

CHAPTER I

CONCEPTUAL FRAMEWORK

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1.0.0 INTRODUCTION

Education plays an integral role in the development of an individual. It helps in shaping his ideas, perception, personality and attitude. Education helps to discover him as a true human being and gives him strength in this physical and spiritual world. It gives motivation and inspiration to live a fruitful life. It enriches individual with free mind and spirit. Apart from it, education is considered as a sociological, economical and cultural need of any human being. Education provides manpower to different sectors of economy in any country. Schools, colleges, universities and other institutions help in constructing a robust mechanism of imparting education to the people of any country. In this process of imparting education, various disciplines offered to students vary from arts, languages, sciences, social sciences, technology, etc. with different purposes to prepare manpower for the development of the country. Different subjects are taught to students to have a mastery over disciplines for productive contribution to the society. Most of these activities are done generally in a formal setting in schools, colleges, universities and other similar institutions. Apart from formal education, there is non-formal and informal education which is also an important tool for education. Science education for students and popular science for masses can be imparted through non-formal education. Popular science is important for community as it is important to educate society on rational thinking, open-mindedness and scientific temperament. Non-formal education institutes functions for providing science education for students and general public. Community Science Centres is one of the institutes which are established across India for this purpose. In Gujarat, Community Science Centres are formed whose objectives are to popularize science with conduction of different activities. This study focuses on functioning of Community Science Centres in Gujarat with respect to organizational structure, human resource management and financial management. The research is also carried to know to what extent the Community Science Centres in Gujarat has succeeded in attaining objectives of non-formal science education.

1.1.0 SCIENCE EDUCATION

Science, in the broad sense, refers to any systematic knowledge or practice that is achieved through scientific method and research. Science continuously seeks physical and logical explanations for the behaviour of the object in nature and tries to dispel suspicion and superstition. One cannot underestimate the scope of science in today's world. Science is the backbone of human existence. The practical effects of science can be seen in motion everywhere. From path breaking discoveries in atomic science, discovery of newer vaccines in life science, technological advancements in the field of communication, transportation to weather prediction, science has left no aspect of humans untouched. Science education is an important ingredient which makes a person knowledgeable. Hence, teaching of science is one of the important aspects of the education imparted to the people of our country. The importance of science is immense. It helps in transforming societies. The countries of developed world are examples of it.

Science education plays a pivotal role in developing scientific attitude like rationality, curiosity, objectivity, open-mindedness, critical mindedness, intellectual honesty and observation. Science education also provides scientific thinking among human being which is important for the overall growth of the society. Science boosts the motivation level of individuals and prepares minds without superstitions. People must be able to consider the implications of emerging options in science which impinge directly upon their lives, including the ethical, moral, legal, social and economic aspects. A sense of scientific temperament should be entwined in the masses for healthy growth of society. Understanding of natural phenomenon and logical thinking can be achieved through science education. National Policy on Education (1986, revised in 1992) states that science education will be strengthened to develop in the child well defined abilities and values such as the spirit of inquiry, creativity, the courage to question and an aesthetic sensibility. Science education programmes will be designed to enable the learner to acquire problem solving and decision making skills and to discover the relationship of science with health, agriculture, industry and other aspects of daily life. Every effort will be made to extend science education to the vast numbers who have remained outside the

limit of formal education'. The policy emphasized on the role of agencies working beyond formal education for the development of science education in the country. The policy states that to accelerate the growth of the economy, science education and research should receive high priority. The policy also stressed that science and mathematics should be an integral part of general education till the end of the school stage.

National Curriculum Framework for School Education (2005) also lays down emphasis on importance of science education. Science is a dynamic, expanding body of knowledge, covering ever-new domains of experience. In a progressive forward-looking society, science can play a truly liberating role helping people escape from the vicious cycle of poverty, ignorance and superstition. Therefore, special attention is needed to modernization of science curricula and recommended for science centres catering the requirements of the community. This framework laid emphasis on the process of science learning through activity method, discovery and critical thinking. The context-based and activity based approach to teaching and learning is the output of this framework that enhanced and promoted the activities of science centres those were created in the similar line of activities. These centres are working to promote science education through the formation of meaningful concepts, facilitate application of concepts to realistic settings and to make instruction more attractive through child centred pedagogy. Child centred pedagogy gives primacy to children's experiences, voices and their active participation; the direction is to plan learning in keeping with the children's psychological development and interests.

Science education is significant for knowledge generation. The scientific concepts are important to study for understanding nature. Humans can acquire scientific knowledge to arrive at logical and critical thinking which is important for healthy growth of society. Knowledge can be categorized based on distinct kinds of concepts and meanings involved and processes of validation and justification. Each involves its own kind of 'critical thinking', its own way of verifying and authenticating knowledge and its own kind of 'creativity'. The Sciences have their own concepts, often interconnected through theories, and are attempts to describe and explain the natural world. Scientific Inquiry

involves observation and experimentation to validate predictions made by theory (hypotheses), which may be aided by instruments and controls.

It is also said in the report of Kothari Commission (1964-66) that science has radically transformed man's material environment. It has increased the span of human life. Science is universal and so can be its benefits. Its material benefits are immense and far reaching, but even more profound is its contribution to culture. Science liberates, enriches mind and enlarges human spirit. Its fundamental characteristics have turned out to be the possibility of unlimited growth. Advancement in science deepens our understanding of nature. Further the Commission added that if science is to be pursued with full vigor and zest and is to become a mighty force in the Indian renaissance, it must derive its nourishment from our culture and spiritual heritage and not bypass it. Science must become an integral part of our cultural fabric.

1.2.0 OBJECTIVES OF SCIENCE EDUCATION

The objectives of the science education at school level is framed which may also be applied for the non-formal and in-formal systems. Following are the main objectives of science education in schools according to National Council of Educational Research and Training (NCERT) (2006) and NCF (2005).

- To acquire understanding of science concepts, principles and laws.
- To impart up to date knowledge in science and to know the facts and principles of science and its applications, consistent with the stage of cognitive development.
- To acquire the skills and understand the methods and processes that lead to generation and validation of scientific knowledge.
- To develop their curiosity to learn science and inculcate in them a historical and developmental perspective of science and to enable the learner to view science as a social enterprise.

- Relate to the environment (natural environment, artifacts and people), local as well as global and appreciate the issues at the interface of science, technology and society.
- Acquire the requisite theoretical knowledge and practical technological skills to enter the world of work.
- Nurture the natural curiosity, aesthetic sense and creativity in science and technology.
- Imbibe the values of honesty, integrity, co-operation, concern for life and preservation of environment.
- Cultivate scientific temper-objectivity, critical thinking and freedom from fear and prejudice.
- To experience and internalize science through five sense i.e. sight, smell, hearing, touch, taste.
- To enable to investigate the scientific phenomena rather than just verifying known conclusions.

In a gist, it can be said that the prime objectives of science education is to understand nature, infuse scientific temperament in humans and knowledge generation. These objectives are attained through different modes of education.

1.3.0 MODES OF TRANSACTION OF SCIENCE EDUCATION

Though science education can be provided in formal, non-formal and informal ways, the major share of formal system in providing science education is more which is provided in the school and colleges making it a part of the curriculum. Hence, a uniform pattern of compulsory science education is provided in the school education. The objectives of the science education at school level may also be applied for the non-formal and in-formal systems also.

1.3.1 Formal Education

As per Naik (1977), the formal school is mainly organized to teach something and it is round this specific purpose that everything else, viz., its staff, buildings, equipment and students get organized. The formal school is by and large a full time institution and is meant essentially for non-workers, i.e. children and youth. It is, therefore, utilized more by the well-to-do classes who can afford to send their children to schools earlier and keep them there longer; and for the same reason, the children of the poor who are required to begin their working life early, become its drop-outs. The formal school is manned, by and large, by full-time and professional teachers. The role of a teacher in a formal school is generally that of a superior individual and the general teacher-pupil relationship is of the dominant-subordinate, of the giver-receiver, of the active-passive type. The programmes of formal education are carried out through the school which is a specialized institution for imparting education. The formal system, on the whole, tends to be dominated by concepts of uniformity and rigidity. The school can afford to have, and generally has, 'captive' audiences and also compels them to put in a specific attendance. Here, the persons who wish to educate are mostly non-workers. It is, therefore, essential to introduce work-experience in schools which is a difficult problem.

Sheth (1993) says that formal education is highly structured, loaded with the fixed preconceived goals and objectives which can be imparted within the four walls of a school. It has strict and fixed rules of admission. It is too formal, rigid and inflexible. It is closed system of education. The present day formal education is theoretical, bookish and information oriented where children not only do not react to the neighborhood environment but also to their own home environment. The course curriculum and content is prefixed which cannot always fulfill the needs of the learners. The time and duration of schooling is decided by the administrators which is not always suitable to the learners. It is costly to educate everyone who desires through formal education system. Our schools are kept isolated from the ordinary conditions of real life, by making their learning compartmentalized and away from real life situations. The common people, who mostly remain outside the school system inspired by its huge size and enormous cost, continue to

be deprived of education and thereby of many other good things of life. It is teacher-oriented, making the teacher a controlling unit of the classroom situation. There is very little scope for a dialogue between the teacher and the taught thereby preventing a learner from free expression of his feelings.

1.3.2 Informal Education

Rennie et al. (2003) says that out-of-school learning is self-motivated, voluntary, and guided by learners' needs and interests, so certain aspects of learning are critical to investigate. E.g. the role of motivation, choice and control, interest as well as expectations in the learning process is important.

As cited by Votaw (2008), Falk and Dierking derived a contextual model of learning within informal contexts. In this model, there were three core intersecting elements that contributed to the learning that occurred within the given context. The first element, personal context, included motivation, emotion, interest, attitudes to learning as well as existing knowledge and ideas. Since no two people had the exact same experiences, this context was unique for each learner. Much of the personal context embedded emotion and motivation. Falk and Dierking referred to each group as a 'community of learners' in which each of these communities was distinctive in how they behaved in certain situations. The community in which they were learning affected the amount and type of learning that occurred.

1.3.3.0 Non-Formal Education

As per National Policy on Education (1986), the non-formal education (NFE) programmes, meant for school dropouts, for children from habitations without schools, working children and girls who cannot attend whole-day schools, will be strengthened and enlarged. Modern technological aid will be used to improve the learning environment of non-formal education centres. Talented and dedicated young men and women from the local community will be chosen to serve as instructors and particular attention paid to

their training. All necessary measures will be taken to ensure that the quality of non-formal education is comparable with the formal education. Steps will be taken to facilitate lateral entry into the formal system of children passing out of the non-formal system. Effective steps will be taken to provide a framework for the curriculum on the lines of the national core curriculum but based on the needs of the learners and related to the local environment. Learning material of high quality will be developed and provided free of charge to all pupils. NFE programmes will provide participatory learning environment and activities such as games and sports, cultural programmes, excursion, etc. For adult education, the policy states that comprehensive programmes of post-literacy and continuing education will be provided for neo-literates and youth who have received primary education with a view to enabling them to retain and upgrade their literacy skills and to harness it for the improvement of their living and working condition. These programmes would include establishment of continuing education centres of diverse kind to enable adults to continue their education of their choice and creation of learners' groups and organizations.

Naik (1977) says that in a non-formal programme, the central point is learning: either by oneself or learning together by a group of interested individuals. The programmes are basically meant for those who want to learn while working and therefore part time. Non-formal programmes can be run by full-time and professional teachers. But they are also run by a very large number of para-professional or non-professional teachers or by volunteers or by anyone who is prepared to share his knowledge with others who desire it. The teacher is engaged as an equal in the joint enterprise of learning along with his students and there is a continuous feedback from the teacher to the students and vice-versa. The students learn from each other while the teacher merely acts as the facilitator. The programmes of non-formal education can be built round almost all social, economic and cultural institutions such as farms, factories, shops, libraries, museums, drama and so on. Infact, the capacity of non-formal institutions enables it to tap the immense educational resources of the community which are not utilized by the formal school. In this system, programmes tend to be dominated by concepts of diversity, flexibility and elasticity. The attendance in non-formal activities is generally voluntary: people turn out

and participate in a programme only if they find it relevant and interesting and worth their time and effort. This very nature makes decentralization inevitable because the clientele must be brought into the process effectively to define their needs, interests and priorities. The cost tends to be lower because of the use of para-professionals and non-professionals and optimum use of all community resources.

Sheth (1993) says that non-formal education is an open system of educational programmes concerned with economic, social and political responsibility, so that every human being becomes an authentic human being. Raising critical consciousness on the part of participants is central to the programme of non-formal education. The programmes are need-based and developed as per the needs of the targeted population. Its clientele population might include children, adults, drop-outs, illiterates, semi-literates and professionals. It focuses on improvement of social and personal living, occupational capability and vocational competency. Non-formal education helps a person to develop a skill of converting his literacy in the education direction, makes him autonomous, capable of dialogue, critical and constructive and far-more capable of self cure. The participation and decentralization at all levels is precondition for successful implementation of the programme. The perception regarding development on the part of the people affects the development programme greatly. So change of perception on the part of clients of non-formal education is essential. The contribution of education will depend on the demands and signals of socio-politico-economic structure of the society. Therefore non-formal education need not be expected to be neutral to its environment.

The aspirations of the people based on their needs and interests, social, cultural, political, economic are to be satisfied by providing educational programmes by the flexible system of education. Both formal and non-formal education are complementary to each other and provide learners an opportunity for learning.

1.3.3.1 Relation between Formal and Non-formal Education

Pandey (2005) says that there is closed relation between the objectives of formal and non-formal education. Both the systems of formal and non-formal education aim at improving the quality of life and raising the living standards. The major objectives of the system is to develop the personality of the child through inculcating values, attitudes and other necessary skills of life so that the children can become productive members of the society. Non-formal education has been introduced to cater the needs of out-of-school children who are either drop-out from formal schools at various stages or have never been to school who could not avail of the facilities provided by the formal system due to socio-economic compulsions. It also intends to meet the essential learning needs of children living in remote and sparsely populated areas where the establishment of the formal school is considered to be non-viable.

As per Pandey (2005), non-formal education has uniqueness of flexibility in respect of timings, vacations, curriculum and multiple point entry, etc. and adjustment according to local specific needs of the area and locality. School hours, school vacations and curriculum are adjusted according to needs of the community. Because non-formal education is aimed at different groups with different purposes and requiring different approaches, strategic goals in non-formal education programmes are better conceived in terms of problems that must be solved. In formal education, policy-makers, teachers and administrators can more or less dictate what students must learn and even how they must learn because they hold the keys to certification and advancement through the system. Educators in non-formal programmes do not have these incentives to offer. They can only attract people who want to learn something in order to improve their lives and to gain access to opportunities otherwise out of reach. In other words, people who choose to participate in non-formal education programmes are usually those who have taken responsibility for their own learning and achievement.

An effective non-formal education programme recognizes this important quality of its learners and keeps the learner in control of his or her learning. The learner must be

allowed to take charge of his or her own learning. A corollary is that communities of learners must be encouraged to take responsibility for opportunities for their members to learn. The non-formal education providers must be encouraged to take responsibility for opportunities for their members to learn. Non-formal education providers must be responsive to learners' needs and interests. One size does not fit all. This means that non-formal education providers must help create curricula and materials that respond to the specific needs of specific groups of learners. The provider must work with the group to clearly identify the problem to be solved and the resources needed to solve it. All communities get benefits of non-formal education and thus help in capacity building of individuals. The subject of science can also be taught in a non-formal method.

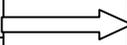
1.4.0 SCIENCE IN NON-FORMAL EDUCATION

In the formal setting science education is taught as a subject in the elementary as well as secondary education and as a discipline in higher secondary and university stage. Apart from formal system, there are other systems like non-formal and informal system. In non-formal system, different open institutes provide science education through different courses e.g. National Open Schools and different open universities. Science education can also be taught in both formal and non-formal method. It can be communicated through communication mediums like print media, electronic media, social media, internet as well as science awareness activities in different institutes. A need is felt to inculcate scientific knowledge, scientific attitude and scientific temper for the masses in the community through formal, non-formal and informal education.

In the non-formal and in-formal system, there are many agencies in the society either supported by government or private organizations. These agencies provide science education to the citizens of the country irrespective of the age groups. One of the major functions of imparting science education is done by non government organizations (NGOs) in the form of Community Science Centres.

As per Kumar (2013), pedagogically, it is found that there are at least four rich themes in education theory that is specially related to the various forms of learning activities found in science centres and museums—curiosity or intrinsically motivated learning in education, multiple modes of learning, play and exploration in the learning processes and the existence of self developed world views and models among people who learn science. Generally in the traditional science teaching in Indian schools, there is a tendency of teachers to teach abstractions, definitions and explanations of phenomenon that, for the most part, students have never had the opportunity to explore. They usually put explanations before first-hand experience of natural phenomena, whereas science centres, which are hub of non formal science education in the country, reverse the process. The shifting paradigm of education and learning is emphasized in these non-formal settings of learning. Table 1.1 shows the paradigm shift of learning in education. Science centres present phenomena in the form of exhibits that are interactive and manipulable, exhibits whose purpose is to enable visitors to explore and experiment. A major factor in student achievement in science is the quality of science education given in a school. Effective classroom teaching helps children develop the essential thinking skills they need to weigh evidence, solve problems, balance risks and rewards and make sense of their environment. The science centres offer a variety of engaging, hands-on learning opportunities that allow children, families and guests to explore new ideas at their own pace. These interactive experiences are designed to meet different learning styles.

Table 1.1: Paradigm shift of learning

From		To
Teacher-centric		Child-centred learning environments
Transmission of information		Construction of knowledge
Knowledge as given and fixed		Knowledge as it evolves
Teacher directs, guides and monitors learning		Teacher facilitates, supports and encourages learning
Learning by rote		Learning through activities, exploration and discovery
Disciplinary, linear exposure		Multidisciplinary, divergent exposure
Memorizing		Understanding

It was observed that previous education was confined to classroom, teachers, textbooks and concerned subjects. Now there is a paradigm shift which shows that learning takes place anywhere and not necessary by the teachers only. It could be through technology and its implications on the desire of the learner where he or she is interested to learn. Thus, a major shift is coming in learning through different means.

Non-formal education institutes use 'learning by doing' method and 'keep it simple make it fun' principles which provoke, entertain, attract and engage the visitors through guided exploration and facilitated activities. The environment displays and the outcomes involved in a visit to a science centre form an extremely complex but interrelated total experience that is unique to each visitor. The state of the art laboratories at science centres allow visitors to participate in more complex experiments. The programs for school groups extend and deepen the educational impact of exhibits. The science centres and museums have expanded their role in communities by partnering with schools and community organizations to extend science learning into places where students already spend their time after school. Children and teens can discover new interests, develop new skills, prepare for college and learn about careers in science and engineering. Science centres and museums are thus developing into a new kind of public learning centre, fulfilling some of roles of the public-education that modern universities have neglected.

Science education programs such as demonstrations, science fairs and seminars, nature trails, quizzes, film shows, computer awareness and training programmes, sky observation, vacation workshops, environment related programmes, science exhibition at science centres and museums are designed to meet local educational needs and fill gaps in the local educational systems. Science centres also implements demonstration method to learn science. Demonstrations seek participation of students, thus providing an opportunity for learning science as inquiry. They are excellent motivation factors in learning. Demonstrations are helpful in explaining skills which explain even minor points which students can observe. They promote relevant and useful discussion in the classrooms, gives opportunity to ask questions and to make critical observations and suggest measures to improve. It is essential that a demonstration must be relevant and

purposeful and the purpose must be appreciated by the students. A demonstration must sustain interest among the students. An effective demonstration can lead to thinking and students can ask searching questions. After the completion of the demonstration the students should analyze their observations or should study the recorded data and attempt to come to conclusions.

Thus non formal education can be considered as a missing ingredient in between formal and informal education. Because non-formal education is flexible, relevant, functional, practical and need-based out of school programme. It is systematic and deliberate effort. It is an education by objectives.

Most part of the learning in Community Science Centres is based on experience and experimentation which makes it easier to understand scientific concepts. The students and public can easily understand scientific concepts through experiential learning.

1.4.1 Experiential Learning

As per Association for Experiential Education (2011), the characteristics of Experiential Learning are as follows.

- Experiences are structured to require the learner to take initiative, make decisions and be accountable for results.
- Throughout the experiential learning process, the learner is actively engaged in posing questions, investigating, experimenting, being curious, solving problems, assuming responsibility, being creative and constructing meaning.
- Learners are engaged intellectually, emotionally, socially, soulfully and/or physically. This involvement produces a perception that the learning task is authentic.
- The results of the learning are personal and form the basis for future experience and learning.
- Relationships are developed and nurtured: learner to self, learner to others and learner to the world at large.

- The educator and learner may experience success, failure, adventure, risk-taking and uncertainty, because the outcomes of experience cannot totally be predicted.
- Opportunities are nurtured for learners and educators to explore and examine their own values.

The educator's primary roles include setting suitable experiences, posing problems, setting boundaries, supporting learners, insuring physical and emotional safety and facilitating the learning process.

Considering the characteristics of experiential learning, it can be said that learning in real sense takes place in the non-formal setting, particularly science education where the classroom learning is being strengthened through non-formal science education institutes. The experiential learning is not only confined to the school children as it is not confined to the schools only. Considering the proximity of non-formal education centres like science centres, it is accessible to the learners of ages, irrespective of their previous educational knowledge. Hence science education is being imparted to whole community through non-formal science education by these science centres.

1.5.0 SCIENCE EDUCATION FOR COMMUNITY

Scientific theory is developed and when it is practically implemented in the society, a new technological revolution takes place. Science should not be restricted to school and college premises. Apart from curriculum based science, a general science should also reach to communities for development of society. Science communication to the masses is essential to educate public about different scientific aspects. Science popularization is necessary so that public do not remain ignorant about various scientific phenomena occurring in their surroundings or outside atmosphere. Science communication has a great potential in shaping the lives of the people and making their decisions more informative and rational.

Science and Technology Policy (2003) emphasize the importance of science and its popularization among masses. It states that there is a growing need to enhance public awareness about the importance of science and technology in everyday life and the directions where science and technology is taking us. Science, Technology and Innovation Policy (2013) also focus on public awareness and public accountability of Indian science, technology and innovation sector. It states that public understanding of science is an important dimension for introducing and reaching the benefits of modern science and technology to the people. The civilizational aspect of science or scientific temper needs to be promoted across all sections of the society systematically.

Salvi (2002) states that science communication is a much neglected field in India. There is a crunch of good science communicators who can disseminate science to general public. From high school onwards, communication skills are given the least priority among science students. Hence science students lack this skill which proves hindrance to science communication. Scientists also are engrossed in their research work. So they do not pay heed to communicate science to layman. Community benefits from concrete science communication encouraging them to build scientific attitude. Development of scientific temper and scientific attitude in daily life among the people are very much important for socio-economic development of the citizen. It is important to create awareness among the people about removal of prevailing superstitions from the society through scientific approach so that socio-economic development can take place.

As per Sehgal (2010), science literacy can raise, or create, awareness about an issue, or a useful practice; against a harmful practice, tradition, or a superstition. It can help demystify so-called miracles performed by self-styled godmen or things like uncommon natural phenomenon, diseases etc that generate needless awe, fear, or apprehension. It can encourage people to adopt logical thinking and reasoning, more and more often in whatever they do, with real life examples, which get the message home effectively. It can help raise levels of scientific literacy among people in general. It is necessary for a concrete set-up to provide science education to community through science

communication. A specific mechanism of science education is required to spread among masses for building a healthy scientific society.

The popularization of science and technology must make knowledge a central component of culture, of social awareness and of collective intelligence. It must also contribute to an effective integration of cultural, ethnic, linguistic, social and economic issues. The technical possibilities of gaining access to information are changing our vision of the world and transforming the relationship between human beings and the appropriation and dissemination of knowledge. Today, access to knowledge is synonymous with development, wellbeing and quality of life. In this context, scientific and technological literacy is a social and ethical right of all human beings.

It is a great moment in the history of civilization to impart science education to the whole community through these non-formal institutions. The future will see that like traditional customs, science education would be a part of the culture. It can help to a large extent to wipe out blind beliefs, superstitions, etc. from the society. The time will remember the contribution of these non-formal centres of science education.

1.5.1 Science and Culture

Science and Culture are also interlinked with each other in the society. Khened (2013) says that scientific knowledge and culture has been an integral part of India, which has a long history of more than 5000 years. Traditional knowledge in ancient science and technology, medicine, etc has been associated with the Indian culture. The rich scientific, technology and cultural heritage of India can be seen in the marvel architectural, archaeological, edifices and museum collections that are spread across India. The acceptable public understanding of scientific culture extends from a minimum amount of scientific knowledge, when any individual should ideally possess, to a more global view of social mastery of scientific and technological developments. Scientific culture is also seen as an asset for economic development.

As per Persson's study (as cited by Khened, 2013), the role of science centres in enhancing the public understanding of science and in helping create a scientific culture in society has been widely accepted. The science centres play a crucial role of redundancy (factor of safety) which the design engineers adopt in making every design fail safe. The same analogy can be taken forward to the science centres, which are a necessity supplements to formal school education, though as a redundant factor, in ensuring that development of scientific culture in society is made more effective and fail safe akin to the engineering designs. The term 'scientific temper' was first used in India by Pandit Jawaharlal Nehru in 1946 in his famous book named 'Discovery of India'. Nehru relentlessly expanded the notion of scientific temper and strived hard to convince the political and scientific leadership to inculcate scientific temper among its citizens. The science centres and other likeminded institutes have a major role to play in a non-formal setting. These institutes will help in accentuating the process of spreading scientific literacy and scientific temper for developing a scientific culture in society. The role the science centres play in social appropriation of science and technology is becoming increasingly significant across globe. This aspect can best be understood looking how effective science communication can be realized by the science centres through the multifarious approaches that science centres adopt in achieving their objectives.

As per Khened (2013), the science centres have a multifarious objectives which include popularization of science, enhance the understanding of science, imparting scientific temper, etc which they try to achieve through various programmes, exhibitions, competitions and events that are organized for different sections of society. Scientific methods are more often than not applied by every individual subconsciously in day-to-day activities to solve everyday problems. The science centres play a role in perpetuating such a process of thinking in society. The parameter that one could consider to gauge the scientific temper or scientific attitude is characterized by the traits which include: a) Healthy Skepticism, b) Universalism, c) Freedom from prejudice or bias, d) Objectivity, e) Open mindedness and humility, f) Willingness to suspend judgment without sufficient evidence, g) Rationality, h) Perseverance-positive approach to failure. Questioning is central to developing rational thinking and therefore, most of the exhibits installed in the

science centres accentuate this very innate nature of human beings to ask questions which is central to scientific thinking and scientific culture. The science centres play a major role in society in developing the above traits through multifarious activities.

According to Sehgal (2010), scientifically literate person is likely to be better placed to critically examine and analyze pros and cons of issues with scientific content and a better participant in debates on issues concerning science and technology because of informed opinion. He can better able to appreciate technological advances and to make use of them to his/her advantage and less affected by superstitions and blind beliefs. He can better able to differentiate between fact and fiction also.

In India, different non-governmental organizations have initiated awareness for science which took shape of movement. These people movements played a major role in cultivating scientific attitude in the minds of people.

1.5.2 People's Science Movements

As per Ramchandran (2013), science popularization groups, generally known as people's science movements, have played a cardinal role in disseminating science. Early efforts in pre-independent India were made by educators, teachers and science workers. Srirampur College established in Bengal in 1818 probably initiated first public demonstration of modern science in India through public lectures accompanied by experimental demonstrations by its teachers. Besides popular science lectures, initial science popularization efforts included translation of science books in the vernacular and writing of popular science articles.

The origins and development of science movements in India can be traced back to the pre-independence era. The scientists like Satyendra Nath Bose had initiated the formation of movements like Banjeeya Vigyan Parishad, Assam Science Society, Bigyan Prachar Samithi (Orissa) and so on. The 1950s and 1960s witnessed the emergence of numerous voluntary groups around various aspects of the application of science and technology in the development process, especially in the rural areas. Even though the professional

scientific organizations have, by and large, continued to confine themselves to the narrow concerns of their disciplines , a large number of individuals, scientists, dissatisfied with their scientific practice, have increasingly been drawn to science based social activist groups.

Non-governmental Organizations (NGOs) in large scale are playing crucial role in taking science to the masses. People's science movements have emerged as an important dimension of science popularization movement in India. The above stirrings have mostly been at the level of groups working at micro regions or around some specific issues. But there are a few instances where science based social activism has developed into mass movements or revealed such a potential. Organizations like Tamil Nadu Science Forum (TNSF) and Kerala Sastra Sahitya Parishad (KSSP) have been started by intellectuals and science writers with a focus on disseminating science among the common people and to cultivate scientific temper and a scientific world outlook among them. They knew that the matrix of science can be woven only on a fabric of literacy and drew itself closer to the society through literacy movement. The Kerala Sastra Sahitya Parishad (KSSP) is one such novel example of people's science movement launched for science popularization.

1.5.2.1 Kerala Sastra Sahitya Parishad

The main goal of the Kerala Sastra Sahitya Parishad (KSSP) is to translate science in simple language and make the people endowed with a new world outlook. The ideology of the KSSP is epitomized by its slogan 'Science for Social Revolution'. KSSP started functioning in an attempt to popularize science among the masses. The present ideology is the evolutionary product of its activities and experiences. Science should become a powerful weapon in the hands of the majority in their fight against impoverishment. An important characteristic of the KSSP is its partisanship with the cause of majority. The KSSP takes, on every issue, a stand partisan to the majority. It strives to arm the majority with the weapon of science and technology in their tight against impoverishment, against the exploiters. KSSP now has extended its jurisdiction to the questions of basic issues

related to health, literacy, formal and non-formal education, protection of environment, rural housing, pollution, social forestry, gender, equity etc.

There were three distinct streams of people, social reformers, science writers and Malayali scientists in Bombay and Bangalore who came together in the formation of the Kerala Sastra Sahitya Parishad. The first was the social reformers and activists who saw in science a useful ally in their struggle against the outmoded past. As a concept of organized science popularization programme, the history of the KSSP can be traced with the formation of Sastra Sahitya Samithi in 1957. It was a science literary forum formed by a group of concerned activists and science writers who had gathered in connection with the traditional arts festival at Ottappalam High School in the Palakkad District. The third stream of people who contributed to the formation of the KSSP was the Malayali scientists working in various scientific institutions in India. The formation of Sastra Sahitya Parishad-Malayalam (SSP (M)) at Bombay in January 1966 by a few scientists working at the Bhabha Atomic Research Centre (BARC) was a turning point for the KSSP.

The publications from KSSP resulted in increased contact with the sphere of formal education. Its journals developed a unique style of popular science writing in Malayalam. The period between 1967 and 1977 witnessed the growth of the KSSP into a mass movement. All the basic contours of the present day activities, organizational structure and style of functioning evolved during this period. The KSSP launched the first agitation campaign for making Malayalam the medium of instruction in October 1975. In 1971, the KSSP workers formed a separate society named Scientific, Technical and Educational Publishing Cooperative Society (STEPS). By the early 1970s, the involvement of the KSSP in non-curricular activities in school became more widespread. An important innovation in the mass contact programme of the KSSP was the Sastra Jatha (Science Procession). In 1977, KSSP launched the experiment of Sastra Kala Jatha. The Jatha consisted of a group of science activists. The formation of rural science forum was another conscious effort to link the KSSP's activities to villages where majority of people live. Rural Science Forum was intended to provide an opportunity for villagers to take

part in non-formal bodies for local planning. An activity spectrum that included various cultural activities, participatory research into village resources and problems, monitoring and evaluation of village level development activities etc. were suggested.

KSSP had evolved into a mass conscientisation movement taking up a wide range of issues and reaching out to millions of people spread all over Kerala utilizing a variety of media such as printed and spoken words as well as visual arts. The new activities in turn brought in new activists. By late 1980s, KSSP has started very serious discussions on the concept of development. Some of the innovative programmes of KSSP have evolved from informal gatherings. It is through them that a collective leadership has emerged. Its greatest asset is self-emerging volunteers. KSSP uses print and audio-visual medium and has organized massive leaflet campaigns on many subjects. It has developed a unique form of theatre which is a combination of street, folk and proscenium theatre called 'Kalajadha' or 'Caravan of Art'. It publishes three science magazines separately for primary school children, high school students and the general public. KSSP also organizes, every now and then, massive lecture campaigns on a variety of topics and each campaign result in several thousand lectures which reach out to hundreds of thousands of people.

As per Sarma and Duttachoudhury (2013), the ultimate objective of proper science communication is to provide opportunity for the people to understand, interact or experience the phenomenon/process of doing science and technology so that they derive meaningful response/message which is very personal to them. This personal meaning derivation depends on factors like social strata from which they come from, their prior knowledge regarding the subject, comfort level in assimilation of science and technology and the setting from which they come from-social, political and cultural.

The wide ranging backgrounds of visitors pose tremendous challenge to the designers at science centres as the designed presentations need to cater to people from all walks of life. The resources of science centres have created immense impact for community participation.

1.6.0 IMPACT OF SCIENCE CENTRES ON COMMUNITY

According to Rautela and Sanyal (2010) science centres render a valuable service to their communities. As a result of visitor oriented activities, science centres have a profound impact on learning, motivation and attitude of a person. The centres strengthen the motivation of students and influence learning strategies as well as attitudes towards science. Science Centres provide a medium 1) for building up a trust between the public and the scientific knowledge through dialogue, participation, engagement and experience, 2) to translate a particular scientific information into a fairly comprehensible and relevant mode to the population, 3) to motivate public by educating them on intricate scientific topics, 4) for engaging the general public with scientific issues and play imperative roles in sustaining values in local communities and 5) to provide learning environment and support science education programme of educational institutions. The science centres are meant for creating science awareness and development of scientific temper in the society. It is a hub of scientific discussion on important issues, promoting scientific solutions of their local problems, clarifying the scientific issues confronting the community, eradicating superstitions or unscientific belief and creating awareness on health issues relevant to the society. The science centres provide a significant range of educational, social, cultural and economic benefits to their communities. They serve as educational forums and centres of expertise, providing opportunities for community involvement in their activities through friends' groups, volunteers, project work and in other useful ways.

Ghose (2010) suggest that science centres encourage critical analysis of social, cultural, technological and natural environment and to inculcate an ability to identify the problems and work towards appropriate solution with scientific attitude for the welfare of mankind. Science Centres supplement curriculum education in schools and colleges as well as impart non-formal education to the community as a whole. They develop a spirit of inquiry by encouraging curiosity and questioning processes promoting and supporting innovative ideas and activities. It assimilates information relating to mutual interaction of science, technology and society and disseminates the information through exhibits and activities.

As per Ghose (2013), in exhibits at science centres, interaction has the following criteria: a) two way communication and/or b) multiplicity of options. Passive exhibits are those which have visual or tactile appeal but are non-working in nature as found in collection-based science museums. Active exhibits are those which are animated or working, usually by push button switches, in the same manner every time they are operated. Interactive exhibits are those, which are operated by visitors so as to build up a visitor-exhibit dialogue. These are generally hands-on exhibits. Now a new term is coined which is called minds-on exhibits, which may or may not be hands-on, but are those exhibits where visitors go through a discovery process by themselves or cross the barriers of time and space in a simulated situation.

As per Ramchandran (2013), the present day science centres offer participatory activities instead of passive observation of artifacts and are hugely popular with the public. The root of this popularity is the interactivity of exhibits on scientific principles and which captures the public's interest with buttons to push, lights that turn on and sounds that echo through its noisy halls. Instead of attempting to transmit scientific truths, they show an increased sensitivity to the social relevance of science. Science centres show visitors how to think about and use scientific information to form well supported opinions. They are more and more a tactical instrument used to strengthen the flourishing relationship and dialogue between science, society and public opinion, continually contributing to the creation of a true scientific citizenship, indispensable for understanding our world. Interactivity attracts, engages and wakes people up. Interactivity is about being reciprocal. The visitor acts upon the exhibit and the exhibit does something that acts upon the visitor. Rather than being content with interactivity, they also seek to show visitors how scientific issues are important in the greater context of their society, nation, and world.

According to Persson (as cited by Khened, 2013), the impact of science centres could be divided into four main types-**1) personal 2) societal 3) economic and 4) political.**

- 1) The **personal impact** of science centre is defined as the change that occurs in an individual as a result of his/her contact with science centre. It includes factors such as a) science learning (cognitive development) through non formal means; b) scope for free choice and lifelong learning; c) development of skills; d) scope for nurturing creativity; e) changed attitudes towards science or its appreciation; f) social experience, family learning; g) motivation, interest and outlook change; h) career choice formation; i) increased professional expertise through training programmes; j) personal enjoyment; k) adoption of science in day to day activities.

- 2) The **societal impact** is defined as the effect that a science centre has on groups of people, organizations and on the community as a whole and natural and social environment. The examples of societal impact are; a) community leisure activities; b) creating a science awareness and development of scientific temper in the society; c) community partnerships, involvement of local clubs and societies; d) science centres as hub of scientific discussion on important issues; e) environment restoration; f) promote scientific solutions of their local problems; g) enhance employability through skill and knowledge development; h) clarify the scientific issues confronting the community; i) eradication of superstitions or unscientific belief; j) create awareness on health issues relevant to the society; k) promote use of improved scientific practices and technological tools to improve productivity and profitability of the individuals and community; l) infrastructure development, m) develop into a centre of community activity and symbol of pride for the community.

- 3) The **economic impact** of a science centre is the direct and indirect effect it has on employment and the economy. It includes factors such as: a) local/regional/international tourism; b) income brought into the science centre from visitors; c) income brought into community by visitors; d) job creation for staff (particularly for the youth) and outside service providers; e) urban

redevelopment; f) appreciation of real estate; g) business activity develops for variety of vendors; h) demand creation for science education resource material.

4) The **political impact** of a science centre is its influence on government policies and priorities (laws, local regulations, urban planning decisions by municipality, etc). It is its impact on all levels of government and political leadership who consider and promote development of science centre as an essential parameter of social and regional development. The political impact refers to the system in which the policy-makers and policies are affected by the learning, knowledge or value or social development attached. The influence is administered by the interests and attitudes of the politicians, administrations and citizens while having a query about the public interest involving science and technology, public action like law-jurisprudence-ethics, politics, including regulating norms and the participation of the citizens in making scientific and technological decisions.

- Garnett developed a model on the description of the impact of science centres described by Persson (as cited by Rautela and Sanyal, 2010).

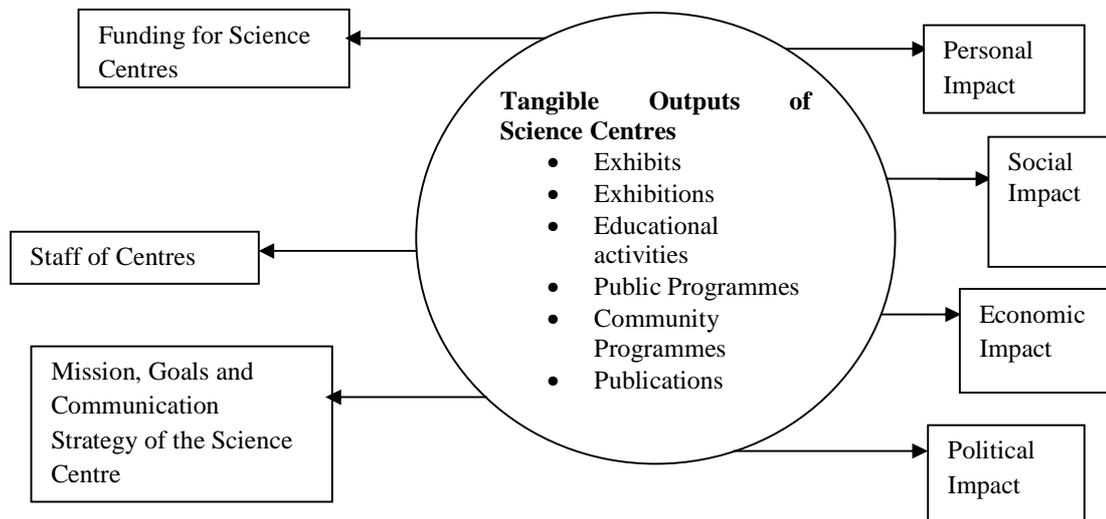


Figure 1.1: Model on Impact of Science Centres developed by Garnett

Community Science Centres also helps in promoting scientific temper. It is important for upliftment of the society.

1.6.1 Science Centres Promoting Scientific Temper

One of the important functions of Science centres is to develop scientific temper in the individuals. As per Chowdhury (2013), science is ‘reasoned knowledge’ about facts, things, persons, natural phenomena and social behaviour. ‘Temper’ is a particular state or habit of mind especially with respect to disposition. Therefore scientific temper represents a spirit of inquiry based on logical reasoning. The ability to think objectively, logically and analytically leads to the development of scientific temper. It is by nurturing scientific temper that one can be liberated from dogmatism, irrational beliefs and superstitions. The science centre is often overlooked as a channel for science popularization. Though it is often dismissed as an educational attraction for children or as a tourist destination, it has as much potential for promoting scientific temper. One advantage is that it is a place for communication as much as it is a method and so can act as a physical forum or hub for such activity. Its exclusive mission is to aware public on topics relating to science and technology for developing a scientific temper. Its ability to deliver multisensory learning experiences also gives it an edge over other media. Science centres evolved as activity oriented institutions with hands-on interactive exhibits, organized activities involving visitors in experimentation so that they discover science by themselves. On the other hand, exhibits could be developed to supplement formal education in schools, as well as for non-formal education of the public. Exhibits could have broad based social relevance for creating scientific temper in the community. Parallel to the exhibits, science centres organize extensive activities, both in house and outreach, for schools and communities.

Rautela (2013) says that science centres are places where construction of meaning takes place and scientific and technological advances are understood in right contexts. Although trust in scientists remains high, science centre audiences do not automatically accept that all scientific advances mean progress for everyone. They want to engage with

scientists and to understand the long term implications of their research. There is thus a need for dialogue between scientists and public during the course of the scientific progress that leads to development and societal change.

Chowdhury (2013) says that superstitious beliefs have retarded human progress from time immemorial. In order to combat superstition and to uncompromisingly defend rationality and good science, science centres and museums are spearheading various anti-superstition campaigns in the form of awareness, demonstrations, workshops, popular lectures, film shows, etc. There are several false beliefs prevalent in our society regarding solar eclipse. Some people even lock themselves up in their homes to avoid the bad rays from the eclipse. Many also take a dip in holy rivers to cleanse themselves after the eclipse and some avoid cooking and eating during the eclipse. During the time of eclipse, science centres and museums make elaborate arrangements for the observation of solar or lunar eclipse and organize several other activities like popular lectures, quiz etc. to aware people that eclipse poses no danger to humankind. The science awareness programmes are aimed at stimulation and nurturing scientific attitudes and temperament among people. These are for popularization of science among children, teachers and people besides introduction of new and interesting activities. The other activities include exposing students to the fascinating world of science through face to face interaction with eminent scientists, demonstration lectures by eminent experts from various fields, provide opportunities for children to create science toys, watch fascinating experiments, science films and participate in delightful activities like aero-modelling, origami and sky watching.

Ghose (2010) says that science centres do not believe in 'top down' system of teaching-learning process with demands blind acceptance of authoritative explanation and information. They believe in 'bottom up' system where the people have to build up their understanding of science through hands-on minds-on process. Science centres believe in the dictum of 'do it', then 'observe it' and 'accept it' without raising any question. There is no blind acceptance at centres.

Interactive science centres emphasize, through its hands-on exhibits and activities, that science is not just some theories or mathematical equations or even some test tube experiment. As per Ghose (2010), science is a logical thought process through which we can understand the laws of nature. The concept of science develops in a child's mind through observation of nature-e.g. sunrise and sunset, flowing river etc. In this observation, a child uses all five senses to fathom the mysteries of nature. At a more matured age, the young mind gets intrigued with laws of nature relating to sound, light, heat, etc. With further maturity in thinking, visitors try to correlate the scientific phenomena with their understanding of life relating to environment, ecology, biotechnology, etc.

As per Chowdhury (2013), India with a tradition of skepticism and a heavy baggage of superstitions and religious dogmatism has repeatedly rediscovered itself. After independence 'spreading scientific temper' was propounded as the basis for science communication. Globalization, privatization and economic structural changes, instead of reinforcing, have pushed the agenda constructing a scientifically tempered society to the back burner. As a nation-state we need to redefine the notion of scientific temper in the present context and implement its constitutional duty to spread 'scientific temper, spirit of enquiry and humanism.

As per Islam (2013), science centres render a valuable service to their communities. As a result of visitor oriented activities, science centres have a profound impact on learning, motivation and attitude of a person, on local economies, on social processes and on policy making at official level. The personal impact means enhancing the knowledge or skills of an individual or group; economic impact is a measurable contribution to the economy of the surrounding community; societal impact means any identifiable impact on social processes at the individual or social level; political impact encompasses any influence at the decision making level or in gaining mileage. The science centres are institutions that offer hands on science learning environment. They strengthen the motivation of students and influence learning strategies, attitudes towards science and the

career choices of young people. The centres are among the major tourist attractions all over the world. They are also prime elements in cultural tourism.

Science centres are great medium to create scientific temper for rural communities. They can create vast impact in the minds of rural fraternity for science education.

1.6.2 Science Centres for Rural Communities

The science centres can educate rural school children in science subjects. The centres can suffice for learning science where rural schools lack resources in teaching science. Kumar (2013) states that to develop the frame of minds of the people from rural and remote areas, to expel superstitions, to establish an opinion through proper argument and above all to extend the knowledge of scientific experiments, it is necessary to move science from the laboratory to the grass root level. Therefore, a scope should be made available to the rural populace to grow up with the knowledge with special consciousness regarding science. Then in turn they can pass their knowledge and share information to the next generation. Sustainable rural development requires a holistic approach integrating economic, environmental and socio-cultural issues with human values and human dignity as the base. This paradigm requires careful selection and application of technologies with an understanding of the conceptual framework of sustainability. Clearly the formal and informal production sectors in rural areas play important role where majority of our population lives. As technology is not beneficiary neutral, special attention is needed to understand their technological requirements and dynamics of the rural situations. Special efforts are needed to reach out to the underprivileged sections of the society.

Science centres can work through various channels like hands-on exhibits, demonstrations, shows, community training programs, seminars, workshops etc. For smooth operation of above functions, science centres have different components in general.

1.7.0 COMPONENTS OF SCIENCE CENTRES

Science centres comprises of many sections which performs the functions of science popularization. Different science centres have different components but generally it comprises of following components: a) Planetarium b) Science Park c) Exhibits d) Mobile Science Exhibition e) Drama and Play f) Interactive Components and Simulation g) Science Camps.

Though science museum is not a component of science centres, it is found with some science centres. In India, some science museums work as separate entity while some museums are adjoined with science centres. As per International Council of Museums (ICOM), a museum is a non-profit, permanent institution in the service of society and its development, open to the public, which acquires, conserves, researches, communicates and exhibits the tangible and intangible heritage of humanity and its environment for the purposes of education, study and enjoyment. Ghose (2013) states that science museum is a generic term with two key words. The word 'science' encompasses diverse subjects relating to philosophy and history of science, basic science, technology, industry and natural history. The term 'museum' involves activities relating to collection and conservation of artifacts, research and documentation, display and public education. Initially science museums were set up with touch-me-not artifacts, encased in glass cabinets, projecting the scientific and technological heritage of a country or of the human civilization. Some science museums came up with additional push buttons that were active exhibits which demonstrated the basic principles of science and the functioning of a contrivance. Manekar (2013) observed that to cope up with the rapid social transformations, science museums around the world were also in the process of transforming themselves. Science museums had already introduced the new approach of participatory, working and animated exhibits to support and supplement static displays of objects and artifacts. Interactive educational programmes were also launched in progressive science museums.

According to Ghose (2013), in early years, science museums were generally considered as ugly ducklings, because exhibits were mostly old machineries and mechanical contrivances, with nuts and bolts, compared to aesthetically pleasing paintings and decorative art specimens in other museums. In recent years, interactive exhibits with high-tech communication strategy have transformed the ugly ducklings into beautiful swans, attracting large number of visitors. Hands-on exhibits created a playground situation in the museums, with children jumping and thumping with excitement. The specially designed exhibits are primarily educational in character and the education is imparted through enjoyment. Learn through fun is the motto of science museums, which have also coined a new term edutainment. The new trend brought in a qualitative change in museum curatorship. Scholastic research on collection yields to creative design of educational exhibits and historians are replaced by scientists, engineers and educationists.

Thus, different tools are used by science centres for science popularization. It is important to note that science popularization had spread its wings in India by making aware public since decades.

1.8.0 SCIENCE POPULARIZATION IN INDIA: HISTORICAL INITIATIVES

As per Massarani and Moreira (as cited by Mahanti, 2013), science popularization, the attempt to take science to the public, began with the very process of creating modern science in Europe. Galileo is regarded as father of modern science. His 'Dialogue on the Two Chief World Systems, Ptolemaic and Copernican' published in 1632 marked a crucial moment in the scientific revolution. Galileo make serious attempts to inform the public about the new discoveries in physics and astronomy through his public lectures and writings.

Biswas (as cited by Mahanti, 2013) says that in India, like many other parts of the world, science popularization began in the 19th century before modern science took roots in the country. Early attempts of science popularization or preparing the ground for it were made by social reformers, educationists, science teachers in schools and colleges and

government officials managing the scientific departments. Srirampur (also Serampore) College, established in 1818 by three missionaries namely William Carey, Joshuah Marshman and William Ward, was the first Indian college for higher education including the study of European science. The college built a laboratory, a museum and an observatory. It published science books and college's periodical named Dig-Durdarshan carried articles on science. One of its most outstanding teachers, John Mack (1797-1845), delivered popular science lectures accompanied by practical demonstrations.

Narlikar (as cited by Mahanti, 2013) says that Raja Rammohan Roy (1772-1835), a great social reformer and regarded as the father of modern India, was one of the earliest exponents of scientific outlook in the country. He worked relentlessly for removing the prevailing unscientific beliefs and argued for narrowing the gap in attitude towards science and technology between India and Europe. As per Sengupta (1999), Henry Louis Vivian Derezio (1809-1831), who taught at the Hindu College, attempted to persuade his students to imbibe the spirit of rationalism. The Hindu College was established in 1823 in Kolkata, which was later renamed as the Presidency College.

Saraswati (as cited by Mahanti, 2013) says that Raja Rammohan Roy's attempts for spreading a rational outlook in the country were taken forward by a number of accomplished individuals like Rajendralal Mitra and Ramendrasunder Trivedi. Rajendralal Mitra, the first modern indologist of Indian origin and scholar, played a pioneering role in preparing the ground for spreading the spirit of science. He was the first to challenge the sanctity of tradition, bread away from its entangling meshes and establish the need for scientific objectivity in Indian historical thinking. As per Chacraverti (as cited by Mahanti, 2013), Ramendrasunder Trivedi played a very important role in science popularization in the late 19th century. His influence could be gauged from the fact that Satyendra Nath Bose, the celebrated Indian physicist and who made pioneering effort in communicating science in the vernacular acknowledged that it was Trivedi's staunch commitment to writing and reflecting on science in the vernacular served as a guideline for establishing the Bangiya Bigyan Parishad.

As per Habib (as cited by Mahanti, 2013), in the 19th century, efforts were made to translate science books in the vernacular in different parts of the country. Master Ramchandra (1821-1880), a well-known mathematician and a teacher of science in the Delhi College (later renamed as Zakir Hussain College), did a pioneering work by translating mathematics and science books into Urdu. Translation of science books and writing of popular science articles were taken up in other Indian languages. Father Eugene Lafont (1837-1908) of the St Xavier's College (Kolkata) played a pioneering role in creating public interest in science and promoting science education in schools and colleges.

In 1876, Indian Association for the Cultivation of Science (IACS) was established at Kolkata by Mahendra Lal Sircar (1833-1904). The establishment of IACS was a milestone in the history of scientific research and science popularization in the country. It was the first scientific research institute established by Indians. The initial activities of the IACS were confined to organizing popular science lectures. This institute inspired others to take up the cause of science popularization. Palit (as cited by Mahanti, 2013) says that Dawn magazine, under the aegis of the Dawn society, established by an eminent educationist Satishchandra Mukherjee, took up the task of communicating scientific ideas by publishing popular science articles. Vigan Parishad Prayag was established in Allahabad in 1913 for popularization of science in Hindi. A popular science magazine called Vigyan was started in 1915 by the Parishad which is being continuously published since then. Among the activities undertaken by the Parishad included publication of science books and organization of popular science lectures. Many of the well-known names in Hindi science communication were directly or indirectly inspired by the Parishad.

Indian Science Congress was established in Kolkata in 1913. Since its inception, the ISCA recognized the need to spread the messages of science amongst the general public. Also, before India's Independence, namely the National Academy of Sciences of India at Allahabad (1930), the Indian Academy of Sciences at Bengaluru (1934) and the National Institute of Sciences of India (1935), now Indian National Science Academy, first

established in Kolkata and later shifted to New Delhi were established. In addition to the national science academies, many scientific societies like Indian Chemical Society (1924), Indian Botanical Society (1921), etc. were formed. After post independence, the first Prime Minister of India, Pandit Jawaharlal Nehru put emphasis on science and scientific temper. Scientific temper was incorporated in Indian Constitution as one of the fundamental duties of every citizen of India (Article 51-A) through an amendment in 1976 which stated to develop the scientific temper, humanism and the spirit of inquiry and reform.

Realizing the need for a coordination agency for conceptualizing, implementing, networking and monitoring science popularization activities in the country, the Government of India established the National Council of Science and Technology Communication (NCSTC) in 1982 as a division of the Department of Science and Technology. The Council took initiatives for development and dissemination of popular science and technology (S&T) resource materials, training in Science and Technology (S&T) communication, coordination with other agencies engaged in science communication, field based programmes, incentive schemes in the form of awards, fellowship for encouraging science communicators as well as nationwide science popularization campaigns. Vigyan Prasar, an autonomous organization, was established in 1989 under the Department of Science and Technology, Govt. of India for taking up large-scale science popularization tasks. The Council of Scientific and Industrial Research (CSIR) through its constituent organization National Institute of Science Communication and Information Resources (NISCAIR) has made important contribution in the field of science communication.

1.9.0 SCIENCE POPULARIZATION IN INDIA: PRESENT SCENARIO

At present, Governmental institutions like National Council of Science and Technology Communication (NCSTC), Vigyan Prasar and National Institute of Science Communication and Information Resources (NISCAIR) are active in popularizing science. There are private institutions across country, science and astronomy clubs,

science centres and science museums which impart science education for public. There are popular science magazines and journals like Nature, Current Science, Scientific American, New Scientist, Vigyan Pragati, Resonance, Safari, etc which are published today.

University Grants Commission (UGC) has set up Consortium for Educational Communication (CEC) for promoting higher education through media technology. The consortium has set up Electronic Multimedia Research Centres (EMRCs) at different universities of India. These centres produce educational audio-visual programmes for countrywide classroom. These EMRCs were established by UGC as early as in 1983. These programmes are for students of various disciplines. Vyas Higher Education Channel was established by CEC-UGC under the aegis of Ministry of Human Resources Development, Govt. of India. Vyas Channel was launched on 26th January 2004. The channel produces educational programmes on undergraduate subjects. Indira Gandhi National Open University (IGNOU) has its own Electronic Media Production Centre which produces educational programmes. These programmes are being telecast on Doordarshan channels and available in audio and visual form. CEC produces e-content for National Mission on Education through Information and Communication Technology (NME-ICT) under Ministry of Human Resources Development (MHRD).

Gyan Vani is a radio channel dedicated for educational programmes run by IGNOU. Gyan Dhara is an internet audio counseling service offered by IGNOU where students can listen to the live discussions by the teachers and experts and can interact with them on telephone and chat. EDUSAT is a satellite specially launched for the purpose of education. For the utilization of EDUSAT service, Satellite Interactive Terminals (SITs) are installed at various colleges and universities across the country. Bhaskaracharya Institute of Space Applications and Geo-informatics (BISAG) is a state level nodal agency which imparts education to school children via satellite network. Gujarat Government operates 16 educational channels called 'Vande Gujarat' (Video Network for Development and Education) available on Direct-To-Home (DTH). Television channels include Discovery, Discovery Science, National Geographic, Animal Planet as

well as science programmes on Rajya Sabha TV and Lok Sabha TV are well-known for science content.

As per Bast (2015), podcasts are recorded radio shows/talk shows freely available online. Audio-books are books that are narrated by professional artists. These are similar to podcasts such that the files can be synced to electronic gadgets and listened offline. Massive Open Online Courses (MOOCs) include recorded video lectures, discussion forums and periodic assessment of progress by way of online-based quizzes. There are blogs and social media meant for science popularization activities. A number of Science and Technology Museums around the world offer 360 degrees virtual tour of the museum made available through their websites. Apps are executable applications that the users can install in the suitable electronic devices such as smart phones, tablets, smart watches, etc. Apps are specific to the operating system (OS) used in the gadgets.

Science centres and science museums, one of the means of science popularization, have also created an excellent reputation since decades. Their historical and present initiatives are remarkable.

1.10.0 SCIENCE CENTRES: HISTORICAL BACKGROUND

Throughout its history, science museums and centres have been searching for ways to engage public in the process of science and foster interest in science and to effectively communicate scientific knowledge. For science communication, the contribution of science museums, centres and planetaria has been significant. Science museums, which flourished in 18th and 19th century in Europe, housed, preserved and displayed scientific and technological artifacts. As per Rautela (2013), one of the earliest science museums was the Conservatoire des Arts et Metiers in France was created in 1794 and opened in 1797. In Britain, the displayed items of Crystal Palace Trade Exhibition in 1851, eventually led to development of the Science Museum in London, whose workers believed that displaying scientific items were of great benefit for both intellectual progress and industrial development. As per Sommerkamp (2005), industrial engines at

the Deutsches Museum in Munich from 1925 and the chemical demonstrations at the Palais de la Decouverte in Paris from 1937 were important developments. In 1933, The Chicago Museum of Science and Industry developed a simulated coal mine into which visitors descended. In 1935, Franklin Institute in Philadelphia had a huge exhibit of beating heart where individual can walk through. These early science museums had a long and distinguished history of interpretation and explanation alongside their exhibitions. The Children's Gallery at the Science Museum in London, which opened in 1931, also has a claim to be one of the first science centres.

1.10.1 Modern Science Centres

The trend of science centres advanced and grew further. As per Pedretti (2002), Frank Oppenheimer founded The Exploratorium in San Francisco in 1969. Also, Ontario Science Centre opened in Toronto in 1969. In 1981, the Ontario Science Circus visited Birmingham (UK) and the Science Museum in London. Supported by the Science and Engineering Research Council of Canada, the eleven-day visit was considered extremely successful and encouraging. As a consequence, the Science Museum (UK) experimented with its own modest Discovery Rooms in 1981, 1982 and 1984. There was an opening of Launch Pad exhibition in 1986 which saw a great success. If the Launch Pad was the first hands-on centre within a UK museum, the first stand-alone science centres were at Techniquest in Cardiff (1986) and the Exploratory at Bristol (1987). By this time the interactive movement was firmly taking shape in the UK, supported by Sainsbury Foundation, Leverhume Trust, Nuffield Foundation and the Department of Trade and Industry. The movement was moving equally rapidly throughout Europe with opening of new centre like Inventorium at La Villette in Paris in 1986. The idea of Children's museums was came to fore and they were also established in different parts of the world.

1.11.0 HISTORY OF SCIENCE CENTRES: INDIAN SCENARIO

India has rich history of science centres and science museums. As per Ghose (2013), Indian Museum, which was established in 1814, developed its first industrial collection

taking inspiration from Great Exhibition of Calcutta. For full fledged science museums, India had to wait for more than half a century when in the early 1950s, a nucleus science museum was set up in a small area in the National Physical Laboratory with science educational exhibits collected from an exhibition of the UNESCO. Around the same period, Central Museum (later renamed Birla Museum) was set up in Pilani, Rajasthan with a mixture of art and science exhibits through the generosity of House of Birlas.

In 1956, K.S.Krishanan, director of the National Physical Laboratory (NPL), New Delhi, brought in R.Subramanian for setting up a nucleus science museum in NPL. Subramanian set up the museum which displayed crystal collection, automatic telephone exchange and spark generator. The museum was closed down in 1960s. In 1956, Council of Scientific and Industrial Research (CSIR) decided to set up the first major multi-disciplinary science museum at Kolkata. Thus, Birla Industrial and Technological Museum (BITM) was opened in 1959. With inauguration of BITM, the movement of science museums and centres in country started. A similar Visvesvaraya Industrial and Technological Museum (VITM) was opened to public in Bengaluru in 1965. These two museums were strongly influenced in their approach by the Deutsches Museum at Munich (1903-1906), Germany and the Science Museums in London and Chicago.

In 1973-74, a task force of the Planning Commission assessed the activities of the science museums functioning under the CSIR and recommended certain course of action for the rapid growth and sustenance of science museums in India. This paved the way for forming a separate autonomous body, the National Council of Science Museums (NCSM) in April 1978. Thus, the first science centre called Nehru Science Centre in Mumbai came into existence.

Planetariums have made important contribution towards advancing the cause of science popularization. As per Mahanti (2013), the first planetarium of India, was set up was in New English School-Pune in 1954 which was named as Kusumbai Motichand Planetarium. It was housed in a concrete dome having an approximate diameter of 9 metres. The Birla Planetarium at Kolkata inaugurated in 1962 was the first major

planetarium in India. Mumbai's Nehru Planetarium was established in 1977 and Delhi had its planetarium in 1984.

1.11.1 National Council of Science Museums (NCSM)

The objective of National Council of Science Museums (NCSM) is to take science to people and making people for science. Using interactive, engaging and entertaining modes of communication, science centres have gradually become places of attraction and number of visitors is increasing day by day. NCSM aims to portray the growth of science and technology and its applications in industry and human welfare with a view to develop scientific attitude and temper and to create, inculcate and sustain a general awareness amongst the people. NCSM has special focus on providing hands-on and minds-on experiences to these young students in order to motivate them to take science and technology as career as well as acquire scientific temper.

Nehru Science Centre became a trend setter in the science museum movement in India on several counts. It made a paradigm shift from science museum to a participatory science centre having 'hands-on and minds-on' approach for most of its exhibits and activities. It broke the tradition of confining science exhibits within the four walls of a museum/centre and brought them out into a Science Park.

1.11.2 Nehru Science Centre

Nehru Science Centre boasts of halls of science, science park, auditorium and activity centre. The hall of science consists of galleries full of exciting, interactive exhibits on topics of science for knowledge of general public and students to enhance their understanding and make them appreciate the principles of science applicable in our day to day lives through fun and pleasure. The 3D (three dimensional) film show and planetarium shows are also organized daily. Nehru Science Centre organizes science demonstration lectures, workshops, teachers training programmes, seminars, popular science lectures and activities as well as exhibitions for popular science. It organizes

events for specific days like National Science Day, World Environment Day, International Museum Day, World Science Day, etc. for creating scientific awareness.

1.12.0 SCIENCE CENTRES AND SCIENCE MUSEUMS: PRESENT SCENARIO IN INDIA

The phenomenon of science centre expanded which became an important destination for providing informal science education. The important of science education for the community has been realized at the central and the state level. At present, the Central Government, State Governments, local authorities and different bodies, especially non-governmental organizations have taken initiatives to establish science centres for communities across country.

The present day centres encourage debate on topical and contemporary issues on science and technology. Science centres also address national priorities such as developing a scientific temper and innovation culture by providing platforms in leisure time to have face to face with innovators and innovations and make grass root level innovations themselves. Real laboratories are provided to young students to experience real scientific enterprise with a purpose to motivate them to pursue careers in research and make innovations.

The state of Gujarat has also taken a lead to establish community science centres in the state.

1.13.0 COMMUNITY SCIENCE CENTRES IN GUJARAT: HISTORICAL BACKGROUND

The credit for setting the first community science centre in Gujarat goes to the well known scientist Dr. Vikram Ambalal Sarabhai. Vikram Sarabhai felt the need to build a scientific temperament among public especially children. He was keen for setting a Community Science Centre in which general public mostly school children could learn science by doing demonstration on various scientific phenomenon. He established

Community Science Centre in 1966 at Ahmedabad in Gujarat. The mission was to explore the magic of science beyond textbooks. Later, the centre was named as Vikram Sarabhai Community Science Centre (VSCSC) after his death in 1971. The concept spread to other locations of Gujarat and similar Community Science Centres were established gradually in different parts of the state.

The Gujarat Council on Science and Technology (GUJCOST) was established in 1986 under the Education Department, Gujarat State. It is functioning as an autonomous body registered under Societies Registration Act since February 2000 under Department of Science & Technology, Government of Gujarat. The objectives of GUJCOST is to promote popularization of science and the spreading of scientific temper, attitude among the people of the state to identify areas in which science and technology can be utilized for the achievement of the socio-economic objectives like backwardness, unemployment and poverty and of addressing itself to the problems of the rural area, and under-privileged sections of society and to devise policy guidelines for academic and field policies for the purpose of strengthening the planning and programming amenities for the development of Science and Technology. GUJCOST organizes various activities like Science and Technology (S&T) related seminars, workshops, science quiz, question-answer programmes, celebration of Science and Technology (S&T) days and forming science clubs. They are involved in science research projects and creating awareness about patent and intellectual property rights.

1.14.0 COMMUNITY SCIENCE CENTRES IN GUJARAT: PRESENT SCENARIO

Community Science Centres in Gujarat are being established as 1) non-governmental organizations which are under GUJCOST and adhere to the Community Science Policy of Govt. of Gujarat, 2) non-governmental organizations which are not under GUJCOST and do not adhere to the Community Science Policy of Govt. of Gujarat and 3) independent science centres, science museums, planetarium and science parks operated by local bodies.

There are 25 Community Science Centres in Gujarat (as in 2014).

(A) There is a network of 18 Community Science Centres in different districts of Gujarat which are under GUJCOST. The Community Science Centres under GUJCOST are established at two levels-

1) Regional level

The science centres at Vadodara, Rajkot and Bhavnagar are of regional level catering the need of the specific region.

2) District level

The science centres at Jamnagar, Gandhinagar, Sabarkantha, Amreli, Junagadh, Anand, Surat, Surendranagar, Banaskantha, Patan, Porbandar, Dang, Kutch, Bharuch and Narmada are of district level catering the need of only specific districts.

3) There are seven Community Science Centres which are not under GUJCOST and perform its function independently.

1) Science City managed by Department of Science and Technology, Government of Gujarat.

2) Vikram Sarabhai Community Science Centre at Ahmedabad which is established as non-government organization.

3) Community Science Centre at Dharampur taluka in Valsad under National Council of Science Museums (NCSM), Government of India.

4) Vigyan Nagari at Bhavnagar City established by Monghiben Balvihar Trust.

5) Lokbharti Community Science Centre run by Lokbharti Gram Vidyapeeth.

6) Science Centre operated by Surat Municipal Corporation.

7) Narmadanagar Community Science Centre at Bharuch managed by Gujarat Narmada Fertilizers Company.

Community Science Centre on a large canvas is considered as Science City. As the Community Science Centres under GUJCOST were registered under State Government, their total population was known. The science centres which were independent, their total population was not known. The researcher had listed independent Community Science Centres which were performing well across Gujarat.

GUJCOST is instrumental in setting up of network of community science centres in the state. The scheme was executed on establishment and development of community science centres in Gujarat from 1996 to 2009 under public-private partnership model. This scheme was modified in 2009 and a new policy on community science centres was implemented called Community Science Centre Policy, Government of Gujarat. Under this policy, objectives and programmes of Community Science Centres were framed and required minimum standards for sanctioning financial assistance was specified. As per this policy, those organizations that want to establish Community Science Centre and want to come under the aegis of GUJCOST should have independent building, laboratories, technical equipments and human resources for science communication. GUJCOST is the nodal agency under which the centres get partial funding from the state government. It is not compulsory for a science centre to be under GUJCOST. Any organization can establish and run science centres independently.

1.15.0 GENERAL OBJECTIVES OF COMMUNITY SCIENCE CENTRES IN GUJARAT

Community Science Centres in Gujarat have below mentioned objectives.

- To inculcate, nurture and disseminate science among people.
- Development of scientific temper among children and citizen and to increase the public contact with scientific activities.
- Socio-economic development through scientific attitude.
- To provide scientific activities to students at various stages of their study.
- To generate scope for activity based learning and to develop kits/teaching aids for the use in school science teaching as well as to improve the quality of science education in schools.

- To create awareness among the people about harmful and non-scientific activities to society, prevailing superstition, bad customs and to make efforts towards its removal in urban and rural areas.

Community Science Centres perform their functions keeping in mind above said objectives of science education. These objectives are achieved through organization of different activities. Community Science Centres of Gujarat have chalked out various programmes and activities to attain objectives of science education.

1.16.0 COMMON PROGRAMMES AND ACTIVITIES OF COMMUNITY SCIENCE CENTRES IN GUJARAT

Community Science Centres in Gujarat have common programmes for non-formal science education which are as follows.

- Science Clubs for students.
- To organize workshop on science subjects to guide students and teachers.
- Lectures, workshops and seminars on various science subjects.
- Community based programme-rural and urban.
- Celebration of scientific days.
- Science Exhibition, science quiz, science project.
- Demonstration of science experiments.

Apart from common programmes, some science centres have their unique science popularization programmes. For e.g. Vikram Sarabhai Community Science Centre at Ahmedabad operates a science exhibition train for science popularization which runs across India and stops at different railway stations of cities. At railway stations, people watches science exhibition on various themes. Community Science Centre at Dharampur and Gujarat Science City at Ahmedabad have gigantic exhibits on scientific principles.

1.17.0 RATIONALE OF THE STUDY

Science is a special tool for the materialistic development and prosperity of a country. Along with this it is considered a way of life. Science is very important as a subject in education. It inculcates scientific attitude much needed in a country like India where caste, creed, custom and ritual govern the society. Science education generates analytical thinking and rational outlook and sharpens insights. Science education should not remain confined to traditional education. Science should also reach masses so that people can build scientific attitude in them. As India is a country where superstitions are deeply rooted in the culture, the general masses need science education to eradicate these practices. Popular science is important to make people understand science in a simple way and make aware about evils of society so that it can be eradicated. Science popularization is necessary for general masses so that people develops national cohesion as well as scientific temper in them. Community Science Centres are important medium for science popularization and active learning.

The science centres plays important role in imparting science education through their activities in popular science. These institutions sensitize people on rational behaviour. Though the centres functions for larger community, yet their main target is students. Community Science Centres applies active learning approach in popularizing science. At these centres, learning is done in the natural atmosphere so that students and general community can have deep insight into the scientific principles and their applications in the day-to-day activities. The participatory approach of learning at these centres makes science easy to learn as Science demands observation skills and curiosity for experimentation. A great sense of visualization and critical mindedness is needed to understand science. Community should possess or develop these qualities in them for strengthening scientific inclination. Community Science Centres are the models in which the purpose of science education is served in an integrated manner. These centres impart science education to all type of learners irrespective of their age, status and qualification. However, their main focus is school students. The centres spread awareness on science through different science communication activities. Most of these centres are voluntary

organizations working with the government machinery for the spreading of science education among the general community.

There is a need to understand the functioning of Community Science Centres in achieving these objectives set for them. These centres should be increased and empowered so that they expand its working. The researcher had felt that it is important to know how efficiently these centres are working for education. It is significant to know what students and teachers feel about Community Science Centres in Gujarat in terms of learning, non-formal education, their experiences with centres and future prospects, as both teachers and students are main stakeholders of education. The response of community members is also crucial as the centres work for them. The researcher perceives that it is essential to study the problems faced by Community Science Centres in achieving their objectives. Some Community Science Centres are working excellent while some are not functioning well. There is a need that all science centres can learn from each other and a healthy competition can be an advantage for those who avail services of the centres. National Policy of Education, 1986 also focus on learners group and organizations and education centres for wider reach in society. Thus, this research holds importance for community development. The trend of community learning is increasing and can help in sufficing traditional education.

The researcher did not found any in-depth research study on Community Science Centres of Gujarat which focuses on critical analysis of objectives of the centres, examining the extent of the achievement of these objectives, understanding of different issues and problems related to administration, infrastructure, financial management, human resources management and implementation of activities at these science centres. No such studies were reported to reveal the holistic aspects of the Community Science Centres in a specific geographical area like a state or a country. Even, no studies were found to be considered as learning lessons for effective management of Community Science Centres in Gujarat.

A need of research has been raised where the functioning of Community Science Centres in Gujarat should be studied in detail. A critical analysis of objectives of these centres was required. It is important to know how non-formal way of education was imparted in these centres. The study of extent of the achievement of objectives and different functions as well as science popularization programmes of the centres was important aspects which required research. This was very identical in nature and serves special purpose for community education in the modern time. It was also important to study the functions and problems faced by these centres. Hence, the present research is an attempt to study the community science centres in Gujarat in detail.

1.18.0 STATEMENT OF THE PROBLEM

A Study of Community Science Centres in Gujarat

1.19.0 OBJECTIVES OF THE STUDY

The study was designed with the following objectives:

1. To critically analyze the objectives of the Community Science Centres in Gujarat.
2. To study the extent of objectives achieved by the Community Science Centres in Gujarat.
3. To study the functioning of these Community Science Centres in Gujarat terms of
 - General Administration
 - Financial Management
 - Human Resource Management
 - Infrastructural facilities.
4. To study the problems faced by the Community Science Centres in Gujarat.

1.20.0 EXPLANATION OF TERMS

Community Science Centre: These are organizations working to provide science education to students and public in a non-formal way.

1.21.0 DELIMITATION OF THE STUDY

The research was delimited to study of Community Science Centres in terms of infrastructure, financial management, human resources management and effectiveness of programmes in science education.