybody. Only when the patterns of our personal traits match with the patterns of a particular input, the motivational properties work at their best. An analogy from physical science may, perhaps, elaborate my point. A resonance (rapid and uncontrolled increase in the size of vibration) occurs when the frequency of the forced vibrations matches with the natural frequency of an object. For example, resonance was the cause of a collapse of the Tacoma Narrows bridge, USA, in 1940, when the frequency of the wind (forced vibrations) coincided with the natural frequency of the bridge. Another example from social sciences may also be useful. All children watch violence on television. But only those children adopt violence who already possess some 'inherent disposition toward it' or have an 'inherent biological basis for its expression'..

In general, initiation may not work at all if one has no apparent, or latent patterns of, loving sympathy for an activity. But once motivational input succeeds in its purpose of arousing loving sympathy in a person for some activity, it could prove inexhaustive. For example, one can become motivated after meeting a leading scientist in a laboratory working like any other human beings. And after that moment, she or he may start feeling much more competent and willing to become a scientist. And consequently, she or he may start receiving intrinsically rewarding experiences as feedback.

10.4 Motivation in science museums and centres

People and environment, independently or in combination, appear to be two great and viable sources of motivational inputs. For example, among Nobel laureates, we find several examples of what Kreb (1967) calls 'the genealogy of outstanding scientists'. One 'family tree' starting with the German chemist Leibig last century lists more than 30 Nobel laureates. Another family started with the von Baeyer and extending over four generations includes 16 Nobel laureates. We also come across the fact that only a few laboratories, such as Cavendish laboratory, Fermi's laboratory, Lawrence's laboratory, to name a few, have produced a great proportion of the total Nobel laureates in the world. The phenomenon of clusters of laureates can better be understood in terms of conducive learning environments which provide necessary motivation, inspiration and training.

From the above discussion, it seems clear that rewards and punishments are not the only antecedents of motivation. Both people and environment have capacity to switch a person on. In a motivating learning environment there has to be something about the activity or message itself that a person will want to focus attention on and want to become involved with. Numerous authors consider attention, involvement (time devoted in the task), self-efficacy, past experiences and perceptions of message relevances as important components which promote motivation (Bandura, 1977). It has already been discussed in the context of attitude change (Chapter 6) that a stimulating science centre environment largely fulfils these pre-conditions for motivational changes to occur.

On the basis of their years of research on curiosity in school children, Maw and Maw (1965) characterised a child as exhibiting curiosity to the extent that he:

- reacts positively to new, strange, incongruous, or mysterious elements in his environment by moving toward them, by exploring them, or by manipulating them.
- exhibits a need or desire to know more about himself and his environment.

- scans his surroundings, seeking new experience.
- persists in examining and exploring.

On the basis of our review of numerous behavioural studies (Chapter 5), it appears pretty clear that students do really run from one exhibit to another and remain involved in specific exhibits up to a few minutes. In other words, we can say that the behaviour of a child in a science museum is compatible with the Maw and Maw's characterisation of exhibiting curiosity. Indeed, according to the existing literature pertaining to the participant-observation studies, behaviour within a museum space is found to be directed (purposive). The available behaviour of individuals in a science museum gallery can be divided into four categories:

10.4.1 Reacts positively to a new environment

The first type of behaviour is behaviour directed toward some exhibit in a gallery of the museum space. In a hypothetical example, if a person is presently sliding blocks in a jigsaw puzzle (i) and then pay attention to a Lissajous pattern (like a figure of 8) on the screen made by a bright red laser light (j). We can describe it as transition behaviour having the direction from i to j. This is represented as $D_{i,j.}$ The category is often characterized as *hands-on but minds-off.* But, attention is said to the first and prime antecedent for motivation as it infer about one's willingness to learn.

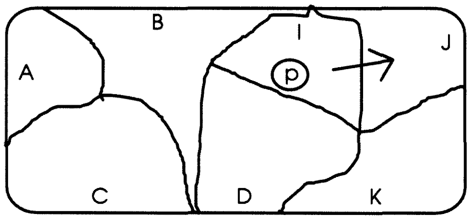

Figure 10.2 Watching Lissajous pattern is a goal for a person presently half-heartedly engaged in some activity in gallery space.

10.4.2 Persistence in examining and exploring

The second type of behaviour is behaviour directed toward the exhibit which one consciously chooses to explore and, therefore, follows "deep-processing strategies". Integration of new information and prior knowledge is at the heart of a set of behaviours that have been called deep-processing strategies (Nolen, 1988). The behaviour of a person participating in a jigsaw puzzle is directed from I to I. This is represented as $D_{i,i.}$

10.4.3 Running away tendencies

A third category of behaviour is behaviour directed away from the exhibit space in which one is presently located but not toward any other specific region. In this behaviour category, one appears eager to leave ones present location. This is represented as $D_{i,-i}$. This type of behaviour may lead one to leave the gallery space and, eventually, to the museum space. This type of behaviour essentially represents one's anxiety, uneasiness and incompatibility in the environment.

10.4.4 Creative behaviour

The above discussed three categories enclose all "special" behaviours a person exhibits in a museum space. First and second types of behaviour have enormous potential of invoking motivational patterns in individuals. These types of behaviour lead, may be very rarely, to a fourth category - curious, stimulated and creative behaviour. To this affect Sally Duensing gives an account of her experience of the Exploratoratorium, San Fransico. Once Duensing saw a boy who was making an arch bridge. But, the boy was arranging blocks in a different way then that suggested in the label. When Duensing asked him to follow the correct way, the boy replied that he knows the right way but he wants to see what will happen if done his way (Duensing, 1987).

The forces that cause a person to follow meaningful behaviour, such as described in categories 1, 2 and 4 above, play a paramount role in building motivation. All encounters or events or settings, however, do not necessarily possess motivational properties. For example, every year governments and international agencies issue warnings and launch impressive and innovative campaigns against smoking and drug addiction. Yet, many people who strongly wish to get rid of these habits find it excruciating to do so. There usually exists an inhibition or barrier between one and one's goal. Also, self-concept is important. Some people value their personality traits so high that they easily overcome the barriers. Other people have such critical circumstances that they succeed in achieving their goals due to external pressures. And still other people can get their required motivational inputs from either social and/or physical environment. Keeping in mind so many variables involved in the process of motivation, the level of motivation in a science centre can be assumed as a function of the sum of meaningful encounters and enjoyable experiences.

$$\text{LEVEL OF MOTIVATION (M)} = f\,[\,\Sigma D_{i,j} + \Sigma D_{i,i} + \Sigma D_{i,i}\,(\text{creative})\,]$$

In a hypothetical example, suppose a few student have experienced 15 events (motivated (1) and/or non-motivated (0)) during a visit to the science museum. After the visit, their level of motivation may be high or low depending upon the nature of experience and their ability. Some of the possibilities may be as follow:

$M_1 = 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 = 0$ (low)

$M_2 = 1 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 = 1$ (high)

$M_3 = 1 + 0 + 0 + 0 + 0 + 1 + 0 + 0 + 0 + 0 + 0 + 1 + 0 + 0 + 1 = 0$ (low)

$M_4 = 1 + 1 + 1 + 1 + 1 + 1 + 1 + 1 + 1 + 1 + 1 + 1 + 1 + 1 + 1 = 0$ (low)

Above discussion tells us that only one event is enough to motivate us and to change our life. There is no guarantee of high level of motivation for a given person even if all of the 15 encounters were meaningful.

Given the complexity of motivation concept and motivational processes, measurement of motivation evidently is a challenging task. The oscillator model of motivation suggests *performance* as a result of the meaningful encounters and enjoyable experiences in science centre as an appropriate measure of motivation. In this study, students are not assumed completely devoid of motivation before the visit. The existing motivation of students has been labelled as 'continued motivation'. The purpose of this study is to find out the impact on continued motivation of students in science as a result of their science centre visitation. As not much work has been attempted in this direction, it seems essential to develop a new scale for the measurement of change in continued motivation.

10.5 Development of motivation scale

As has been said earlier (Chapter 6), scale development is both an art and science. The science lies in the techniques used for the selection and rejection of items, the art in the item writing. To develop a reliable and valid motivation scale, it was decided to follow the same procedure as one employed for developing attitude scales. According to numerous authors, the development of a reliable and valid scale is a process that consists of several distinct stages (Gardner, 1975; Koballa, 1984). The main stages of this process are:

1. Conceptualisation
2. Item formulation.
3. Content validation
4. Finalisation of the scale - pilot testing employing four different samples, factor analytical investigation, and Cronbach's coefficient of final questionnaire.

Stage 1: Conceptualisation

The first stage in the development of the scale was to identify various elements of motivation which, in turn, would be helpful in deciding on individual items. The psychological studies of the lives of eminent artists, scientists and philosophers reveals that great accomplishments are matters of opportunity and involvement. When Isaac Newton, for example, was asked how he managed to surpass the discoveries of his predecessors, he replied, " By always thinking about them." Similar message lies also in the famous quote of Thomas Alva Edison, "Success is made up of 99 per cent perspiration and 1 percent genius."

We know from our own experiences that most students read science text books and perform laboratory experiments to secure better grades. But the same can not be said if one instead of purchasing a door-bell directly from a corner shop reads a circuit, goes to the market to purchase the components and then assemble the bell. For our purpose, activities that students perform for their own pleasure or intrinsically rewarding experiences rather than for any apparent external rewards would be useful. The scarce resources are amount of time and concentration rather than the information available or the information processing capacity of the mind. Thus, involvement and motive (of involvement) can be reasonably assumed as essential ingredients of motivation.

Stage 2: Item formulation

To formulate individual items and the scale, following three points were considered as ground rules:

1. The scale should work at different levels, that is neither answer for specific item should be obvious nor it should be too complicated. Target population was from 8 to 12 graders (Aged 12 to 17) from government schools in Delhi and Guwahati in India.

2. The scale should work equally well for pre-visit and post-visit tests. It requires that each item should be closely related with the science centre visit - its content, activity or environment, and should relate to the constructed motivation concept.

3. The scale should not take too much time of students.

To formulate items, a performance-oriented approach was adopted. All activities, reading, writing, collecting, building and so forth, were chosen which firstly require involvement and secondly exhibit motives clearly. The criterion of the approach was that most of the students should be able to answer all items on the basis of their everyday experiences in school and home, and the responses should evaluate and discriminate their performances. For example, item 1 (given below) could be answered by almost everybody easily and also categories of responses allow us to evaluate the individual response. To avoid any incongruency, the term 'seldom' and 'sometimes' were defined as : 'Seldom' - once in six months and Sometimes - Once in two weeks.

Item1	Categories of responses			
I read science articles in newspapers	Never	Seldom	Sometimes	Regularly

Stage 3: Content validation

Each item was considered time and again consulting Edwards' (1957) fourteen criteria for writing Likert statements. Following five experts were consulted to assess the quality of each item in the context of clarity, ambiguity, generality, and to validate the content of the questionnaire.

1. Gaynor Kavanagh, Lecturer, Department of Museum Studies, Leicester.
2. Simon Knell, Lecturer, Department of Museum Studies, Leicester.
3. Jannette Elwood, Lecturer, Department of Education, Leicester.
4. S. Dabas, Post Graduate Teacher, Government Co-Education Model Senior Secondary School, B-4, Paschim Vihar, New Delhi.
5. S. C. Gupta, Post Graduate Teacher, Government Co-Education Model Senior Secondary School, New Delhi.

Stage 4: Finalisation of the scale - construct validity and reliability

To make sure that the scale holds equally well for populations having different cultural backgrounds and education systems, and ultimately, that the scale represents a wider population sample, the 8-item inventory was administered to four different samples, three in schools of Delhi and one in Guwahati, comprised of grade 8 to 12 students. For the sake of convenience of students, the questionnaire was also made available in Hindi. The *item-total correlations* (r-value) were found reasonably high ranging from 0.18 to 0.85 (Table 10.2, section 6.1-6.4). Most items were found to hold equally good for different populations. The internal consistency of the scale is estimated 0.70 (for 275 cases; Table 10.2, Section7).

The factor analytic investigation supported our construct of the multi-level concept of motivation. The level of motivation is designated as 'level' hereafter. The correlation matrix was factor analysed using Principal Factor Analysis with Varimax rotation. Three groups covered 59 per cent of the total variance (Table 10.3). Loadings exceeding 0.4 were considered to identify the factors. The graphical representation of our motivation construct is shown in Figure 10. 3. The grouping of items is noted as follows:

Level 1
1. I read science articles in newspapers
4. I read science articles in magazines
7. I make science projects in home

Level 2
2. I collect scientific toys and specimens
5. I write science articles
6. I read science fictions and comics

Level 3
2. I collect scientific toys and specimens
3. I attend popular science lectures
8. I participate in science drama shows

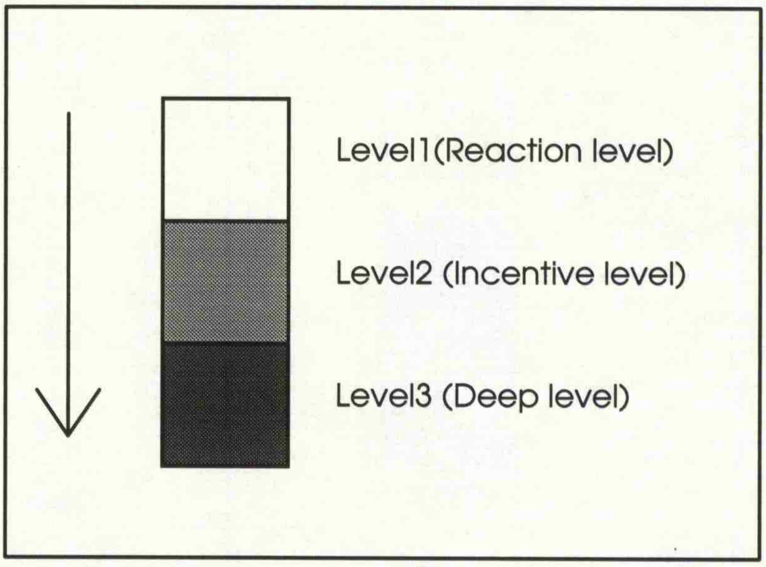

Figure 10.3 Graphical representation of Motivational Depth Gauge (Terms in brackets are used and defined in the Motivation Depth Gauge of Peterson (1992: 40)).

Table 10.2 Summary of pilot test findings

SN	Item	Sub component	Frequency (In percentage)				Item-total Correlation				Final
1	2	4	5				6.1	6.2	6.3	6.4	7
			Never	Seldom	Some-times	Regular-ly	n=21 α=0.88	n=27 α=0.44	n=35 α=0.61	n=39 α=0.78	n=275 α=0.70
1	I read science articles in newspapers	1	3.6	17.5	63.6	15.3	0.75	0.54	0.50	0.54	0.53
2	I collect scientific toys and specimens	2/3	18.5	40.0	32.7	8.4	0.85	0.30	0.57	0.71	0.62
3	I attend popular science lectures	3	21.8	29.1	31.6	17.1	0.79	0.36	0.33	0.47	0.57
4	I read science articles in magazines	1	7.6	26.2	48.0	17.8	0.85	0.18	0.30	0.70	0.58
5	I write science articles	2	36.7	30.9	20.4	11.3	0.77	0.72	0.77	0.73	0.66
6	I read science fictions and comics	2	13.5	29.5	42.5	13.8	0.62	0.34	0.63	0.73	0.54
7	I make science projects in home	1	22.5	45.8	25.1	5.8	0.68	0.35	0.61	0.51	0.48
8	I participate in science drama shows	3	49.8	29.8	15.6	3.6	0.59	0.78	0.40	0.69	0.57

Table 10.3 Factor Analysis (Varimax Rotation) - Continuing Motivation in Science (N =275)

Item	Level 1	Level 2	Level 3
1	0.72		
2		0.40	0.53
3			0.78
4	0.70		
5		0.73	
6		0.83	
7	0.69		
8			0.71
Variance	32.8%	13.7%	12.6%

Table 10.4 shows the results of testing each dimension as a single entity. The coefficient alphas of the dimensional scales are quite high considering the low (three) number of items in each.

Table 10.4 Summary data for three motivational levels

Dimensions of Attitude Scale	Number of items	Eigen Value	Coefficient
Level 1	3	2.62	0.77
Level 2	3	1.09	0.65
Level 3	3	1.00	0.74

Evaluative Quality

The evaluative quality of an item is ensured by comparing between the low-score group and high-score group subjects. Kelley (1939) found that if the total scale scores are distributed normally, the selection of respondents from the upper and lower 27 per cent of the distribution provides optimal discrimination. Figure 10.4 and 10.5 graphically illustrate skewed and bipolar distribution of responses suggesting good discriminating power of items. The two items presented here are selected on the basis of their mean attitude scores. Both items represent a sort of contrast as item1 secures maximum mean score (3.284) and item 8 minimum (1.149).

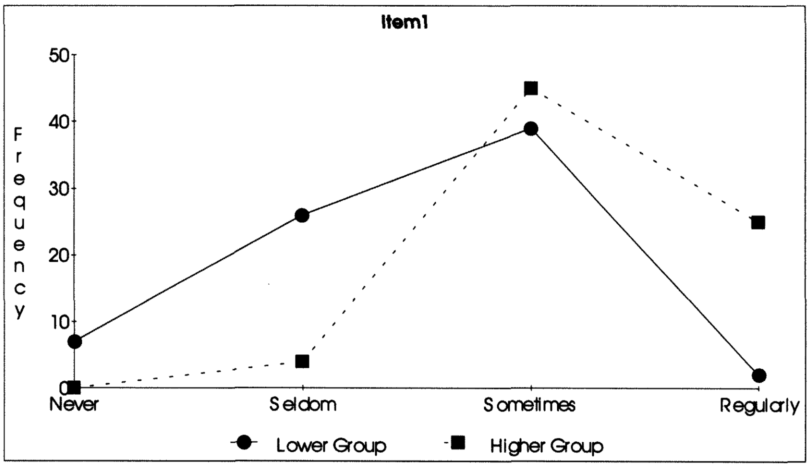

Figure 10.4 Distribution of responses of lower and higher group students over four categories.

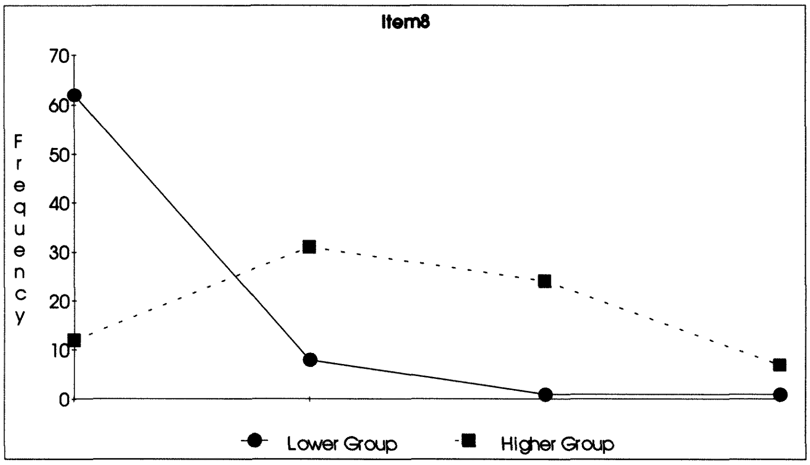

Figure 10.5 Distribution of responses of lower and higher group students over four categories.

Conclusion

The motivation in science scale for young students has passed several tests suggesting some degree of validity. Almost all subjects were able to attempt full questionnaire suggesting accepted reading level and clarity of items. High item-total correlations, clarity, evaluative character of items, suggests a valid scale which could be used to compare group means of pre- and post- visit tests.

In the next chapter, we shall use the scale for determining the mean motivation score for a group of students. In order to compare the pre-visit and post-visit motivation scores, appropriate statistical techniques will be employed.

Chapter11

Immediate and Long-Term Impact on Continuing Motivation in Science in Response to a Science Centre Visit

Introduction

In this chapter, the preliminary results of the study in which the constructed 'continuing motivation in science' scale has been used are presented. The aim of this chapter is to find out the immediate and long-term impact of a science centre visit on composite and different levels of motivation. Composite motivation is the sum of all eight items in the scale. Specifically, four research questions have been addressed:

1 Are there differences in continuing motivation in science amongst students as a result of their science centre visitation?

2 Are there differences in continuing motivation in science between male and female students as a result of their science centre visitation? If yes, then what is the pattern of the differences in long terms?

3 Are there differences in continuing motivation in science between secondary and senior secondary students as a result of their science centre visitation? If yes, then what is the pattern of the differences in long terms?

4 Are there differences in continuing motivation in science between biology and physical science stream students as a result of their science centre visitation? If yes, then what is the pattern of the differences in long terms?

The present chapter is divided into two parts. In the first part, immediate impact and, in the second part, long term impact on students' continuing motivation in science in response to a science centre visit will be discussed.

11.1 Participants, data collection and experimental design

This investigation took place within a large school system in Delhi. Eight schools from the system's more than 500 government schools were selected and invited to participate. The sample represented a geographically vast area on Delhi State map. Principals were contacted with detailed plan of the study in which the same students were to be tested twice: *before the visit* and *after the visit*. Two hundred and seventy five students participated in the pre-visit test and 227 in the post-visit test. The post visit test was conducted at best the next day and at worst within three days of the visit.

In this part of the study, in order to compare (using t-test) the impact of the science centre visit , only those 168 students were considered who participated in both, the pre-visit and post-visit, tests. This method is known as 'within-subjects' design and the sample, as 'paired or related sample'. As a result of a treatment, the means of paired samples are less likely to differ than the means of unrelated samples since the score comes from the same cases.

11.2 Presentation of findings and discussion

Data were analysed using independent and paired t-tests. In the pre-visit test, secondary students (junior) are found to have significantly higher mean scores than the senior secondary students in all the three levels of motivation and in composite motivation as well (Table 11.1).

The significantly higher motivation scores of junior students indicates either they have higher motivation and their motivation decreases as they study further or they do not evaluate their performance rightly and tend to boast about it. In any case, both possibilities find support in literature. Simmons and her colleagues (Blyth, Simmons and Carlton-Ford, 1983; Simmons and Blyth, 1987) found a decrease in motivation in the context of schooling across the transition from elementary to secondary. On the other hand, some researchers (Nicholls, 1979; Stipek, 1984; Marsh, 1989) demonstrated that competence and expectancies are higher during the elementary classes than during secondary school.

Boys secured higher mean scores, though statistically insignificant, than girls in composite motivation and in its all three levels (Table 11.2). Girls, in general, are found to have slightly lower mean motivation score than boys (Haertel *et al.*, 1981;

Zerega *et al.*, 1986). The authors suggested that the small difference in motivation may not affect science achievement in early adolescence, but the situation may lead girls to do worse in science achievement than boys in their late adolescence. This finding, however, may be attributed to the decrease in self-esteem of girls as they grow. Simmons and her colleagues (Blyth, Simmons and Carlton-Ford, 1983; Simmons and Blyth, 1987) provided important evidence related to decrease in self-esteem in the context of schooling across the transition from K-8 setting to high school setting.

Table 11.1 t-Test - Comparison of secondary and senior secondary school student (Pre-visit Test)

	Secondary Students n = 108		Sr. Sec. Students n = 60			
Scale	M	SD	M	SD	t	ρ
First level motivation	2.65	0.498	2.49	0.603	1.88	0.062
Second level motivation	2.38	0.633	2.01	0.651	3.66	0.001
Third level motivation	2.35	0.653	1.88	0.675	4.48	0.001
Composite motivation	2.47	0.434	2.14	0.524	4.31	0.001

Table 11.2 t-Test - Comparison of Male and Female Students (Pre-visit Test)

	Female Students n = 75		Male Students n = 93			
Scale	M	SD	M	SD	t	ρ
First level motivation	2.53	0.487	2.64	0.580	1.29	0.199
Second level motivation	2.16	0.618	2.32	0.691	1.63	0.105
Third level motivation	2.12	0.680	2.23	0.712	1.00	0.318
Composite motivation	2.28	0.456	2.40	0.515	1.60	0.112

Grade-based findings

In grade-based pre- and post-visit test comparison (Figure 11.1), an over all decrease has been recorded for junior boys as a result of science centre visitation (Table 11.3). In contrast, senior students have attained non-significantly in their motivation scores (Table 11.4). They have gained significantly in level 3 (deep level) motivation score. One point should also be noted that neither there is decrease in case of junior students (2.65→2.62) nor gain in case of senior students (2.49→2.51) in level 1 (reaction level) motivation score. In the case of senior students, the upwards curve for higher motivational levels is a really an interesting finding.

Table 11.3 t-Test - Comparison of pre- and post visit motivations of secondary students (N = 108)

	Pre-Visit Test		Post-Visit Test			
Scale	M	SD	M	SD	t	ρ
First level motivation	2.65	0.498	2.62	0.560	0.61	0.543
Second level motivation	2.38	0.633	2.32	0.593	0.99	0.324
Third level motivation	2.35	0.653	2.19	0.555	2.71	0.008
Composite motivation	2.47	0.434	2.36	0.492	2.59	0.011

Table 11.4 t-Test - Comparison of pre- and post visit motivations of senior secondary Students (N = 60)

	Pre-Visit Test		Post-Visit Test			
Scale	M	SD	M	SD	t	ρ
First level motivation	2.49	0.603	2.51	0.615	0.22	0.828
Second level motivation	2.01	0.651	2.10	0.713	1.18	0.244
Third level motivation	1.88	0.675	2.04	0.700	1.97	0.053
Composite motivation	2.14	0.524	2.21	0.564	1.47	0.147

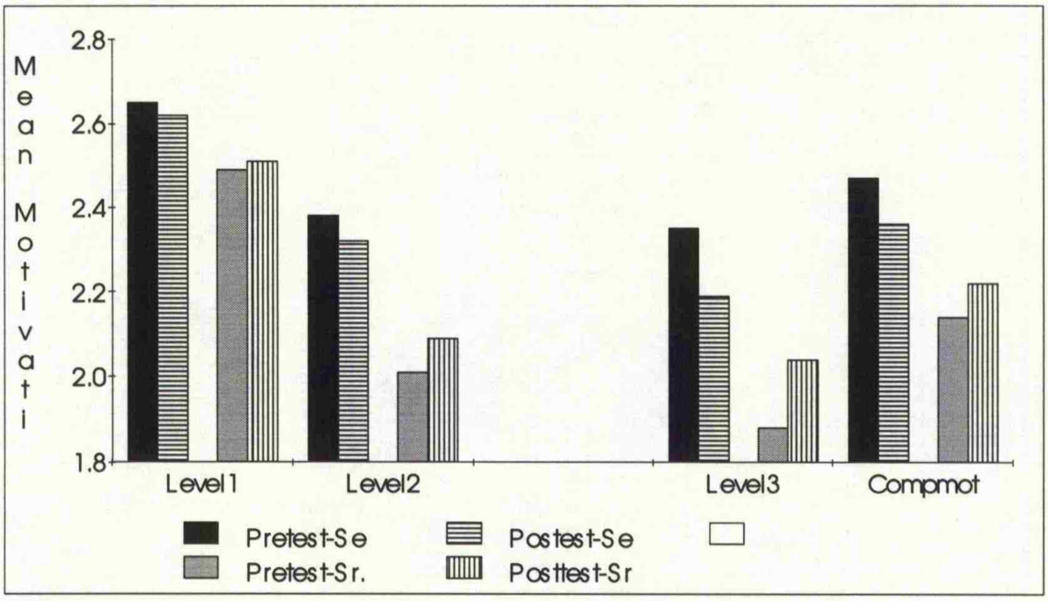

Figure 11.1 Graphical representation of changes in Mean Motivation Score in pre- and post-visit tests for secondary and senior secondary students.

Grade based findings are intriguing. The higher pre-visit scores of junior students and a considerable decrease in their scores during post-test appears to indicate that junior students over-estimate their performance and competence. The decrease may be attributed to the fact that junior students may become perplexed or overwhelmed in science centre's information rich environment. In other words, junior students may realise their actual standing in science. And if it is so, it may have good as well as bad consequences in specific situations.

In spite of the decrease in the post-visit science motivation, junior students still have more motivational score than the senior students. The finding seems to confirm that students have higher self-concept, expectation and competency in their early years.

Gender-based findings

In gender-based pre- and post-visit test comparison (Figure 11.2), neither boys nor girls appear to gain or loose anything significant in their motivation scores as a result of their visitation (Table 11.5 and Table 11.6). On the basis of this finding, similar pattern of relations between motivation, strategy use for spontaneous learning, and achievement can be predicted for boys as well as girls.

The finding seems to suggest that by the time students finish school, many external factors, including social, cultural and religious, do seem to act as a potent source for students in their attempt to sort out and establish their gender identity. These factors as well as gender-neutral science curriculum and science teaching might differentially influence male and female students in their science achievement and future occupation.

Table 11.5 t-Test - Comparison of pre- and post visit motivations of female students (N = 75)

	Pre-Visit Test		Post-Visit Test			
Scale	**M**	**SD**	**M**	**SD**	**t**	**ρ**
First level motivation	2.53	0.487	2.50	0.524	0.47	0.636
Second level motivation	2.16	0.618	2.12	0.610	0.47	0.638
Third level motivation	2.12	0.680	2.11	0.613	0.27	0.786
Composite motivation	2.28	0.456	2.25	0.494	0.68	0.498

Table 11.6 t-Test - Comparison of pre- and post visit motivations of male students (N = 93)

	Pre test		Post test			
Scale	**M**	**SD**	**M**	**SD**	**t**	**ρ**
First level motivation	2.64	0.580	2.64	0.619	0.06	0.954
Second level motivation	2.32	0.691	2.34	0.662	0.22	0.829
Third level motivation	2.23	0.712	2.17	0.615	0.94	0.348
Composite motivation	2.40	0.515	2.36	0.541	1.08	0.283

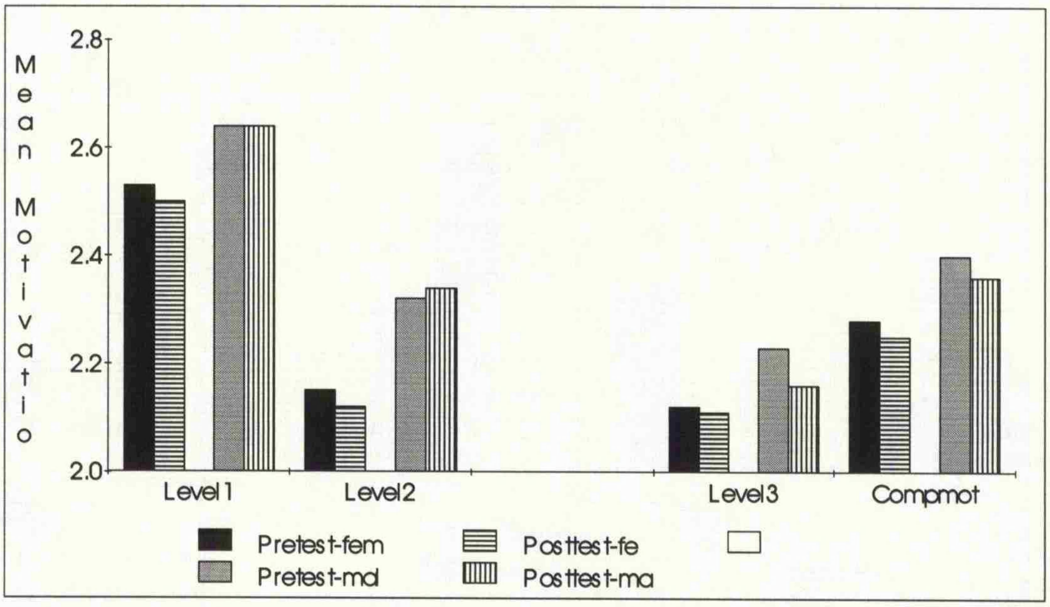

Figure 11.2 Graphical representation of changes in Mean Motivation Score in pre- and post- visit tests for male and female students.

Subject-based findings

In subject-based pre- and post-visit test comparison (Figure 11.3), neither biology stream nor science stream students appear to gain or loose anything significant in their motivation scores as a result of their visitation (Table 11.8 and Table 11.9).

Table 11.7 t-Test - Comparison of pre- and post visit motivations of students who do not like science (N = 4)

	Pre-Visit Test		**Post-Visit Test**			
Scale	**M**	**SD**	**M**	**SD**	**t**	**ρ**
First level motivation	2.75	0.687	2.17	0.430	1.85	0.162
Second level motivation	1.50	0.192	1.92	0.569	1.21	0.312
Third level motivation	1.67	0.272	1.67	0.385	0.00	1.000
Composite motivation	2.06	0.315	1.88	0.395	1.73	0.182

Table 11.8 t-Test - Comparison of pre- and post visit motivations of students who have special interest in biology stream (N = 65)

	Pre-Visit Test		**Post-Visit Test**			
Scale	**M**	**SD**	**M**	**SD**	**t**	**ρ**
First level motivation	2.64	0.501	2.51	0.587	1.90	0.061
Second level motivation	2.08	0.617	2.11	0.622	0.53	0.596
Third level motivation	1.98	0.648	2.07	0.622	1.23	0.223
Composite motivation	2.26	0.451	2.23	0.510	0.64	0.527

Table 11.9 t-Test - Comparison of pre- and post visit motivations of students who like science (N = 99)

	Pre-Visit Test		Post-Visit Test			
Scale	**M**	**SD**	**M**	**SD**	**t**	**ρ**
First level motivation	2.56	0.577	2.64	0.500	1.31	0.194
Second level motivation	2.32	0.670	2.34	0.687	0.30	0.765
Third level motivation	2.30	0.700	2.24	0.632	0.87	0.388
Composite motivation	2.38	0.512	2.39	0.544	0.05	0.957

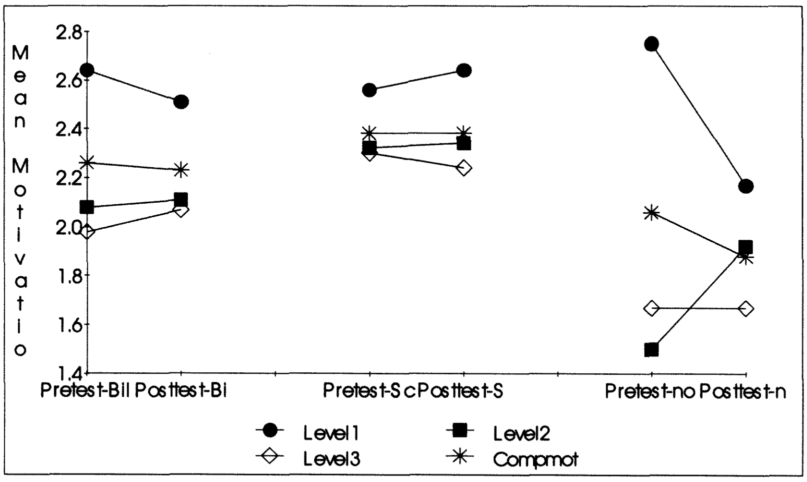

Figure 11.3 Graphical representation of changes in Mean Motivation Score in pre- and post- visit tests for biology students, science students and those who do not like science.

Part II

Long-Term effects of a Science Centre Visit on Continuing Motivation in Science

In the first section, students' motivation (except for senior students) in science was found to almost unaffected as a result of their science centre visit. While it is implausible to expect a miraculous over-night change in the performance of students, the possibility of gradual improvement in the science-related performance of students spread over a period of several month cannot be ruled out. This study is designed to find out the long-term impact of a science centre visit on different levels of motivation.

11.3 Data collection and sample

In this part of the study, in order to compare the impact of the science centre visit, it was decided to collect data from different groups of participants (unlike the previous section where the same students took the pre- and post-visit tests). This method is known as 'between-subjects' design and the sample, as 'unrelated sample'. All 275 students (out of which 168 students visited the science centre and have been included in the first part of the study) forms the pre-visit sample (Time1). All 227 students (out of which 168 students took the pre-visit test and have been included in the first part of the study) constitutes the post-visit sample (Time 2). The post-visit test was conducted within three days after the visit. In the later-visit sample (Time 3), 225 students from five schools are included who visited the science centre five to six months ago (that is, during December 1993 and the first week of January 1994).

Detail of the Sample

	Female	Male	Junior	Senior
Time1	110	165	177	98
Time2	94	133	144	83
Time3	128	97	178	47

11. 4 Presentation of ANOVA results

Effect of Time (One Way Design)

In mean motivation scores, there is found virtually no immediate or long term change. This finding throws light on the nature of motivation. Compared to attitude, motivation appears to be highly specific. Data of individual candidates also substantiate this argument. While as a result of the science centre visit a student (Reena Khullar, Girl, X class, physics favourite subject) gained 13 points (previsit 11 → postvisit 24), another student (Vikas Sonkar, XII class, biology favourite subject) lost fifteen points (previsit 25 → postvisit 10) (In the test one can get maximum 32 points).

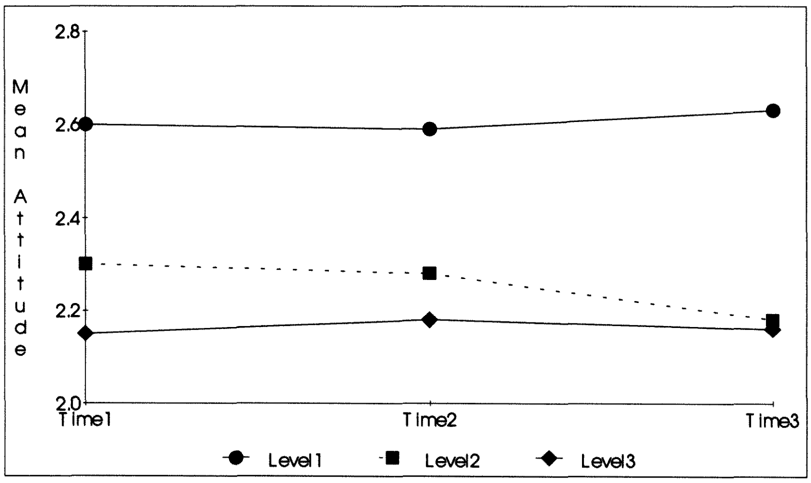

Figure 11.4. Graphical representation of changes in Mean Motivation Score in pre-, post- and later- visit tests.

Sex and Time Interaction (Two Way ANOVA)

Significant effect of sex has been observed in levell (reaction level) (F=8.971), level2 (intermediate level) (19.058) and composite motivation (10.781).scores (Table 11.10). The combined interaction of time and sex is observed insignificant in all levels of motivation and in composite as well.

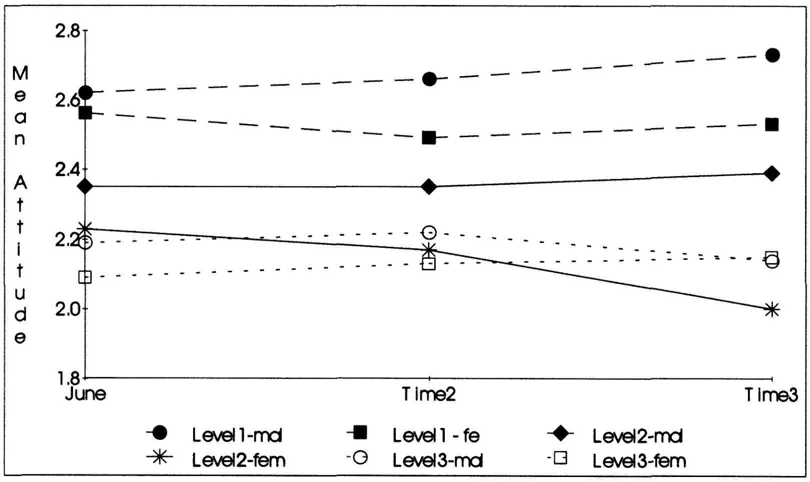

Figure 11.5. Graphical representation of changes in Mean Motivation Score in pre-, post-, and later- visit tests for male and female students.

Grade and Time Interaction (Two Way ANOVA)

Significant effect of grade has been observed in level2 (intermediate level) (F=10.175), level 3 (deep level) (F=12.452) and composite motivation (F=6.492) scores (Table 11.10). The combined interaction of time and grade is significant in all levels of motivation and in composite as well.

The motivational gain pattern for senior students is quite interesting. In the first level motivation, they have gained 6.4% in the post-test and 16.46% in the later-test over the pre-visit test score. In the second level motivation, they have gained 5.39% in the post-test and 17% in the later-test over the pre-visit test score. In third level motivation, they have gained 9.42% in the post-test and 15.7 % in the later-test over the pre-visit test score. In composite motivation, they have gained 5.10% in the post-test and 16.66 % in the later-test over the pre-visit test score. Evidently, senior students have maintained their growth curve even long after the visit.

On the contrary, junior students have exhibited consistent decay. In the first level motivation, they have lost 2.25% in the post-test and 3.38% in the later-test over the pre-visit test score. In the second level motivation, they have lost 3.69% in the post-test and 11.65% in the later-test over the pre-visit test score. In the third level motivation, they have lost 2.19% in the post-test and 5.7 % in the later-test over the pre-visit test score. In composite motivation, they have lost 3.66% in the post-test and 7.32 % in the later-test over the pre-visit test score.

It appears that the finding here has something to do with the classroom climate and teaching style. In senior secondary classes, reading and lecture predominate. Even laboratory activities rely on the printed word. Career-related stresses, exactness and tough assessments may be some of the factors which make science uninteresting for senior students. The study suggests that the extra-curricular science-related activities may be extremely motivating and stimulating for senior students.

The decrease in the motivation of junior students point to the situation in which some of the students come to know their actual standing in the field in a information-rich environment. It is a well-known fact that science and mathematics are a kind of torture for a large section of students. They study science because it is a compulsory subject in the school curriculum. It is plausible to think that a visit to science centre may increase their anxiety or uneasiness towards science. The higher level of presentation and irrelevant material from the point of view of junior students may be another cause for the observed decrease in motivation of junior students.

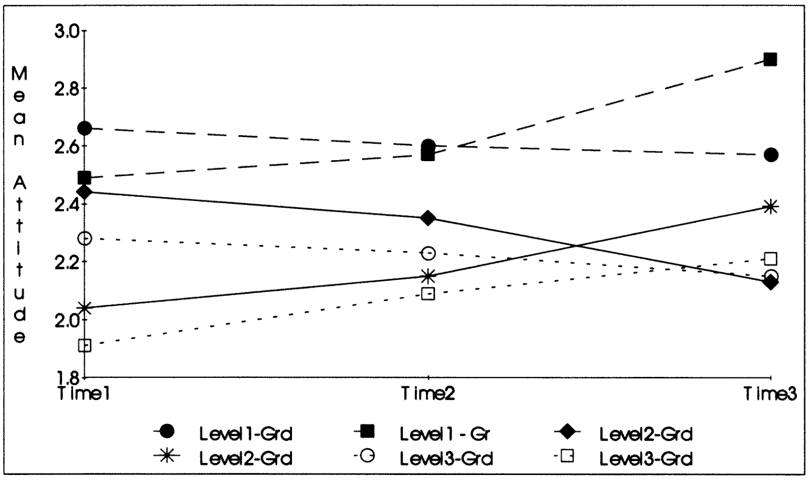

Figure 11.6. Graphical representation of changes in Mean Motivation Score in pre-,post- and later- visit tests for secondary and senior secondary students.

Table 11.10 Analysis of variance of major variables.

Subscale	**First level motivation**		**Second level motivation**		**Third level motivation**		**Composite order motivation**	
Source of Variation	**F Ratio**	**F Prob.**	**F Ratio**	**F Prob**	**F Ratio**	**F Prob**	**F Ratio**	**F Prob**
Time	0.403	0.669	2.194	0.112	0.172	0.842	0.173	0.841
Grade	0.003	0.954	10.175	0.001	12.452	0.001	6.492	0.011
Time* Grade	8.687	0.001	10.953	0.001	5.130	0.01	13.027	0.001
Time	0.104	0.901	2.623	0.073	0.200	0.819	0.374	0.688
Sex	8.971	0.001	19.058	0.001	1.427	0.233	10.781	0.001
Time* Sex	0.917	0.400	2.537	0.080	0.403	0.668	0.613	0.542

Table 11.11 Summary of variation of motivation mean score for various populations

Subscale	**First level motivation**		**Second level motivation**		**Third level motivation**		**Composite order motivation**	
Source of Variation	**Mean**	**Sign. level**	**Mean**	**Sign. level**	**Mean**	**Sign. level**	**Mean**	**Sign. level**
Time1	2.60		2.30		2.15		2.35	
Time2	2.59	NS	2.28	NS	2.18	NS	2.33	NS
Time3	2.61		2.17		2.15		2.31	
Time1 - Female	2.56		2.23		2.09		2.30	
Time1 - Male	2.62		2.35		2.19		2.39	
Time2 - Female	2.49	NS	2.17	NS	2.13	NS	2.26	NS
TIme2 - Male	2.66		2.35		2.22		2.39	
Time3 - Female	2.53		2.00		2.15		2.23	
Time3 - Male	2.73		2.39		2.14		2.42	
Time1 - Grade1	2.66		2.44		2.28		2.46	
Time1 - Grade2	2.49		2.04		1.91		2.16	
Time2 - Grade1	2.60	0.001	2.35	0.001	2.23	0.01	2.37	0.001
Time2 - Grade2	2.57		2.15		2.09		2.27	
Time3 - Grade1	2.57		2.13		2.15		2.28	
Time3 - Grade2	2.90		2.39		2.21		2.52	

Discussion and conclusion

In the post-visit test, while some students gain in their motivational orientation, others show a decrease. Statistically, such results are of little use as the average of the scores tells nothing significant. The result, therefore, infers that motivation is a highly specific concept. Statistical average techniques have inherent limitations in specific situations.

As a result of the visit, low-motivated students appears to have been benefited more than high-motivated students. On the one hand, out of 50 students from the high-motivated group, nine students (six boys and three girls) had lost four or more points and only one student (boy) gained. On the other hand, out of 50 students from the low-motivated group, nine students (six boys and three girls) had gained four or more points and only two students (girls) lost.

The results also highlight the gain of senior students. Only senior students have gained in the post-visit test and maintained their growth in the later-visit test. The increase in their motivation is attributed to the impact on the higher levels of motivation - that is intermediate and deep level motivation.

The significantly higher motivation scores of junior students in the pre-visit test and the subsequent decrease during the post-visit test infers one possibility that students, specially junior ones, are not able to evaluate their performance rightly. In these circumstances, individual student may be given attention. For example, in an informal chat the investigator can ask questions about one's performance. Then the investigator can decide in which category of responses an individual student falls. Such method, though time consuming, will produce more reliable and uniform responses for coding and subsequent analysis, and may also reveal some qualitative aspects which pencil-paper test strategy cannot.

Chapter 12

Conclusion: Indian Science Centres and Challenges of the Present and the Future

Introduction

In this concluding chapter, I shall bring together all the factors and evidence which characterise Indian science centres as learning environments. The chapter is divided into four parts: the first part is concerned with the images of science in the mind of students before and after the science centre visit; then the empirical evidence of affective gains as a result of the science centre visit is summarised in the second part; the third part deals with the interest components of exhibits and the processes which help or prompt students to learn attitudes and scientific facts; and the final part contains the summary of the thesis and recommendations for how science centres can be transformed into more effective learning environments.

This concluding chapter takes an unusual approach, as a lot of new material is entering into it. For example, in the third part, data and information pertaining to students' strong liking and disliking with regards to exhibits are mentioned for the first time. On the basis of gathered evidence, I intend to present a new model containing seven domains of exhibit development, predicting different levels of exhibit effectiveness from the least effective to the most. Almost all exhibits developed in science centres can be placed in one of the seven domains.

The final part is of most significance, as it makes recommendations for a fine synthesis of people's needs and aspirations, social and cultural knowledge, the objectives of museums, and the highly effective domains of exhibit development.

12.1 Images of science

'Science' is a buzzword in today's society. Yet, it is not a predefined or well-understood subject. It can be, and is, seen differently by different people. It can be seen as revolutionary or conservative, objective or subjective, detached or attached, constructive or destructive, chaotic or systematic, partial or impartial, sceptical or open, masculine or feminine, exploratory or delivered, fun or nuisance, and so on. Scientific knowledge can surprise us, can help us, and can trouble us. Ultimately, what we extract out of it depends on how we perceive it.

Students learn about science from many different sources. An image of science is projected in their minds as a cumulative result from various influences in schools: textbooks, teachers' behaviour and personalities, laboratories, resources and science related extra-curricular activities. Images of science are also shaped by out-of-school influences: parents' personalities, peers' inclination, television, cartoons, fictions and other media coverage of science news. Children enter schools alive with questions about everything in sight. It is a fair understanding that in their early school years, they gradually develop what science is really all about. In the present study, it is attempted to uncover the images of science which students construct through their early age experiences.

In the pre-visit, post-visit and later-visit tests, students were asked to write why they like or dislike science (or a particular subject of science) most. The question was indirectly asked to learn what they understand about science, what images or perceptions of science they have, and how these images are affected as a result of their science centre visit. Purposely, the question was kept open-ended. The categories of the image of science were not thought or chosen beforehand. The statements made by students were found to fall in ten different but consistent categories (Table 12.1). There were also other, albeit infrequent, responses. For example, the responses of only three students were observed to represent the 'aesthetic view of science'. Some students' responses were also found to represent two or more different images.

According to the popular view, science is seen as a body of knowledge about the world which exists 'out there', probably independently of the particular scientific methodology used to study it. While for some students this knowledge is useful, for others, once acquired, it nourishes the brain and prepares them for holding science-related careers. When this knowledge is applied to solve real world problems, it mostly produces useful gadgets and is rarely related to negative impacts. For most students, science, largely compartmentalised and differentiated, altogether is a different world, clearly dominated by abstract mathematical formulations. In sum, most students who take a sympathetic view see science as objective, authoritative, non-controversial, value free and positive.

Table 12.1 Various images of science which students commonly develop as a result of their experiences in school and out-of-school activities.

Images of Science	**Example (Student's Identification Number)**
Science as a provider of knowledge	We learn something or other from science. It adds to our knowledge. Also science helps us to lead happy life (3).
Materialistic view of science	By virtue of science we have got many things like we can enjoy TV, telephone, car, scooter, bus, washing machine, mixer and radio. So I like science (120).
Science as an agent of national development	Through science only our nation can progress. Scientists have made new methods by which every work can be done in less time (176).
Science as a human endeavour	Science has proved a boon for humankind. It is helpful in human development. In it, man has performed new experiments and invented things (16).
Science as a gateway to invention and discoveries	There are new methods and inventions in science (126)
Science as an intellectual activity	It enriches my mind with new knowledges everyday. It helps us to know the reasons of unknown facts. It satisfies our curiosity (94).
Science as a classroom subject	Sums and reactions in chemistry are easy and so I am able to solve them. I also secure good marks in it (144)
Science as a destructive force	Science also helps in developing mighter atom bombs, capable of human destruction on large scale (158).
Science as a threat to environment	Chemicals in factories are thrown into rivers that results water pollution. Similarly gases from factories adds to air pollution (40).
Science as an incomprehensible and boring subject	There is too much *jhanjhat* (complexity) in integrating and deriving the formulae in science subject and learning chemistry (108)

The responses of two different samples of students - one who never visited the science centre (control group) and the other who visited the science centre five to six months before - are compiled in Table 12.2.

Table 12.2 Images of science in the mind of those students who never visited the science centre and who visited the science centre five-six months ago.

Images of Science	**Pre-visit Students** (Percentage)	**Students visited five months ago** (Percentage)
Science as a provider of knowledge	23.43	35.55
Materialistic view of science	11.72	7.11
Science as an agent of national development	8.98	4.00
Science as an human endeavour	9.76	8.00
Science as a gateway to invention and discoveries	13.67	12.44
Science as an intellectual activity	8.20	14.22
Science as a classroom subject	17.96	13.33
Science as destructive force	4.30	1.70
Science as a threat to environment	3.52	-
Science as an incomprehensible and boring subject	11.33	13.33

In general, there appears no significant difference in the pre-visit and post-visit images of science. Surprisingly, less percentage of the post-visit students perceive negative associations of science. Comparatively more post-visit students see science as a provider of knowledge and as an intellectual activity. The images of science appear to be quite stable. In one sense, this points to the similarity of the ideological basis of school science courses and science centre displays, and also to the woeful lack of relevance of most school science courses and science centre displays to the way science progresses in society (for example, the role culture and social moods play in the scientific developments). There seems to be no visible gain on the root problem of school science teaching.

> A major problem in teaching science at all levels ... is to bring students to an understanding of the structure of science, the nature of scientific theories, the evidence for these theories, and the mechanism for relating the terms of these theories to experience (Bork, 1975).

The presented science and technology in the science centre do not seem to be potent enough to change students' views about science. But, as we are aware, science, in the scientific world, is no longer considered as a heap of isolated facts. It is a special type of intellectual activity which aims at the formation of general explanatory theories, in order to generate new knowledge. In a nutshell, all scientific theories are provisional. In the beginning of the present century, for example, Einstein believed that the Universe was static. In 1917, he proposed that alongside the normal attractive force of gravity, there is a repulsive force at work too. And by tuning the strength of attraction and repulsion, a static equilibrium could be achieved. But when, in the late 1930s, he came to know from Edwin Powell Hubble (1889-1953), a reputed American astronomer, that the universe is not static, but expanding, he immediately dropped the idea in disgust. But, the recent data, on the rate at which universe is expanding, released by the Hubble Space Telescope team brings scientists back to their starting point, and demands a radical re-think on the theory of the universe, possibly by taking into account Einstein's cosmic repulsion forces.

Uncertainty and limitations are the legacy of the twentieth century science. Science centres are increasingly required to project this aspect of science in their displays. Science centres can empower young visitors in a real sense by telling that the collection of facts is no more science than the building of a science laboratory; that science is not merely a process of discovering and recording natural phenomena but it is also a process that develops our ways of thinking about nature (technologically as well as conceptually effective); that, rather than being neutral, it is 'elitist' - in the sense of being useful to its devotees and harmful to its ignoramuses; that technical solutions are not necessarily the best social solutions; that there is no 'absolute truth' in science; and, most importantly, that they can also change the course of scientific developments by working on supposedly settled problems in science.

Science in science centres should be empowering people in handling scientific matters. The popular phrase "Science tells us..." readily misleads. Science does not tell us anything; it is people who tell us things on the basis of their investigations into a subject matter and their constructed understanding. Ideally, at the exit, science centre visitors should have a sense that science is a mode of inquiry that is common to all human beings.

12.2.1 Attitudes toward science

Over all, there has been observed a significant increase in attitudes of students toward science as a result of their science centre visit. The main beneficiaries are junior students, male students, and students who pursue their studies in physical sciences (Table 12.3).

As a result of the visit, although all students gain in their short-term attitudes to science, in the longer-term, it seems that junior students take their visit more as fun or a sort of leisure outing. In contrast, senior students appear to take the visit quite seriously and consolidate their attitudes with time.

As a result of their experiences in the science centre, the attitude of girls towards science is found to be enhanced (in four attitude dimensions). This gain is, however, noted to decay quickly with time. Thus, female students appear to have short-term benefits. In contrast, male students appear to consolidate their attitudes with time.

Table 12.3 t-Test - Comparison of pre - post composite attitude towards science.

	Pre	test	Post	test		
Category	**M**	**SD**	**M**	**SD**	**t**	**ρ**
Full Sample (168)	3.72	0.52	3.81	0.55	2.17	0.044
Female Students (75)	3.80	0.53	3.77	0.62	0.29	0.772
Male Students (93)	3.65	0.51	3.84	0.48	4.21	0.001
Junior Students (108)	3.63	0.50	3.81	0.42	3.96	0.001
Senior Students (60)	3.86	0.53	3.82	0.73	0.47	0.093
Life Science Stream (65)	3.76	0.49	3.81	0.65	0.57	0.57
Physical Science Stream (99)	3.71	0.53	3.85	0.46	2.65	0.009

12.2.2 Attitudes toward science centre

Similar to the attitudes toward science itself, there has been observed a significant increase in attitudes of students toward science centres as a result of their science centre visit. The main beneficiaries are senior students, male students, and students who pursue their studies in life sciences (Table 12.4).

Junior students appear to gain in affective terms while senior students, in cognitive. The effects fade away with time and are noticeable in all the cases, but more prominently in the case of girls and junior students. In the longer term, male and senior students appear to gain cognitively. On the other hand, junior and girl students appear to have gained long lasting effects in affective terms.

Table 12.4 t-Test - Comparison of pre-post composite attitude towards science centres

	Pre	test	Post	test		
Category	**M**	**SD**	**M**	**SD**	**t**	**ρ**
Full Sample (168)	3.85	0.61	3.99	0.54	2.65	0.01
Female Students (75)	3.87	0.610	3.97	0.434	1.23	0.224
Male Students (93)	3.82	0.611	4.00	0.618	2.44	0.016
Junior Students (108)	3.80	0.588	3.93	0.605	1.67	0.098
Senior Students (60)	3.93	0.614	4.11	0.385	2.70	0.001
Life Science Stream (65)	3.92	0.393	4.08	0.337	2.92	0.005
Physical Science Stream (99)	3.81	0.720	3.95	0.641	1.62	0.108

12.3 Continuing motivation in science

In the post-visit test, while some students gained in their motivational orientation, others showed a decrease. Statistically, such results are of little use, as the average of the scores tells us nothing significant. The result, therefore, infers that motivation is a highly specific concept. Statistical average techniques have inherent limitations in specific situations. Some trends, however, can be of note and merit.

As a result of their visit, low-motivated students appear to have benefited more than high-motivated students. On the one hand, out of 50 students from the high-motivated group nine students (six boys and three girls) lost four or more points and only one student (boy) gained. On the other hand, out of 50 students from the low-motivated group nine students (six boys and three girls) gained four or more points and only two students (girls) lost. The tendency of boasting or exaggeration in the pre-visit test may be one of the possible causes of decrease in motivation of high-motivated students.

The results also highlight the gain of senior students. Only senior students have gained in the post-visit test and maintained their growth in the later-visit test. The increase in their motivation is attributed to the impact on higher level of motivation - that is intermediate- and deep-level motivation.

In future studies, there is a clear need to modify the method of motivation measurement, especially with regard to minimising the possibility of exaggeration by a few students.

12.4 Effectiveness of exhibits

As has been said in the introductory chapter that the idea of education - learning and teaching - in museums is not new, but the noteworthy point today is that, since the early 1960s, the idea has been increasingly taking a concrete shape. The 1960s was a time when the science teaching was moved by the progressive educational theories, innovative developments in instructional designs and communication technologies. It was also a time when museum professionals and some educators identified the educational potential of museums and envisaged the role that museums can, and should, play in order to resolve or mitigate the public concern aroused by the role of science in world wars, space wars, cold wars and in society at large. Moved by the sense of public accountability, several individuals and interest groups took the responsibility for improving the quality and value of museum experiences.

As objects and exhibits occupy the central place in the design of museum experiences, a growing number of individuals and institutions began to work with exhibits, or to design new exhibits, with a view to providing effective instructional communication. The effectiveness of an exhibit was thought in terms of its capacity to involve the visitor. While committed to the idea of an active pedagogy, Oppenheimer (1968) disparaged the heavy reliance in museums on "button-pushing". He mainly applied Brunerian and Piagetian principles of educational psychology in his design of interactive exhibits (Mainly Brunerian philosophy: 'any subject can be taught effectively in some intellectually honest form to any child at any stage of development'). Rather than merely button-pushing, his idea of inter-activity was the event where the visitor directs his or her action and controls the exhibit in some way and, as a consequence or reward of that act, confronts a 'sense of wonder' or 'puzzlement'.

In a survey, Stevan Saslow found that his students preferred the Oregon Museum of Science and Industry to the Art Museum. Their spontaneous comments with regards to preference were: things moved; things were arranged in an intelligible, explanatory form; there was action (Saslow, 1970). Washburne and Wager (1972) also found visitors to be more interested in dynamic, animated, and three dimensional (including scale models) presentations. Similarly, Screven (1974) noted that the addition of responsive devices (audio tape cassette and punch board questionnaire device) to exhibits tends to increase visitor motivation and results in more time spent in front of the exhibit and greater effort to master its content. By this time, it was well realised that merely involvement of the visitor in the exhibit was not the predictor of a significant interaction between the two. The second phase was to match curriculum content with the learners developmental stage (Piagetian work) and with the learner's existing concepts (Constructivist approach).

In the late 1970s and early 1980s, we find more stress on 'learning as a must phenomenon' in museum settings using progressive and sequential curriculum. Linn and her colleagues (1977) observed that a combination of hands-on activities with structured instruction leads to more learning than a free standing and unstructured sequence. Shettel (1976) conceptualised the exhibit effectiveness in terms of its attracting power, holding power and teaching power. Griggs defined the teaching power of an exhibit as:

> an exhibit communicates its message if a visitor, on seeing the display, can comprehend the information without any misunderstanding or misconception about its conceptions and intentions (Griggs, 1984).

Similarly, Miles and his colleagues (1982) defined the effectiveness of an exhibit in terms of its teaching capability. The effectiveness of the exhibit was seen in proportion to its cognitive capabilities - transmission of information about scientific matters from the exhibit to the visitor.

In the present study, I have explored the components of interest in exhibits from the students' point of view. I have collected three sets of data: the first set has come from the observation study of 50 students (based on the attracting power of exhibits); the second set of data has been collected from students who visited the science centre up to three days before the test. Two hundred and four students out of 227 (90%) volunteered and shared their best spent moments in the science centre; and the last set of data has come from the students who visited the science centre five to six months before the test. In the later-visit test, 184 students out of 225 (82%) voluntarily shared the basis of their best and long-lasting impressions (Table 12.5, 12.6, 12.7 and 12.8).

Mostly students remembered those exhibits which they enjoyed; those moments when they learnt something unique/unbelievable/mind-boggling; and when they experienced 'real-life-like-situation'. From the available data, the following factors emerged as being of considerable importance.

LEARNING THROUGH PLAY

There is no clear demarcation between the kingdom of playful learning and of serious learning. Intellectual learning is so much part of children's spontaneous activity that we often tend not to take notice of it or give it full credit. More sadly, play, particularly in reference to the years spanning school education, is commonly abhorred by some parents, educators and journalists. Learning with enjoyment emerged as being a factor of considerable importance in this study. In numerous stances, students referred to exhibits as 'games'.

> In the science centre the most exhibit I liked was science fun games. I liked it because this exhibit was not only of fun but there were to kill two birds in one arrow, that is, we make our mind clear about science there with enjoying games. Sometimes we feel bored in understanding the science facts, but there I was so much interested that I got some new facts and ideas and also I did those facts experimentally. I was able to know science, what is science there and so I liked science fun games (Post-visit; S.No. 62).

> In the science centre, we liked talking over telephone because beside being interesting it was also a game. I was seeing in it the photograph of the caller. I relished it (Later-visit; S. No. 21).

Many students expressed that 'through fun they can learn (various principles of) science better'. The findings here support the view that play is essential for human beings. And the act of its suppression will be devastating for both individuals and institutions.

NOVELTY, WONDER AND CONFLICT

By nature, human beings are inquisitive. They continuously make efforts to decode the complexities of their immediate surroundings. The stimuli of their exploratory activities are said to be novelty, surprise, conflict or uncertainty (Reilly, 1970: 141). The findings here also suggest that students remember those events which satisfy their curiosity, or help solve their long-standing,deep-rooted problems, or which are novel in some way and/or create a sense of wonder among them.

> I liked "Wireless Communication" exhibit in the science centre because it was the wireless tube light without wire started lightning when I switched it on. I have never seen (tubelight glowing) ... that by taking tube in our hand without wire connections (Post-visit; S. No. 23).

RELEVANCE, GRATIFICATIONS AND UTILITY

Accepted wisdom and the conclusion of commercial media, both suggest that effective media-message invariably is the outcome of the fine tuning between the media output and the gratification of certain individually experienced needs. This study also reveals that students remembered those exhibits where they were able to conceive or find the social relevance or utility.

> I like the most in the science centre was that a camera fitted in a room which takes up photographs of people inside. It is because of the security provision of that system. It is very effective in complex situation e.g. suppose a treasure is kept in a room where a thief enters to take that treasure and he would be caught immediately (Post-visit; 37).

EXPERIENTIAL EDUCATION

There can be seen a substantial enthusiasm among educators for "experiential education" - the notion that people learn best and most when they are actively involved and personally experiencing that about which they are learning. From the collected statements, learning through experience sprang up as a factor of considerable importance.

> I liked wave tank. When walking along the tank I felt as if I was walking on the sea beach. Till date I have not been to the sea. Having run along the tank and observed it, I realised the experience of waves at seaside. Besides this, I also got the idea about the bottom of the sea. Though artificial but it was really very nice (Post-visit; 42).

SIMULATION

There is an essential difference between play and simulation: play is competitive, whereas simulation is mostly co-operative. Basically, simulation is 'being in a life-like situation', for example reading the news in a reconstructed setting of a television news studio. In a simulation, visitors take on the roles which are representations of roles in the real world, and then make decisions in response to their assessment of the setting; they experience simulated consequences which originate as a result of their decisions and performances; and they have opportunity to reflect on the relationship between their own decisions and the resultant consequences.

QUALITY OF PRESENTATION

While describing their best liked exhibits, some students gave weight to the presentation because: it was presented intelligently; it was visually attracted; it was colourful; it was systematic; (costumed figures and mannequins) were constructed and placed very nicely; experimental procedure was fascinating; it made information easily accessible; and it was participatory. The findings confirm the primacy of participatory aspect in the positive museum experience.

Table 12.5 Gallery-wise frequency of recorded memorable events

	Heritage	**Fun Science**	**Information Revolution**
Post-Visit Test	15	77	72
Later-Visit Test	19	82	38

Table 12.6 Popular exhibits in the *Heritage* gallery [in decreasing order]
(Numbers in the bracket represent the location of the exhibit on the floor plan Figure 5.5, Chapter 5)

Observation Data	**Post-Visit Data**	**Later-Visit data**
Zodiac (1)	Zodiac (1)	Atom 2500 years Ago (11)
Sagar Jyoti (55)	Atomic Reactor (59)	Zodiac (1)
Yantar Mantra (30)	History of Zero (6)	Radio Telescope (31)
Properties of Matter (9)	Radio Telescope (31)	Atomic Reactor (59)
Big Numbers (4)	-	Sagar Jyoti (55)
Decimal Place Value (5)	-	-
Atomic Reactor (59)	-	-

Table 12.7 Popular exhibits in the *Fun Science* gallery [in decreasing order] (Numbers in the bracket represent the location of the exhibit on the floor plan Figure 5.6, Chapter 5)

Observation Data	Post-Visit Data	Later-Visit data
You, Me and Who else (82)	Wireless Communication (65)	Head on a Platter (86)
Head on a Platter (86)	You, Me and Who else (82)	Lift the Ball (51)
Electronic Organ (45)	Pythagoras Theorem	Fun Mirrors (88)
Cone Runs Uphill (2)	Fun Mirrors (88)	Rising Arc (5)
Message from Depth (17)	Planetary Motion (37)	All Roads Lead to Rome (40)
Movies (58)	Soap Solution (16)	You, Me and Who else (82)
Iris (69)	Plasma Globe (64)	Plasma Globe (64)
Chance of Your Choice (10)	Floating Ball (1)	Transfer of Momentum (28)

Table 12.8 Popular exhibits in the *Information Revolution* gallery [in decreasing order] (Numbers in the bracket represent the location of the exhibit on the floor plan Figure 5.7, Chapter 5)

Observation Data	Post-Visit Data	Later-Visit data
Computer Cluster (50)	Teleconferencing (45)	Cave (Enclave A & B)
Ragmala (12)	Computer Cluster (50)	Early TV Studio (39)
Dawn of the Era (A)	Early TV Studio (39)	Computer Cluster (50)
Early TV Studio (39)	Consumer Electronics (51)	Teleconferencing (45)
Teleconferencing (45)	-	-
Nostalgia (24)	-	-

12.5.1 Search for an ideal exhibit

All exhibits which are vividly remembered by students are important to us. These exhibits left an indelible print in the mind of students for several reasons: they are unique/unbelievable/mind-boggling; they are enjoyable; they are rich in experience; they help in making sense; and so on. All these reasons can be place under three headings- **Play, Simulation** and **Case Study.**

Play is a behaviour whose central mode of operations is to puzzle, to tease, to doubt at reality ... In the actions of play, reality is explored via curiosity and the conflict for the rules of how things, events, ideas and people operate (Reilly, 1974: 141). Spontaneous play is a means of reducing children's fears and anxieties in a novel environment.

The importance of the play aspect is also vital in the light of the fact that a visit is organised either as a diversion (more valid for school students) to the routine day schedule or as a social occasion (more valid in the family context) taking place in leisure time. It also fosters imagination and reasoning, as through it a child first seeks out the sensori-motor rules, then the rules of object and other people. As play brings its own reinforcement, a child may put whole-hearted effort into the exploration of the exhibit. There is another possibility too: play may be an end in itself. Having identified the tremendous potential of play in learning, it is to be borne in mind that play should not just be self-rewarding.

> The primary purpose of any exhibit design or strategy is to *communicate*, not to *impress*. If educational impact is the consequence of visitor involvement with the content of an exhibit, then entertainment must be designed to motivate this involvement (Screven, 1993).

The creative achievements of scientific thought depend on sustained attention, and imaginative ways of perceiving and efficient ways of processing information. This can be successfully done by employing the techniques of 'simulation' and 'case studies'.

A **simulation** is 'an operating representation of central features of reality'. In other words, a simulation must fulfil two conditions: first, it must represent a real situation and second, it must be operational. The action can, however, be compressed, accelerated, and debriefed to provide an intensive and engaging learning experiences. Simulations set out to elaborate certain mechanisms of the real world, in which people can try out strategies by acting in the various roles integral to those situations, but without sustaining the costs of failure.

A **case study** is defined as an in-depth examination of a real life or simulated situation carried out in order to illustrate special and/or general characteristics. There can be no disputing the premiss that a scientific issue in today's culturally plural world will be having different perspective around it. The case study approach provides a means of taking those different perspective into account in designing the exhibits. It has potential to present to the public arguments for and against a subject matter. It can give visitors a feeling that science is really a matter of figuring out relationships between things we know something about.

The relationship that exists between case study, simulation and play was first recognised by Reid (1977). Ellington and Percival (1981), based on Reid's idea, suggested the relationship between case study, play and simulation as shown in Figure 12.1. This model of Ellington and Percival provides us with a new basis of a taxonomy of exhibit effectiveness.

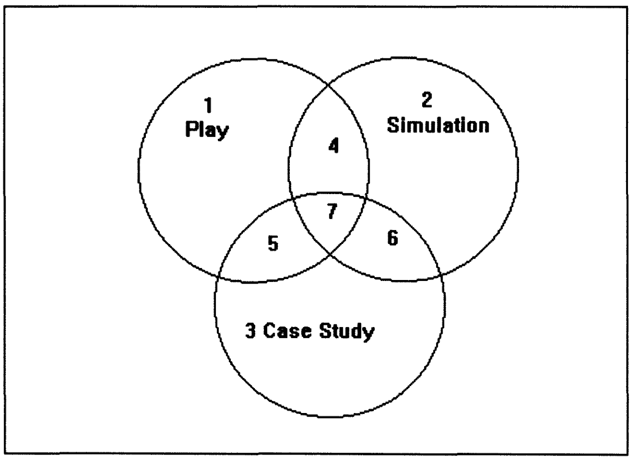

Figure 12.1: Seven areas of focus in exhibit development: 1. Play ; 2. Simulation ; 3. Case Study; 4. Simulated Play; 5. Simulated Case Study; 6. Play as Case Study; and 7. Case Study using Simulation and Play.

An exhibit having dominance of one component, for example play, has far less chances of success and, on the other hand, another exhibit developed in the seventh domain (case study using simulation and play) will have far more chances of achieving excellence and success. In the present study, most of the exhibits which have been remembered by visitors fall in 5th, 6th and 7th domain.

The exhibits which become icons of the museum (Perry, 1993), for example the *Dinosaur* exhibit at the Natural History Museum (London), the *Coal Mine* at the Science and Industry Museum, Chicago and also at the Regional Science Centre, Guwahati, and the *Restaurant Joules* at the Experimentarium near Copenhagen, invariably fall in the seventh domain. To make my point (that a scientific exhibit developed in the higher domain will have fair chances of being communicative and effective) explicit, I shall discuss next a case study from Experimentarium! the Danish Science Centre.

12.5.2 Case study using simulation and play: a case study from Experimentarium! The Danish Science Centre

The above discussion suggests that we can develop effective exhibits (high attracting power, high holding power and successful in communicating ideas). The probability of developing such an exhibit is highest if we focus on the seventh area - that is, case study using simulation and play. In the Indian context, such exhibits, though found in the gallery infrequently, have been proved immensely successful. In this part, I shall explore in the international context the validity of my conclusion. For this, I shall discuss an example from the Experimentarium!.

In the *Restaurant Joules* exhibit, it is intended to give an idea to visitors about the requirement of a balanced diet for good health. Sitting on a chair, visitors begin by recording personal data such as sex, age and so on., and plan their meal out of 56 common items (44 food plates and 12 drinks). As one chooses dishes, energy values in kilo joules are simultaneously displayed on a monitor fixed in the exhibit above the eye level. When the visitor finishes, nutritive constituents of selected food such as, energy, sugar, fat, and alcohol, are displayed on other monitor in the exhibit. The items are discussed separately and the visitor is informed to make changes until the nutritional value of the food is perfect. Visitors interact with the exhibit in groups. Sometimes three or four family members interact simultaneously. Often some members suggest from the back items which should be ordered in the next round.

In this study, visitors behaviour was observed from a nearby station. All visitors who interacted with the exhibit within one hour were observed on successive two days during evening hours. Visitors were observed consistently interacting with the exhibit much longer time (average 2 to 3 minutes; Table 12.9) than the average time of an exhibit anywhere in the world (~ thirty seconds).

Table 12.9 People attended *Restaurant Joules* exhibit in an hour.

Visitors **Date and Time**	**Girls**	**Boys**	**Women**	**Men**	**Total**	**Average time (sec)**
28.06.93 (4.00-5.00 PM)	7	4	8	2	21	171
30.06.93 (5.00-6.00 PM)	7	7	10	5	29	124

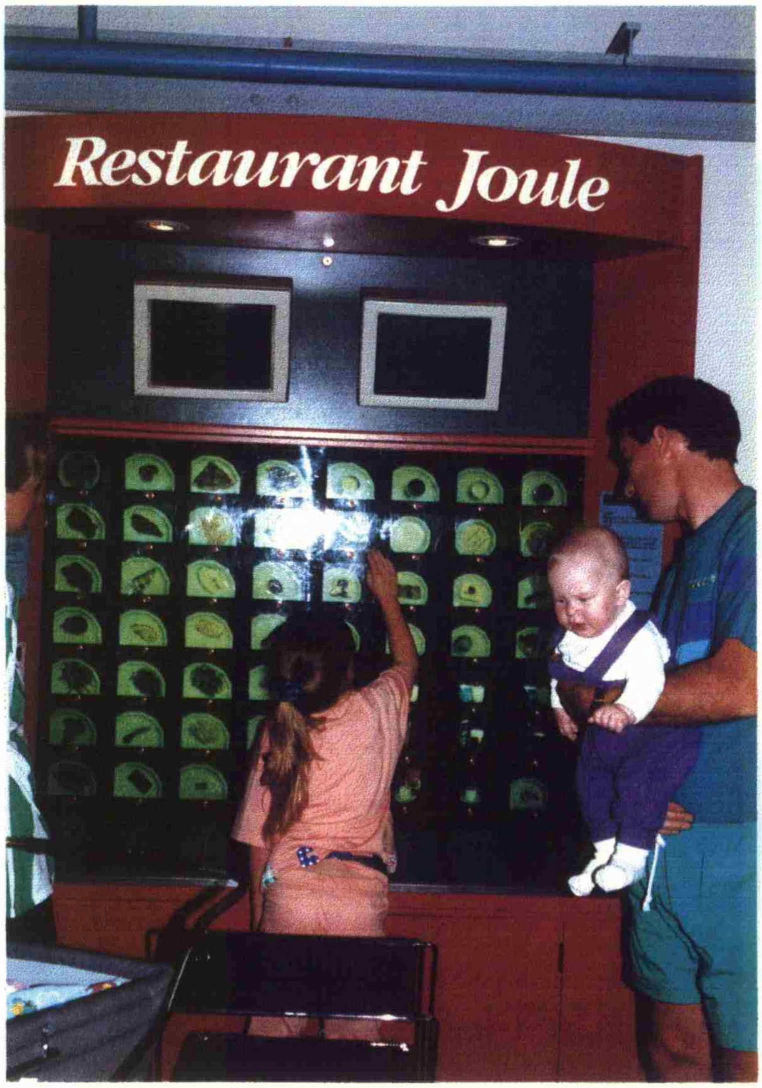

Plate 12.1 A family group with the *Restaurant Joules* exhibit.

Visitors were observed discussing which dishes to chose, and which not, in order to select a balanced diet. They were teasing other family members and cracking personal Jokes, just like those we encounter within an average family dining-room. There were also cognitive comments, for example "No, no fruit cream, it will cross the limit, choose something else." Some family groups were frequently found to be waiting to try the exhibit, like we often do in a city centre restaurant.

12.6 An analysis of findings and recommendations

Basing gathered evidence, there can be no doubt of the usefulness of Indian science centres as learning environments. The visiting students find them interesting; they exhibit exploratory behaviour in the galleries; they look happy in the galleries; they usually express that they had a great time in the science centre; they spend considerable time on selected exhibits; they develop positive attitudes toward science and science centres; they vow to visit the science centre again; and they vividly remember some of the exhibits for years. Although Indian science centres reasonably appear to be qualified as meaningful learning environments, in this section I will touch on wider issues. Millions of Indian children who, live in dire poverty and are fighting against the elitist-bias-system. Do they have anything to do with science centres and, conversely, do science centres have any concern for their uplift and welfare? And if yes, then again there springs up a number of issues pertaining to implementation - for example, what is to be done for them and what is to be left. And, most significantly, what means are to be employed to achieve the target?

Elite versus national integration

India is currently sustaining a delicate political, economic and social stability. However, it confronts a turbulent future - largely dominated by "population growth", "scarcity", "the revolution of rising expectations," "the inertia of tradition and culture," "effective policies but their half-hearted implementation," and "corruption". Nationwide, there can be seen conflicts generated by the ripples of "regional-ism," "communal-ism" and "caste-ism." Ironically, these conflicts have been set in motion by the very efforts which are made to achieve the goals of equality and democracy.

As discussed in Chapter 1, there exists a vast diversity of material and social cultures in Indian society. The major duality is the one which divides the urban and rural areas, but neither of these is internally homogeneous. On the basis of visible incongruity in society, there can be identified five segments - the urban elite (includes industrialists and politicians), the urban middle class (includes government bureaucrats), the urban non-white collar segment, the rural land-owner and the rural poor. As mostly political leaders adopt the policy of appeasement, they have to operate within the compulsion of a linguistic, communal and caste-divided society. For the sake of cheap and obedient labour, industrialists and wealthy people internally have a strong bias against improving academic and living standard of the poor. One study in West Bengal found that 54 per cent of the respondents belonging to the higher strata preferred to employ illiterate labourers, rather than literate labourers (Acharya, 1987: 73). Similarly, the urban middle class is mostly ignorant about the realities of the rural and urban poor's lives.

Hence, it can be reasonably inferred that the whole Indian system remains indifferent to the needs and aspirations of two major and most important groups in the society. These groups are important because without them there is no meaning of development of the country. In these circumstances, the question arises who exactly is going to think about the overall well-being of the poor and, more importantly, to introduce remedial measures. More than anything else, people need awareness, skills and education. In this context, Indian science centres have to shoulder their unique responsibilities in the world, and increasingly have to face peerless challenges in the future.

Ideally, science centres should cater for the needs of the poor schools that either have no science laboratories or have poor facilities. But, these schools rarely visit science centres because of lack of funds. To have funds from local education board, a principal has to run from pillar to post. Women teachers often reject the idea at first hand. Only a few enthusiastic teachers try for funds needed for organising educational trips, and again only very few (influential) teachers can manage funds. For government schools, transport is a major hindrance. In contrast, public schools have their own transport facilities, so they can visit science centres frequently. In this regard, science centres are required to work very closely with district or state education authorities in order to make arrangement of transportation for government school students and special needs children.

Regional versus national development

In the past 15 years, the growth of science museums in India has been very impressive. The curve of growth is linear (roughly one unit per year). One commendable point is that public money is more or less being utilised honestly. There can be found numerous examples in India wherein development takes place at incredibly slow rate. The *Vidya Sagar Setu* in Calcutta, for example, started in the early 1970s, was to complete within five years, but it was inaugurated in 1992 while the work on it was still in progress.

The impressive progress of infra-structure has a dark side, too. The regional disparity in the development is patently evident. There can be seen an immense emphasis on the development in and around Calcutta, whereas almost no development in several educationally backward states, for example Rajasthan, Haryana, Himachal Pradesh and Western Uttar Pradesh. With regards to development of new facilities, there is a clear need of a national vision and concern. Secondly, the vision that link development with the expansion of infra-structure creates a severe but invisible crisis. Most of all, the administration tends to be too pre-occupied with the provision of infra-structure (museum building, facilities and staff) to the neglect of the process required to make the system work efficiently. It is, therefore, urgently needed to exploit the potential of the existing infra-structure to the fullest. The task is stupendous, rigorous and vast, and its accomplishment depends on the set-priorities and administration plan.

Singular versus corporate administration plan

In general, there seems to be three different kinds of administration plan: *Rhetoric* (a paper plan, trickled-down from the higher-ups, with no sense of purpose shared by the head and staff); *Singular* (revolves around a single individual, clear priorities keep things moving but no, or half-hearted, involvement of staff means little impact); and *Corporate* (all partners have a clear sense of being responsible. Curators, teachers, visitors, staff and consultants unite to improve effectiveness). The different types of plan represent a continuum from the least effective, the rhetoric plan, to the most effective, the corporate plan. Ironically, in post-Independent India, the singular plan is found to be dominating, and almost all scientific institutions revolve around individuals.

> All these laboratories were brought into existence in the same way. A planning officer was appointed for planning the work and the building of each laboratory. The plan was usually drawn up on the basis of the work of similar laboratories abroad,... (Bhabha, 1963).

> I recently saw bibliography of publications by the head of a well-known Indian laboratory. This remarkable man had published over fifty scientific papers in one year ... No doubt junior colleagues had done most of the work, or all of it. But their names were not mentioned (Haldane, 1965: 20-21).

Science museums have also been created in a similar fashion. The credit of development, no matter in which state it is taking place, goes to the director general. The hierarchical organisation makes curators and other junior staff conscious of their position, impressing the need for adjustment to their superiors and showing the due respect for authority.

In the light of recent research, awareness of the characteristics of effective museums is wide-spread. The prominent features of museum effectiveness are a clear sense of direction, effective leadership, involvement of all staff in decision-making, intellectually challenging teaching and learning, and the involvement of visitors in decision making and policy implementation. While preparing the blue print of science centre movement in India, the Planning Commission in 1973 proposed a four-tier system in which a great deal of autonomy was envisaged for small science centres. But ironically, the present system creates an environment of full dependency on the senior officials. For example, it provides manuals to all science centres describing how to conduct educational programmes. For small regional and district science centres, there is an increasing need to abolish the ties of dependency on head-quarters.

> Never adopt a technique by its usual name. If you want to do re-engineering, or whatever, call it something different so that you have to think it through for yourself. If you just adopt and implement it, it is bound to fail (Mintzberg, quoted in Fullan, 1995).

Manuals of educational programmes should be considered as helping tools and as the reminder of minimum level of excellence to be achieved rather than as the book of religious practice to be followed strictly. Instead of directing small museums, they should be encouraged to become self-governing. They should be given responsibility for budgets, so that they can set their own priorities.

While furores of 'scientific temper' and 'popularisation of scientific outlook through literacy' has been increased in post-Independent India, research in basic science was decidedly superior prior to that (internationally reputed work of J.C. Bose, S.N. Bose, C.V. Raman, M. Saha, S. Ramanujan, to name a few). The thesis of singular administration plan seems to be the root cause of the general lose in the creativity of Indian science. For science museums to be effective, there is a pressing need to adopt the corporate plan of administration and to work on the principles of openness and collaboration.

Communication versus education

Communicating more effectively with visitors is one essential way in which science museums must broaden their educational role. Basically, there can be identified three forms of relationship between museums and their visitors: *Traditional relationships* (the understanding here is that 'museums-are-by-definition-good-and-noble-things' (Kavanagh, 1995: 130) and that non-visitors are not 'museum-minded'); *Market-based relationships* (treat visitors as clients and consumers, and tend to cater to the affluent and influential sections in society); and *Cultural relationships* (work on the principles of openness and collaboration, and seek assistance, support and understanding in the community as a whole). In most part, Indian science centres take the traditional approach to communication, nonetheless there can be seen some exceptional examples of cultural relationships. Evidently, under traditional relationships, museums have no role to play in making the life of children from lower strata in society and of those who are ignorant or less aware of the development which is taking place around.

Education in India has expanded rapidly, from 23 million children in school in 1951 to more than 130 million today. Painstakingly, as many as half of India's children (government's estimate is 20 million, but the figure could be somewhere between 50 to 70 million) between 6 and 14 years are not in schools. Many children leave schools to work (or are forced by parents to work) - often in hazardous environments - to help their families in the struggle for the survival. There is an another equally major group of children who run away from schools due to pedagogical reasons. Looking back to past developments and experiences, one may not feel very hopeful about the universalisation of elementary education (UEE). The National Policy on Education 1986, in one sense, acknowledges the failure of universal elementary schooling and legitimises non-formal education for out-of-school children. Most out-of-school children belong to the rural and urban poor sections. Science centres in India, like the whole system, do not consider this group as their user.

Primary classes, where the drop-out rate is maximum, most schools do not use the facilities of science centres for several reasons: first, due to poor publicity and marketing, most teachers remain unaware of the science museums and its facilities; second, most schools do not have transportation facilities; third, most schools do not have sufficient funds; fourth, most teachers do not want to take risks due to the lower age of pupils; and finally, teachers also do not find much material in science centres designed for the use of small children. There is an increasing need to create more provision and facilities for primary school children, by taking into account their traditional and cultural backgrounds.

The rural children face a real dilemma. When schools are open they find for themselves enough work in the fields, particularly in October and March-April, and they are relatively free when schools are closed during summer vacations. The 'opportunity cost' of keeping a child in schools during peak agricultural seasons tend to be high for the family. Parents prefer them to work in fields, as education does not pay in direct terms. Being themselves uneducated, they remain unaware of the value of education. Also, they find themselves left out of the process of modern agriculture, as their very poverty makes modern agricultural technology inaccessible to them. In these circumstances, the situation is unlikely to be changed significantly until a policy aimed at amelioration of educational backward go beyond to circumvent a wide range of social truths. Seen thus, it is imperative for science centres in India to formulate a communication policy which looks forward to the complete synchronisation between agricultural seasonalities, the local traditional occupations and the economic and social needs of the people.

There is a prominent example in India wherein, in the early 1980s, the District Science Centre, Purulia, worked closely with the *Kheria Sabars* -a very poor tribal community of about 10,000. The science centre made tribals familiar with the use of new agricultural implements, arranged seeds and fertilizers for their use through governmental agencies, and helped them in digging up six wells for water. The results were very encouraging - apart from good harvests of crops, 5000 thousand Kherias formed their own organisation called 'Kheria Sabar Welfare Association'. The science centre also started two training programmes in traditional crafts, namely the production of bamboo/vegetable fibre items and stone block-making. As the science centre also included marketing of the products, Kherias began earning from the ventures (Bagchi, 1986).

By accomplishing cultural relationships with their visitors, science centres can do a great service to the nation. They can inculcate among young students an interest and awareness for education; can stop those students in the school who are just on the verge of droping-out due to pedagogical reasons; can send run-away students back into schools, and can provide relevant skills to those who work in workshops, agro-based industries and fields. It is imperative for science centres to listen to the otherside, to the silence of the poor who believe that they have systematically and consciously been excluded from the main-stream.

Sociological versus pedagogical account of science

In the Indian context, there is no clear demarcation between science, religion and superstition. The roots of science in India can be traced deep into the past. The ancient account of everyday events, such as death, day, night, thunder, lightning and eclipse, takes today the form of mythical constructs, but was consistent within the epistemological framework of the ancient time. The explanation of the lunar eclipse - the imprisonment of Moon by Rahu - was internally consistent with the belief of Hindus that the heavens were inhabited by supernatural beings. Ironically, little seems to have changed in the wave of the Western science and scientific temper. An event of an eclipse today fascinates some astronomers, terrifies many, and make a fortune for astrologers and soothsayers across the nation. The recent total solar eclipse in India (24 October 1995) was a rare event and there was a real panic.

> Some refused to celebrate Diwali, believing it inappropriate on the eve of such ill omen. Pregnant women were careful to avoid the shadow, fearing

> it would cause the birth of a deformed child, and millions heeded astrologer's advice not to eat during the eclipse (Thomas, 1995).

A detached science centre exhibit demonstrating an event of eclipse, using a light source, a still sphere and a revolving sphere, is surely unlikely to mitigate the complex and incredibly deep fears of the public. Some educated people agree with what their elders say because by following the so-called 'unscientific' practice they do not have to miss much, but by not following they put themselves into a psychological trap, no matter how remote or illogical it is. The case of not receiving adequate and timely support from scientists leads to a loss of faith in science and people may easily turn to religious myths and superstitions.

In the rural areas, science and superstitions travel in the same boat. The introduction of science and technology in the field benefited the peasants as well as science. According to the government's report, up to 1991-92, 67 million hectares of land had been planted with high yield varieties of six food crops. Science benefited in the sense that villagers responsiveness compelled scientists to relate themselves to problems in the field. But, the real problem arose after a time when more and more fertilizers and pesticides were needed to maintain yields. Farmers' costs escalated while the gains in yield went down much less than expected. In these circumstances, an anger among people can lead to anti-technology feelings or faith in religious practice or indifferent attitudes to field-work. This situation in Punjab, the most intensive area of green revolution, provoked sectarian feelings and terrorism.

> Perhaps due to heavy pesticide exposure, birds in the region became dull, and would not fly away on being approached by human beings so that their visibility in the field increased. Incidentally, these birds also resembled a powerful religious symbol. This led to rumours that these had been sent there by a great Guru so that injustice caused to the people could be avenged (Dogra, 1993).

This anecdote is a clear example of how close the farmers are to the religious beliefs and superstitions. The nicely placed bowls full of high yield variety seeds or fertilizers or pesticides in science centre displays are not going to help the farmers. In a free society, expectations, goals and targets are determined by the consumers of science who demand that it be adequate for their purposes. When the exhibition policy run out-of-tune with society's requirement, it may be called dys-functional, irrelevant to current requirements. There is a clear and increasing need to 'get away from the habit of thinking in terms of *what exhibits do to people*, and substitute for it the idea *what people do to the exhibits*'.

To be more effective, meaningful and useful, science centres are increasingly required to take social scenes and moods into account, react to them, participate in them, and help to mold and shape society. If the knowledge of science is mediated socially and culturally, it has fair chance of being perceived as comprehensible and relevant. By fortuitous coincidence, the higher domains (Simulated Case Study, Play as Case Study; and Case Study using Simulation and Play) of our exhibit effectiveness model provide us with a conceptual framework to present science within the wider cultural context of social reality. The model allows us to present science in its natural expression: as an activity arising from the socially and culturally structured world.

Summary

Indian science centres are potent: they are successful in building and increasing students' attitudes towards science; they motivate individual visitors; they provide teachers with food for thought. Some of their displays are successful and others are unsuccessful. It has been found that the effective exhibits arose out of the juxtaposition of three components - that is, play, simulation and case study.

In spite of having an autonomous status, the National Council of Science Museums chose to be located within a bureaucratic system and duplicated many negative characters of a typical government office. This is, indeed, a major weakness of Indian science centres. Their rhetoric seems to be elite integration, instead of national integration. This study strongly suggests that, to be more effective, science centres have to embrace a more socio-pedagogical approach in presenting science instead of a pedagogical approach. There are at least two antecedents of this approach: first, more and more autonomy to small science centres (support instead of direction) and second, the inclusion of local communities and empowering them (directional inputs of the project or programmes should come from here).

As is found in this study, most students see science as a provider, science as an activity which is performed by highly educated and trained persons. Science centres have to blow apart the myth that each and everything has to be 'delivered' to the common people by very highly trained and skilled professionals. On the contrary, through their displays and activities, they need to show that people themselves in conjunction with the local agencies can solve a majority of their problems and protect themselves. They have to convey in them the image of science as an integral part of everyday life and a mode of inquiry common to all human beings.

Epilogue

As the twenty first century rushes towards us, the concept of lifelong learning is growing increasingly important. Nineteen ninety-six has been designated the *European Year of Lifelong Learning*. In 1978, in response to the question on the future of science museums in the 21st century, Frank Oppenheimer foresaw the weakening of the dominance of the classroom kind of education and, concomitantly, the strengthening of the informal education - a kind of concerted effort, an interlocking effort by television, libraries, museums, schools parks (Whitman, 1978).

Recently, World Media raised similar questions in a discussion forum: are we nearing the end of traditional education? Will computer networks, multimedia capabilities, and "virtual reality" make schooling obsolete? In his response, Lewis J. Pearlman, a senior researcher at the Discovery Institute in Washington, D.C., stressed that the very notion of traditional education will become obsolete. 'The new technologies that are now being developed will enable people of all ages and social conditions to learn anything, anywhere, at any time,' he added (*The Christian Science Monitor*, September 24-30, 1993).

In the 21st century, science centres in India have to play a vital role as centres of informal education, especially when the formal education has been failed to deliver its promises. It is a high time for science centres in India both to rethink radically their policies, so as not to disappoint their users, and to shoulder bravely their responsibilities.

Appendix 1	Questionnaire

PRE-VISIT SURVEY

Hallo! I am a research scholar in the Department of Museum Studies, University of Leicester, Leicester, United Kingdom. I am doing some research into the use of science centres. Could you please spare me your valuable time and fill in this questionnaire?

Thank you.

****

Surname		Name		Age	
Sex		Religion		Class	
School					

Which of the following items do you have in your home?

Popular Science Books	Vigyan Pragati	Science Reporter
Television	Science Fiction Films	Video Games
Science Encyclopedia	Personal Computer	

Newspaper (Please, specify which?) ....

Have you been to some field trips (in school group)? Yes/No

If yes, please furnish details-

Nature of field trip	**Place**	**Time** Month & Year
Historical Place		
Zoo		
Botanical Garden		
Industry		
Scientific laboratory		
Science museum		
Natural history museum		

PART A:

A few statements are listed below. You are requested to express your true feelings by ticking in appropriate box. The used abbreviations are:

SA - Strongly Agree A - Agree U - Undecided

D - Disagree SD - Strongly Disagree

Statements	SA	A	U	D	SD
I really like science (Please mention if you like particular subjects)...........................	☐	☐	☐	☐	☐
I feel that everybody should learn about science.	☐	☐	☐	☐	☐
Learning science facts is a drag.	☐	☐	☐	☐	☐
I hate to record observation in science experiments	☐	☐	☐	☐	☐
Science films bore me to death.	☐	☐	☐	☐	☐
I wish science class should be allotted more time than any other subjects.	☐	☐	☐	☐	☐
Working with laboratory apparatus make me feel important.	☐	☐	☐	☐	☐
I would like to join science club.	☐	☐	☐	☐	☐
I like talking about science with friends.	☐	☐	☐	☐	☐
I do not enjoy deriving science formulae using mathematics.	☐	☐	☐	☐	☐
I prefer to see all science specials on television.	☐	☐	☐	☐	☐
Looking through a microscope is not interesting to me.	☐	☐	☐	☐	☐
I hate to study science outdoors	☐	☐	☐	☐	☐
Discussing science issues is very common event in my home.	☐	☐	☐	☐	☐

Statements	SA	A	U	D	SD
I feel like day dreaming during science classes.					
I usually perform experiment several times to confirm results.					
Science has nothing to do with everyday problems.					
Science is the greatest enemy for environment and world peace.					

PART B: Please tick in appropriate space.

Statement	Never	Seldom	Sometimes	Regularly
I read science articles in newspapers				
I work with science related hobbies				
I attend popular science lectures				
I read science articles in magazines				
I write science articles				
I read science fictions and comics				
I make science projects in home				
I participate in science drama shows				

Please fill in (a) and/or (b) :

(a) I like science (or .... subject of science) most because

....

....

....

....

....

(b) I dislike science (or .... subject of science) most because

....

....

....

....

A few statements are listed below. You are requested to express your true feelings by ticking in appropriate box. The used abbreviations are:
SA - Strongly Agree A - Agree U - Undecided
D - Disagree SD - Strongly Disagree

Statements	SA	A	U	D	SD
The field trip helps in understanding of concepts learned in class.					
I like field trips which involve a lot of adventure					
The field trip is a waste of time.					
What I like best in the field trips is the discussion with friends.					
I would like to have more field trips, since they help in building class spirit.					
Field trips do not increase my interest in learning.					
Field trips inspire me to search additional information in text books.					
I hate field trips because my teacher scolds me for silly reasons.					
The field trip is an enjoyable way to learn.					
In field trips I feel exhausted.					
I return from field trips with new experiences.					
I would rather go to cinema than a science museum					
Working alone during a field trip is important for understanding the learning material.					
I love field trips because teacher encourage me to learn.					
I would go to Appu Ghar rather than a science museum					
I like field trips because I enjoy more freedom than that in the classroom.					

Appendix 2 — List of Exhibits

Exhibits in the *Heritage* Gallery

1	Zodiac	31	Ooty Radio T. Scope	61	Chain Reaction
2	Konark Wheel	32	Taj Mahal	62	Kalpakkam
3	Word Numerals	33	Horse And A Lady	63	Radio Isotopes
4	Big Numbers	34	Temple And A Lady	64	Establishments
5	Decimal Place Value	35	Brahma's Discs	65	Nuclear Research Quiz
6	Zero in India	36	Rasashala	66	Quiz on Computer
7	Square Root	37	Tribal Iron Furnace	67	Solar Gadgets
8	Golden Rule of Three	38	Zinc Smelting	68	Solar Energy
9	Properties of Matter	39	Yarghu	69	Energy from Water
10	Gravity, Elasticity Viscosity	40	Demo Counter - Metal	70	Liquid Gold
11	Atom 2500 years Ago	41	Demo Counter - Non Metals	71	Thermal Power Plant
12	Punchbhuta	42	Rosewood Elephant	72	High Yielding Cultivators
13	Tanmatra	43	Non Metal Artefacts	73	High Yielding Crops
14	Triguna	44	Metal Artefacts	74	Water for a Thirsty Land
15	Sulabhsutra	45	Rajasthani Plate	75	Jute, Lac and Seafood
16	Fun with Triangle	46	Brih. Temple	76	Toward Mechanisation
17	Geometry in Indian Art	47	S N Bose	77	Agriculture Quiz
18	Circle and Its Diameter	48	S Ramanujan	78	Rockets - ASLV
19	Area of a Circle	49	S Chandrasekhar	79	Satellite Model
20	Mathematical Series	50	Grand Unification	80	One Country One Nation
21	Unani medicine	51	H J Bhabha	81	INSET 1
22	Surgical Instruments	52	C V Raman	82	Weather Forecasting
23	Ayurveda Medicines	53	J C Bose	83	A Man in Space
24	Ayurveda Today	54	M N Saha	84	Agriculture
25	Three Major Texts	55	Sagar Jyoti	85	Space, Energy
26	Ayurveda	56	Computer exhibit		
27	Indian Archt. Sculpture	57	Television Demo. I		
28	Calendar of World's Civilisation	58	Television Demo. II	86-117	Industry for the People
29	Yanter Mantar I	59	Atomic Reactor		
30	Yanter Manter II	60	Power Reactor		

Exhibits in the ***Fun Science*** Gallery:

1	A precious Gift	31	Gravity Well	61	Seeing is not believing
2	Cone Runs Uphill	32	Pulfritch Pendulum	62	Deception on Bordering
3	Floating Ball	33	Loop the Loop	63	Who's Who
4	Grand Shuttle	34	On a Cycloidal Path	64	Plasma Globe
5	Raising Arc	35	Forced Diversion	65	Wireless Communication
6	Jumping Disc	36	Express Route	66	Polarisation
7	Projective Geometry	37	Planetary Motion	67	Is Light Visible
8	Pythagorous Theorem	38	Follow the Bounce	68	Colour Print
9	Probability Curve	39	Harmonograms	69	Iris
10	Chance of Your Choice	40	All Roads Lead to Rome	70	Colour Shadows
11	Toss a Coin	41	Parabola	71	Changing Colours
12	Acrobatic Stick	42	Rebound Balls	72	Polaroid Goggles
13	Fun with a Triangle	43	Stereo Hearing	73	Lines of Force
14	2D-3D	44	Echo Tube	74	Curie Point
15	Filmsy Prison Walls	45	Electronic Organ	75	Take Home Magnet
16	Soap Films	46	Sound Reflector	76	Identify a Magnet
17	Message from Depth	47	Organ Pipes	77	Magnetic Field
18	Impossible Mixture	48	Nodes and Antinodes	78	Electromagnet
19	Liquid Painting	49	Seeback's Siren	79	Magnetic Field
20	Trickling Drops	50	Lazy Tube	80	Elongated Images
21	Siphon	51	Lift the Ball	81	Vanishing Coin
22	Wave Motion	52	-	82	You Me & Who else
23	Lissajous Figures	53	Vibrating Rings	83	Mirror Room
24	Pendulum	54	Anamorphoses	84	Image Multiplier
25	Sympathetic Swing I	55	Guess the Figure	85	Infinity Mirror
26	Sympathetic Swing II	56	Illusion with a Ring	86	Head on a Platter
27	Sympathetic Swing III	57	Perpetual Motion	87	Kaleidoscope
28	Transfer of Momentum	58	Movies	88	Fun Mirrors
29	Chaos	59	Moire Pattern	89	Pressure & Temperature
30	Energy Level	60	Inside a Pipeline	90	Wave Tank

Exhibits in the ***Information Revolution*** gallery

1	Dawn of an Era	21	Editing Machine	41	Ham Station
2	Post Office	22	Typewriters	42	Communication Cables
3	Cloth Shop	23	Film Studio	43	Computer Age
4	Red Fort	24	Nostalgia	44	First Mini Computer
5	Cave	25	News Board	45	Teleconferencing
6	Indus Valley	26	Early Advertisements	46	Symbols
7	Oral Communications	27	Process Camera	47	Coded Information
8	Information in Nature	28	Telegraph Office	48	NIC
9	Information in Rocks	29	Amrita Bazar Press	49	GISTNIC Booth
10	Indian Art	30	Telecom Workshop	50	Computer Cluster
11	Rock Edicts of Ashoka	31	Telephone Exchange	51	Consumer Electronics
12	Ragmala	32	Recording Room	52	Finger Prints
13	Manuscripts	33	All India Radio	53	Sign Language
14	Coins	34	Sur Lahari		
15	Railway Station	35	Modern Office		
16	Morse Code	36	How Things Work		
17	Early Printing Press	37	TV Map of India		
18	Printing Demo.	38	Radio Map of India		
19	Lighthouse	39	Early TV studio		
20	Railway Artefacts	40	SITE		

Appendix 3 Level of Measurement

Numbers are used in different ways: sometimes they are used in a very rough and ready way and, at other occasions, in an extremely precise manner. Stevenson (1946) proposed that all data can be classified as being one of four types: Nominal/Categorical measures, Ordinal level measures, Interval level measures, and Ratio scale measures (in ascending order of precision).

Nominal measures reflect qualitative differences (for example, yes/no, pass/fail or male/female) and have the requirements of *mutual exclusivity* (each observation cannot fall into more than one category) and *exhaustiveness* (sufficient categories for all the observations). In this system, categories are distinct (for example, males are different from females) but not superior or inferior.

In **Ordinal level measurements**, the categories themselves can be ranked ordered with reference to some external criteria. The museum experience of students, for example, can be put into one of five rankings: excellence, good, average, poor, appallingly bad. The rankings reflect more (superior) or less (inferior) but not how much more or less.

Like an ordinal scale, the rankings of an **Interval measure** reflect more or less of some underlying dimension, but the difference between any two rankings remains equal. For example, 2°C difference in temperature between 38°C and 40°C is the same as the 2°C between 30°C and 32°C. As a further example, age in years is an interval scale because as well as ranking people according to their age, the precise difference between the ages can be quantified.

Ratio scale measures differ from interval measures only in as much as that they gave a potential absolute zero value. It is impossible to have minus number on a true ratio scale. Length, weight, elapsed time, speed, temperature on a Kelvin scale and frequencies are all examples of ratio scale measurement.

Working out Levels of Measurement

	Nominal	Ordinal	Interval/Ratio
Are there different categories?	Yes	Yes	Yes
Can I rank Categories?	No	Yes	Yes
Can I specify difference between categories?	No	No	Yes

Appendix 4 Parametric and Non-Parametric

A good number of well-known statistical tests such as the t-test, the product-moment correlation and analysis of variance (ANOVA), make assumptions about the distributions of scores in the populations. The common assumptions are that:

- the sample is drawn from the population randomly and the data is accurate as interval or ratio (many psychological tests cannot be measured accurately at the ratio or interval levels).
- the scores are normally distributed (have the classical 'bell-shaped' curve) in the population.
- the variances of population scores are the same in the treatment groups.

Statistical tests that involve these assumptions are called **parametric tests**.

If the data do not satisfy these assumptions then the **non-parametric** alternatives to the parametric tests should be employed. (The t tests, however, are an exception, and are said to be robust, that is they can cope with data which does not fully meet the assumptions made by parametric tests in general. The independent t test with different numbers in each group, however, is not robust).

The non-parametric tests are especially appropriate for use with ordinal and categorical measures where mean is not an appropriate measure of central tendency. Examples include the Mann-Whitney, Wilcoxon and Spearman's rho.

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