CHAPTER - I

INTRODUCTION
CHAPTER : I - INTRODUCTION

1.1 Introduction

The prosperity and development of society and nation at large depends on education. The innovation in science and technology revolutionized human being’s standards of living and also added many new dimensions to luxury and prosperity. Thus, it has made life comfortable. Education plays a key role in designing the place of country in global competitiveness. Scientists, engineers, technocrats, and researchers of physical, chemical and social sciences are the backbone of such rapid and continuous development. Higher Education particularly related to Science is in high demand for such positive change. School Education supplies input to Higher Education system. Elementary Education provides basic learning experience which should be rich and interesting for students at Elementary level. The Elementary Education is the incubation period for a student wherein his/her dormant abilities can be waken up and it is the right time to help students to learn science using hands-on experiences. The science-teacher should help students to learn and express their understanding in numerous ways. The formative period spent by students in Elementary Education emerges as the most influential variable in shaping interest of students. This interest should be maintained, and students should be motivated for learning science. The scientific bent of mind, raising questions to solve any problem, suspending judgments without prior evidences and experiences, generating various alternative solutions, and evaluating the solutions with respect to multiple dimensions of the problem are the most inevitable characteristics of learners in the 21st century. Students, teachers and society can develop such cognitive bent of mind only if the learning science finds its due regard by them. It is also important for teachers to put ardent efforts to raise scientific literacy among students at Elementary level. Standard V is the stage wherein students in Gujarat state encounter science subject for first time in life. The elementary science teacher has to be innovative in providing interesting, challenging experiences promoting thinking in students. The elementary science teacher must also have adequate content mastery and thorough knowledge about how students learn science at this stage. The science teacher practicing at Elementary Education should have knowledge of various growth and developmental periods of students including
the multiplicity of intelligences. The teaching of science should not be confined as per the so-called intelligence quotient measured by the traditional psychological tests but the students should be better understood using the theory of multiple intelligences. It is, therefore, science teacher has to plan the learning experiences to accommodate wide variety of students’ individual differences to ensure that all will have equal opportunity to grow and all will have chance to learn using various intelligences while teaching science. The subsequent sections of this thesis discusses the importance of teaching science and the theory of Multiple Intelligences propounded by Prof. Howard Gardner in the year 1983 and 1999 along with the implication of the same in the context of teaching of science at Elementary Education.

1.2 Theory of Multiple Intelligences (MI)

Distinguished Professor Howard Gardner worked on the concept of ‘intelligence’ for a long time. The origin of his work on expounding the concept of ‘intelligence’ tracked back to his pioneer work on brain damaged veterans at ‘Boston VA Medical centre’ and his study of children’s mind under the project zero at ‘Harvard’s Graduate School of Education’. Fundamentally, Gardner (1999) contributed his seminal work to answer the three basic questions in the field of psychology: (1) Is intelligence just one? (2) Is intelligence primarily inherited? (3) Is there inherent prejudice in tests of intelligence?

In his vigourous exercises in comprehending the concept of ‘intelligence’, he attacked on the unitary concept of ‘intelligence’ as defined by the traditional psychologists, and raised a question for the appropriateness of measuring entire mental faculties in so-called quantitative measure such as IQ. Gardner (2004) narrated the incident of a girl taking examination and initiated the discussion that though the test of IQ predicts the success of the girl (or any one) in examination, it fails to predict for the success outside the school affairs. He expressed his idea that psychometric tests address only linguistic, logical with some aspects of spatial intelligence while the rest forms have been entirely ignored such as giving an extempore talk (linguistic) or being able to find one’s way in a new town (spatial).
The traditional psychologists hold the view that all human problem solving is governed by general intelligence ‘g’. The concept of ‘g’ failed to explain different rate of intellectual development among younger children in mastering language skills, drawing, mathematics, dance and other areas. The child prodigies typically excel in one or two areas rather than showing excellence in different areas which should not be, if ‘g’ prevails. For instance, the autistic savants or stroke victims may have weak capacities across the board but some brain-damaged people can play music beautifully but they are severely impaired in their use of language. Such examples show the failure of centrality of ‘g’. Such scenario led Gardner to explain various mental abilities that support a wide range of adult roles found over time and across culture.

Gardner, thus, challenged the notion of general intelligence ‘g’ and questioned the very basis of prevailing intelligence test by asking how an individual’s intellectual capacities could be captured in a single measure of intelligence. He asserted that every one has a set of multiple abilities related to multiple numbers of domains of knowledge in a particular cultural setting. In doing so, he dared to violate the rule of English grammar and used the word ‘intelligences’ rather than using the word ‘intelligence’, ‘talents’, or ‘abilities.’ The theory of multiple intelligences refers to how one is smart rather than focusing on whether one is smart based on IQ test. In other words, the propounded theory of multiple intelligences by Prof. Howard Gardner came into picture in his book ‘Frames of Mind’ in the year 1983, which was criticized by the traditional psychologists. Prof. Gardner made it clear that his theory is always open in the light of new evidences and he is focusing the aspects of mental faculties in a comprehensive manner rather than viewing intelligence from the traditional lens of the psychologists.

Silver, Strong and Perini (2000) indicated that Gardner broke the tradition of IQ theory, which previously adhered to two fundamental principles: (1) Human cognition is unitary (2) Individuals can adequately be described as having a single, quantifiable intelligence. According to Gardner (1999), intelligence is “a biopsychological potential to process information that can be activated in a cultural setting to solve problems or create products that are of value in a culture.”
In other words, intelligence as defined by Gardner can be mentioned as under.

- The ability to solve problems that one encounters in real life.
- The ability to generate new problems to solve.
- The ability to make something or offer a service that is valued within one’s culture.

According to Gardner (1999), there are eight relatively independent types of intelligence that grow and develop differently in people depending upon their hereditary characteristics or environmental experiences operating upon it. The eight intelligences are theorized based on the criteria developed by Gardner (1983) which are discussed as under.

1.2.1 Criteria of Multiple Intelligences
Gardner (1983) worked upon the evidences based on the studies of prodigies, gifted individuals, brain-damaged patients, idiots savants, normal children and adults, experts in different lines of work, and individuals from diverse background of cultures. He devised specific eight different criteria for the abilities or mental faculty to be qualified as candidate intelligence. His criteria can be classified under four different heads such as biological sciences, logical analysis, developmental psychology, and traditional psychological research as mentioned by the Williams (2002).

The eight different criteria designed by Gardner (1983) for building the theory of multiple intelligences are described in brief as under.

(1) The potential of isolation by brain damage.
Gardner as a neuropsychologist was particularly interested in evidence that one candidate intelligence could be dissociated from others. He observed that patients having lesions to a specific area of the brain or impaired faculties due to brain injury but their other faculties remain intact and show capabilities to excel in other areas. He found out that the patients exist who have intelligence spared despite other damaged faculties or there are patients having impaired faculty while others have been spared.
He added that either pattern increases the likelihood that a particular intelligence has been discovered. Therefore, Gardner (1983) pointed out the relative autonomy among human faculties. He exemplified that both the separation of language from other faculties and its essential similarity in forms like oral, aural, written and sign indicates separate linguistic intelligence.

(2) An evolutionary history and evolutionary plausibility.
Gardner (2004) added that human species including all species display areas of intelligences (and ignorance). A specific intelligence becomes more plausible to the extent that one can locate its evolutionary antecedents, including capacities that are shared with other organisms. He gave example that discrete aspects of musical intelligence may well appear in several species but are only joined in human beings. Gardner (1999) further mentioned that most of the evidence came from either inferences about Homo sapiens and its predecessors or information about contemporary species. He added that early hominids had to be capable spatially of finding their way around diverse terrains. Mammalian species like rats also demonstrate highly developed spatial capacities. Evolutionary psychologists attempt to infer the selection pressures that led over thousands of years to the development of a particular faculty from the contemporary operations of human capacities. As per Gardner’s view (1999), these studies give new plausibility to evolutionary accounts of such faculties as the intelligence which scrutinizes either the world of plants and animals or computes the motives of other species. Both above the criteria (1) and (2) are from the biological sciences.

From logical analysis, the two criteria derived are as under.
(3) An identifiable core operation or set of operations.
It attempts to define human intelligence as a neural mechanism or computational system which is genetically programmed to be activated by certain kinds of internally/externally presented information. Gardner (2004) exemplified that sensitivity to pitch relations and the ability to imitate movement by others as core of musical and bodily intelligences respectively. It is important to identify core operations to locate their neural substrate, and to prove that these “cores” are indeed separate. Analysis indicates linguistic intelligence calls for core operations related to
phonemic discriminations, syntax, and sensitivity to pragmatic use of language. On the other hand, spatial intelligence demands the component operations: sensitivity to large scale, local, three and two-dimensional spaces.

(4) *Susceptibility to encoding in a symbol system.*

The use of spoken and written language, mathematical systems, charts, drawings, logical equations are different developed ways by people to communicate culturally meaningful information systematically and accurately. Gardner (1999) added that there are both societal and personal symbol systems with respect to each human intelligence that allow people to traffic in certain kinds of meanings. Therefore, humans isolate events and draw inferences about them that led to have developed linguistic and pictorial symbols to capture the meanings of events. Putting together, human brain seems to have evolved to process certain kinds of symbols efficiently. In other sense, symbol systems may have been developed precisely because of their pre-existing, ready fit with the relevant intelligence or intelligences.

From developmental psychology, (5) and (6) - criteria are drawn and discussed as under.

(5) *A distinct developmental history along with a definable set of expert “end-state” performances.*

Intelligence should have its own trajectory- an identifiable developmental history through which both normal and gifted individuals pass in the course of ontogeny. There may be different critical periods in the developmental history, linked either to training or to physical maturation. Gardner (1999) added that an individual do not exhibit intelligences “in the raw” but s/he does so by occupying certain relevant niches in the society by passing through an often lengthy developmental process. It indicates that intelligences have their own developmental histories. It means people who want to be mathematician must develop their logical-mathematical abilities in certain ways while other people must follow distinctive developmental paths to occupy certain positions in society. For example, clinicians have well-developed interpersonal intelligence and musicians have well developed musical intelligence.
The existence of idiot savants, prodigies, and other exceptional people.
The savant shows stunning strength in particular area with other ordinary abilities or marked deficits. Some autistic children exhibit having outstanding performance in mathematics, drawing or music, or reproduction of melodies. But, they show marked impairments in communication and sensitivity to others. The prodigy is outstanding in a specific area and talents, but s/he is at least average in other areas. Prodigies are able to work effectively with much older people, but they may also have difficulty relating to their peers. The prodigies are experts in an area that draws on one or more intelligences. The examples of idiot savants, prodigies, and autistic persons who exhibit an area of stunning strength along with other ordinary abilities or even marked deficits lead one to observe the human intelligence in relative-isolation. Gardner (2004) indicated that the claim for a specific intelligence is enhanced if the condition of the prodigy or the idiot savant can be linked to genetic factors or to specific neural regions to the extent. He considered that autistic children or youngsters with learning disabilities provide a confirmation-by-negation of certain intelligences.

From traditional psychological research, the criteria (7) and (8) are drawn.

(7) Support from experimental psychological tasks.
Psychologists attempt to find out the extents of the relationship between operations involved in solving by assigning tasks to people. If one activity does not interfere with the other, it can be assumed that the activities draw on discrete brain and mental capacities. For example, people generally have no trouble while walking or finding way around while conversing as the intelligences involved are separate. On the other hand, people find difficulty in conversing or listening to a song with words while solving crossword puzzle. In this case, it indicates the two manifestations of linguistic intelligence are competing. As per Gardner (2004), to the extent that various specific computational mechanisms or procedural systems work together smoothly, experimental psychology can help to demonstrate the ways in which modular or domain-specific abilities may interact in the execution of complex tasks.

(8) Support from psychometric findings.
As per Gardner (2004), to the extent that the tasks that purportedly assess one intelligence correlate highly with one another and less highly with those that
purportedly assess other intelligences, the credibility of his work is enhanced. He also added that to the extent that psychometric results prove unfriendly to his proposed constellation of intelligences, there is cause for concern. He indicated that intelligence tests do not always test what they are claimed to test. For example, many tasks actually involve the use of more than their targeted ability, while many other tasks can be solved using a variety of means such as certain analogies or matrices may be completed by using linguistic, logical, and/or spatial capacities.

Psychometric studies of spatial and linguistic intelligence suggest that these two faculties showing weak correlations. Gardner (1999) referred here the studies of social intelligences which have revealed a set of capacities different from standard linguistic and logical intelligences. Similarly, it is revealed that emotional intelligence, a new construct may well be independent of how one scores on the traditional intelligence-testing items.

Gardner’s theory deals initially with seven different intelligences namely verbal-linguistic, logical mathematical, visual-spatial, bodily-kinesthetic, interpersonal and intrapersonal. He indicated that all the intelligences are relatively autonomous with reference to one another. Gardner (2004) stated that intelligences are not equivalent to sensory systems and mentioned that intelligence is neither case solely dependent on the single sensory system, and nor has any sensory system been immortalized as an intelligence. He went further on saying that intelligences are capable to be realized through more than one sensory system. Later on, Gardner (1999) added one more intelligence namely naturalistic intelligence in his list of the multiple intelligences. Thus, there are total eight different intelligences. According to Gardner (1999), emotional intelligence is the amalgam of the interpersonal and intrapersonal intelligence and Gardner (1999) does not add existential intelligence as the ninth one to the list of multiple intelligences.

Chapman and Freeman (1996) classified Gardner’s multiple intelligences into three major groups: languages, object and person related. Linguistic and musical are classified as languages related intelligence. Logical-mathematical, visual-spatial, bodily-kinesthetic and Naturalist are classified as object related intelligence. The
remaining two intelligences: inter- and intra- personal intelligence are grouped as person related intelligence.

As mentioned above, linguistic and musical intelligence has its own specific notations, symbols that are used to communicate the meaning and information successfully in interaction. Logical, visual-spatial, bodily-kinesthetic and naturalist intelligences are generally dealing with the objects such as logical for working with abstraction and a desire for exploration using inductive and deductive thought processes, visual for sculpture and artifacts of aesthetic appeal. The bodily-kinesthetic is based on the ability to manipulate objects with deftness and using bodily movements to do the task, and naturalist is dealing with the flora, fauna, rock and surroundings. Intra- and interpersonal intelligences are focused on a person’s ability to communicate and ability to know one’s strength and weaknesses and working accordingly to do the task respectively.

### 1.2.2 Description of Eight Multiple Intelligences

The pluralistic view of intelligence is fragmented into different heads and is described in brief as under.

- **Linguistic Intelligence**
  
  This gives rise to competencies related to linguistic intelligence. Lawyers, writers, storytellers, novelists, journalists, public speakers, comedians and poets widely use this intelligence. This intelligence involves the knowledge that comes through language, through reading, writing, and speaking involving understanding of the order and meaning of words in both speech and writing and a sense of proper use of language. It covers understanding of the socio-cultural nuances of a language, including idioms, plays on words, and linguistically based humour.

- **Logical - mathematical Intelligence**
  
  It is composed of components like deductive and inductive reasoning, including solving of logical puzzles, doing calculations and the like. This intelligence uses numbers, mathematics, and logic to find and understand various patterns. It begins with concrete patterns in the real world but gets
increasingly abstract as we try to understand relationships among patterns. It makes one capable to perceive relationships and connections, and to use abstracts, symbolic thought.

- **Visual - spatial Intelligence**
  Many of us knowingly or unknowingly make use of visual-spatial intelligence in day-to-day life which requires the abilities and skill involving the representation and manipulation of spatial configuration and relationship. This intelligence covers sensitivity to colour, line, shape, form, space and relationship among these elements. Painters, land surveyors, architects, engineers, mechanics, navigators, sculptors and chess players generally use this type of intelligence.

- **Musical Intelligence**
  The works of professionals like singers, musicians, composers and instrumentalists demonstrate the use of musical intelligence who are smart enough in pitch discrimination, sensitive enough to rhythm, texture and timbre. This intelligence covers the sounds of world, environmental and musical, and one’s awareness, enjoyment and ability to use these sounds.

- **Bodily - kinesthetic Intelligence**
  This is basically related with abilities, talents and skills to perform skillful and purposeful movements. It encompasses the capacity to manipulate objects and use a variety of physical skills. This intelligence requires sense of timing and the perfection of skills through the union of mind and body. Generally, dancers, gymnasts and athletes widely use this intelligence.

- **Intrapersonal Intelligence**
  Intrapersonal intelligence includes the capacity to understand oneself. This intelligence helps one to know one’s strength and weaknesses. It enables to have an effective working model of oneself covering one’s own desires, fears, and capacities. It enables person to use self knowledge effectively in regulating his/her life. Intrapersonal intelligence is evident in psychologists, spiritual leaders, philosophers.

- **Interpersonal Intelligence**
  Interpersonal intelligence encompasses the ability to understand the intentions, motivations, and desires of other people. Thus, it helps one to work effectively
with others. The interpersonal intelligence includes sensitivity to facial expressions, voice, gestures. It encompasses the capacity to discriminate different kinds of interpersonal cues and the ability to respond effectively to them. Generally, Interpersonal intelligence is highly developed in teachers, therapists, politicians, and religious leaders.

- **Naturalist Intelligence**
  Naturalist intelligence includes the ability to understand, discern and appreciate different kinds of flora and fauna of nature. It covers the capacities such as recognizing and classifying species, raising/taming animals, and growing plants. It also involves curiosity to know about the natural worlds, its creatures, and weather patterns. Generally, farmers, hunters, gardeners, zookeepers, nature guides, forest rangers widely make use of naturalist intelligence.

1.2.3 Key and Subabilities of Multiple Intelligences
Baum, Viens and Slatin (2005) mentioned the key and sub abilities of intelligences as under.

1. Key Abilities of Linguistic Intelligence
   - Involves perceiving or generating spoken or written language.
   - Allows communication and sense making through language.
   - Includes sensitivity to subtle meanings in language.

a. Subabilities
   - Expressive language
   - Invented narrative or storytelling
   - Descriptive/instructional language
   - Reporting
   - Poetic use of language
   - Wordplay

b. Linguistic Intelligence is NOT-
   - Bilingualism (but might include facility in learning languages)
   - Being talkative / liking to talk
2. Key Abilities of Logical-mathematical Intelligence
   - Enable individuals to use and appreciate abstract relations.
   - Includes facility in the use of numbers and logical thinking.

   a. Subabilities
   - Numerical reasoning (calculations, estimations, quantification)
   - Logical problem solving (focusing on overall structure and relationships, making logical inferences)

   b. Logical-mathematical intelligence is NOT
   - Oriented only to numbers (it also includes non-numerical logical relations)

3. Key Abilities of Musical Intelligence
   - Involves perceiving and understanding patterns of sound.
   - Includes creating and communicating meaning from sound.

   a. Subabilities
   - Music perception
   - Music production
   - Composition or notation

   b. Musical Intelligence is NOT
   - Engaged by playing background music

4. Key Abilities of Visual-spatial Intelligence
   - Involves perceiving and transforming visual or three-dimensional information in one’s mind.
   - Allows for re-creation of images from memory.

   a. Subabilities
   - Understanding causal or functional relationships through observation
   - Use of spatial information to navigate through space
   - Sensitive perception or observation of visual world and arts
   - Production of visual information or works of art

   b. Visual-spatial Intelligence is NOT
   - Necessarily visual (blind people need excellent spatial abilities)
5. Key Abilities of Bodily-kinesthetic Intelligence

- Allows use of one’s body to create products or solve problems.
- Refers to the ability to control all or isolated parts of one’s body.

a. Subabilities

- Athletic movement
- Creative movement (including responsiveness to music)
- Body control and fine motor abilities
- Generating movement ideas (as in choreography)

b. Bodily-kinesthetic Intelligence is NOT

- Necessarily demonstrated by a physically active child
- Unstructured release of energy through physical activity

6. Key Abilities of Interpersonal Intelligence

- Is a sensitivity to the feelings, beliefs, moods, and intentions of other people.
- Involves the use of that understanding to work effectively with others.
- Includes capitalizing on interpersonal skills in pursuit of one’s own ends.

a. Subabilities

- Assumption of distinctive social roles (e.g., leader, friend, caregiver)
- Ability to reflect analytically on the social environment or other people
- Taking action (e.g., political activist, counselor, educator)

b. Interpersonal Intelligence is NOT

- A preference for working in a group
- Being well-liked
- Being polite
- Possessing “social graces”
- Being ethical or humane

7. Key Abilities of Intrapersonal Intelligence

- Enables individual to form a mental model of themselves.
- Involves drawing on the model to make decisions about viable courses of action.
• Includes the ability to distinguish one’s feelings, moods, and intentions and to anticipate one’s reactions to future courses of action.

a. Subabilities
• Self-understanding
• The ability to self-reflect analytically
• Articulating that understanding through other types of expression or intelligences (poetry, painting, song, etc.)
• Using that self-knowledge well toward personal or community goals.

b. Intrapersonal Intelligence is NOT
• Preferring to work alone and/or in isolation

8. Key Abilities of Naturalist Intelligence
• Includes the ability to understand the natural world well and to work in it effectively.
• Allows people to distinguish among and use features of the environment.
• Is also applied to patterning abilities.

a. Subabilities
• Observational skills
• Pattern recognition and classification
• Knowledge of the natural world
• Employing that knowledge to solve problems and fashion products (e.g., farming, gardening, hunting or fishing, cooking)

b. Naturalist intelligence is NOT
• Limited to the outside world

1.2.4 Brief Summary of Theory of Multiple Intelligences
Chapman and Freeman (1996) summarized the theory of multiple intelligences which is mentioned as under.

1. There is more than one intelligence.
There are at least eight intelligences qualified as per the eight criteria till date. The theory of multiple intelligences indicates that intelligence originates biologically.
2. Intelligences are educable.
Individual can work upon his/her weaknesses and strengths for further improvement and enrichment. This development process encompasses four stages such as: (1) exposure that activates senses, (2) the opportunity to explore and strengthen an intelligence, (3) formal training of the intelligence through guidance of teachers and parents, and (4) the “embrace” or the mastery of the intelligence.

3. A brain is as unique as a fingerprint.
The theory of multiple intelligences does not indicate that intelligence is purely genetic and inherited though it claims a biological basis of intelligence. It suggests that each person is born with all intelligences and possesses unique profiles of intelligences. These intelligences are developed through life’s journey of learning, experiences, opportunities, influences, and schooling.

4. Intelligences are forever changing throughout life.
Teacher must believe that every learner can learn but they must also have willingness to learn. The learner has to be stimulated and motivated to learn and internalize new knowledge and skills.

The multiple intelligences as theorized by Gardner leads educators to understand learners with wide variety of strengths in different areas of intelligences: linguistic, logical, visual-spatial, interpersonal, intrapersonal, bodily-kinesthetic, musical and naturalist. The theory of multiple intelligences indicates that learner’s strength should not be narrowly defined but teacher should try to activate students’ intelligences by providing different curricular inputs.

**1.3 Importance of Science Education**

The subject of ‘Science and Technology’ is included at Elementary level in School Education with unique purposes. The world is in the era of 21st century wherein globalization has brought numerous changes in mankind’s life. The logic behind inclusion of Science and Technology subject at Elementary level is to emphasize the need and importance of Science and Technology in one’s life so that an individual will be able to take decisions wisely. The role of Science and Technology subject at
primary level is to develop scientific understanding in learners. Such able learner will be able to solve problems appropriately.

According to Harlen (2011), the contribution of Science Education is to

- Sustain and develop curiosity and a sense of wonder about the world around.
- Provide information that can lead to understanding which helps decision-making about matters related to health, diet, lifestyle, etc.
- Enable informed participation in debates about major issues such as environmental preservation, genetic engineering and the use of energy.
- Give access to ways of investigation and enquiry that are based on evidence and careful reasoning.
- Provide satisfaction in finding answers to questions through one’s own mental and physical activity.

Harlen’s views on contribution of Science Education evidently mention the multiple facets of the nature of science and its importance in developing thinking, enquiry and problem-solving skills to gather and evaluate evidences. It also suggests the importance of Science Education to enable students to respond current issues pertaining to environment, genetic engineering and energy scientifically.

According to Roden and Ward (2005), the major purpose of Science Education is not only to produce well-qualified scientists but also to produce well-balanced individual members of society. NCF (National Curriculum Framework) (2005) views science as a dynamic, expanding body of knowledge which covers ever-new domains of experience. It also hopes that science can play a truly liberating role, helping people escape from vicious cycle of poverty, ignorance and superstition. This suggests that teacher has to teach science in a way that helps learner to acquire scientific bent of mind to take up suitable decisions and to learn employability skills. It also indicates major role of Science Education in developing country in India to bring socio-cultural and technological changes for welfare of people.
Alsop and Hicks (2003) discussed below mentioned reasons for need of Science Education.

- Knowledge and understanding of science helps pupils in making sense of natural phenomena.
- Knowledge and understanding of science and of the ways scientists work can help pupils understand basis for decisions in an increasingly technological world.
- Through science, pupils can develop investigative and practical skills which can help them to solve problems.
- Science is interesting and intellectually stimulating.
- Science is an important part of contemporary culture, and is relevant to and has implications for people of all nations.

The reasons mentioned by Alsop and Hicks (2003) indicated that Science Education is the need of hour due to increased complexity of the technological world which governs the day-to-day life of the human beings. Besides, nature of science itself makes its inclusion in curriculum imperative to nurture and develop investigative, critical, logical, problem-solving, and decision-making skills. It is apparent that learning science is of value to learners as it is interesting and develops multiple mental faculties. Another important reason is the fabrication of science in our culture so that learning science will help learners to derive its implications in daily lives. The individual familiar with the science and technology will be able to work efficiently. The investigative and research skills learnt during learning science will empower learner to employ the same to understand the problems and s/he will become able to generate workable solutions to a problem.

It is observed that science has been viewed as necessity for the young generation to cope with challenges and problems in one’s life. One of the aims of teaching of science is to educate the young generation with the investigative and practical skills so that they will be able to take wise decisions. Science has been considered as a part of the culture and the need is felt that the young generation must have an understanding of the surrounding world based on science so that they will be able to contribute positively to build up healthy atmosphere in society.
1.3.1 Objectives of Teaching of Science at Primary Level

According to Settlage and Southerland (2007), the goal of science teaching has moved away from a single-minded pursuit of assembling a new generation of scientists and opined that it is inappropriate strategy to teach science only to produce scientists. Science teaching focuses on helping students become scientifically literate and to help them develop useful and applicable understanding of science. Both the authors recognize that those individuals who have greater skills and stronger understanding of science will have more control over the choices they make about their lives.

Teaching of science seeks basic guidelines from the objectives of teaching science. The objectives of teaching any subject provide the outline to teach. It seeks to explain what to teach and why to teach. The general objectives of teaching science at Primary level (Standard I to V) provided by NCERT in ‘National Focus Group on Teaching of Science’ in the year 2006 are as under.

- To arouse curiosity about the world (natural environment, artifacts and people).
- To engage in exploratory and hands-on activities that leading to the development of basic cognitive and psychomotor skills through language, observation, recording, differentiation, classification, inference, drawing, illustrations, design and fabrication, estimation and measurement.
- To internalize the values of cleanliness, honesty, co-operation, concern for life and environment.
- To emphasize language development through and for science learning.

The ‘National Focus Group on Teaching of Science’ by NCERT (2006) for primary stage (Class I to V) denoted,

“\textit{The pedagogy should essentially be based on the activities in and out of classroom, as well as other methods such as stories, poems, plays and other kinds of group activities……..Activities should allow free exploration, seeing patterns, making comparisons and understanding the web of relationship.”}
The ‘National Focus Group on Teaching of Science’ by NCERT (2006) emphasizes creative expressions of the students in non-formal ways both in and out of school activities, on practical work, on developing elementary technological modules, on surveys of biodiversity, health and other aspects of environment. It also stressed to include the exploratory and imaginative activities.

This shows that objectives of teaching science primarily focus on the development of interest and curiosity towards science. The objectives of teaching of science also focus on discovery of the basic processes embedded in the natural phenomena and the day-to-day life by hands-on experiences. In addition to that, teaching of science also centres its attention to the nurturance and development of values such as cleanliness, honesty, co-operation, concern for life and environment.

1.3.2 Science Process Skills
Science educators have been discussing science both as a product and process. The nature of science is as such it requires inquisitiveness to explore. During the process of exploration while learning science, learners require skills to investigate objectively. The results thus, obtained need to be verifiable and reproducible in the same conditions. The investigation in science requires patience and step-by-step implementation of various mental operations. Such mental operations are clubbed as a particular set of behaviour and termed as science process skills.

Harlen and Elstgeest (2008) referred process skills as the route by which children explore and gain evidence which they use in developing ideas. Both the authors further concluded that if children do not interact with things in a scientific way using process skills rigorously, then the ideas they form may not be scientific in the sense of not really fitting the evidence. Hammerman and Musial (2008) considered process skills of science are the ways of thinking and acting used by scientists in their work. As per Hammerman and Musial (2008), observation, classification and prediction skills are used on a basic level wherein the thinking skills of hypothesizing, controlling experimental variables, and drawing conclusions are of a higher level. Bentley et al (2007) mentioned observation, inference, classification, communication, measurement, and prediction as the basic science process skills. Martin et. al. (1998)
classified science process skills into two major groups: Basic skills and Integrated Skills. The basic science process skills involve observation, classification, communication, measurement, estimation, prediction, and inference. The integrated skills involve identifying, controlling variables, defining operationally, hypothesizing, experimenting, graphing, interpreting, modeling, and investigating. The process skills are discussed in brief as under.

1. Observation
It is fundamental scientific skill and the first step of scientific investigation which leads learner to infer valid conclusions. Settlage and Southerland (2007) mentioned that varied ways of observing such as seeing, tasting, touching, listening and smelling are important to help students to build a more complete understanding of experiences. The shortcuts such as “jumping” to the conclusion without systematized and detailed observation have no place in journey of scientific exploration which can be taken care by “observing” and not “seeing.” According to Trojcak (1979), the entire scientific is built on the skill of observing and mentions that all attempts to gain information about objects or events begin by observing. Wolfinger (1984) defined observation in line with Trojcak’s view, as the ability to observe accurately without making judgments from observations made at first and identified this as the most basic of all science processes.

Young (1994) mentioned observation may include all the senses namely seeing, hearing, feeling, tasting, and smelling. Bentley et. al. (2007) also referred observation as the use of one’s senses to perceive objects, events, their properties, and behaviour. Observation feeds the process of meaning making. According to Gega (1977), a child is said to be observing when he:

• Identifies such properties of objects as colour, size, and shape by using any or all of the senses.
• States noticeable changes in objects or events.
• States noticeable similarities and differences in objects or events.
Settlage and Southerland (2007) denoted that observation should focus on telling “what it is”, and “how it is”, but not “why it is”. Observation should be free from bias. It means that observation should not be messed by one’s own prejudices and opinions to approach objectivity.

2. Measurement
Bentley et al (2007) mentioned measurement as the act of using numbers to describe objects or events. It involves a specific form of observation called quantitative observation. As per Young (1994), measurement is concerned with the kinds of comparisons such as size of objects, areas, speeds, weights, temperatures and volumes… and so on. Trojcak (1979) referred measurement as the comparison of one physical aspect of an object or event with a standard unit. Gega (1977) mentioned child is measuring when he:

- Uses such standard tools as the meter stick, yard stick, ruler, clock, balance, and protractor to find quantity.
- Uses familiar objects as arbitrary units to find quantity.
- Makes scale drawings or models.
- Uses simple sampling and estimating techniques.

Settlage and Southerland (2007) described “measuring” as a special type of quantitative observation and provide the reason that some tools are required to measure which assist one’s observation.

3. Classification
Trojcak (1979) considered classification a complex learning activity that embraces subordinate skills and in which objects and phenomena are grouped according to their common characteristics. Wolfinger (1984) defined classification as the ability to place objects into groups on the basis of the characteristics that those objects either do or do not possess. Young (1994) mentioned recognition of properties and ordering are skills which can be grouped together under the process of classification. Bentley et al (2007) referred classification as the act of grouping objects or events into categories.
based on specified characteristics or attributes. According to Gega (1977), a child is classifying when he:

- Groups objects or events by their properties or functions.
- Arranges objects or events in order by some property or value.

Settlage and Southerland (2007) mentioned “classifying” as the process of organizing objects into groups based on observable properties. One comes to identify the patterns that are not apparent at first sight when objects are viewed as a large group. According to Settlage and Southerland (2007), one should not use a single property to subdivide a group into more than two subgroups.

**4. Inference**

According to Gega (1977), process of inferring is interpreting, or drawing a conclusion from what one observes. Wolfinger (1984) defined inference as an interpretation of the observations one makes during an activity or experiment and pointed out that inference may also be thought as a statement showing a relationship among the parts of a system and frequently detailing cause-and-effect relationship. Young (1994) mentioned that scientists work like detectives. Scientists gather as much as information, think critically and do not make blind guesses. He makes an inference which fits all the information he has at the time. It may not be his final inference but it is an acceptable one for the moment. Bentley et al (2007) referred inference as the act of making statements that attempt to explain or interpret objects or events that are based on observations. Students may need help in distinguishing between observations and inferences. According to Gega (1977), a child is inferring when he:

- Distinguishes between an observation and an inference.
- Interprets recorded data.
- Interprets data received indirectly.
- Predicts events from data.
- Hypothesizes from data.
Settlage and Southerland (2007) defined the term “inferring” as developing an explanation based on and supported by valid observation. Settlage and Southerland (2007) further added that inferences are not the facts but opinions based on supporting facts while judging the inference made.

5. Prediction
Young (1994) mentioned scientists foretell or predict events of the future. They make use of their present observations or measurements to predict which is the first step towards understanding and control of the environment. As per Wolfinger (1984), prediction is a special form of inference that attempts to determine on the basis of data collected that what will happen in future and stressed prediction is not a guess. A reason is given that prediction must have a sound foundation in data that has been collected or in background experiences. Settlage and Southerland (2007) defined “predicting” as making a statement that forecasts what will happen in future and further added that goal of prediction is not to make a “good prediction” simply but to find patterns that allow us to decide whether our observations and the inferences we made from these observations make sense. Prediction process skill is different from “guessing” altogether as one relies on the patterns that one has observed or even measured while predicting. On the other hand, “guessing” has not always much basis for the statement guessed.

6. Communication
Young (1994) viewed communication as a two-way skill in which a scientist has to read what other scientists have written. It includes making of a table, graph or histogram, drawing, diagram or model as he needs to share his idea with other scientists. Wolfinger (1984) defined communication as means for passing information from one individual or group of individuals to others wherein pictures, work sheets, models, movement, oral and written communication have been used. Bentley et al (2007) mentioned communication as transmission of information from one person to another by verbal or nonverbal means by which people interact and share ideas. According to Gega (1977), communicating means as putting of the data (information) based on observations into some form. Gega (1977) further mentioned that a child is said to be communicating when he:
• Defines words operationally (through some action) when needed.
• Describes accurately objects or events.
• Makes accurate charts and graphs.
• Records data accurately as needed.
• Constructs accurate exhibits and models.
• Draws accurate diagrams, pictures, and maps.

The communication process skill includes written text, drawing, models, the verbal inferences and measurements in the form of graph as explained by Settlage and Southerland (2007).

1.3.3 Importance of Science Process Skills in Learning Science
The science process skills help learners to learn science systematically and develop the logical bent of their minds. The process skills-based inquiry helps learners to understand concepts easily and engages their various mental faculties.

Trojcak (1979) mentioned the importance of process skills as under.

1. Process skills trigger assimilation and accommodation and thus they facilitate learning.
2. Process skills equip learners with the tools of making sense out of chaos, and order out of disorder. Learners become able to make continual discoveries.
3. Process skills lead to new awakenings, explorations and revelations.
4. The use of process skills enables learner to move from “I don’t get it”, a state of being bothered to a state of “I’ve got it”. Successful use of process skills regulates learning and motivates learners.

Science process skills provide the framework for development of children’s thinking. Observation and measurement are the backbones or vertebral column which serves as the support systems. The process skills distinguishing spatial and temporal relationships, classifying and communication are like the ribs which are closest to the heart and breath of scientific endeavours. The skills such as inference, prediction, hypothesizing, controlling of variables, interpreting data and defining operationally
are similar to the appendages. They enable a learner to move forward. Experimenting incorporates the most logical operations. It is like the skull which houses the brain. If the backbone is weak; the rest of the skeletal system is affected. (Trojcak (1979))

Martin et al (1998) mentioned basic science process skills which help children to expand their learning through experience. Learners begin with simple ideas and then these ideas compound and from new and more complex ideas. They further added that emphasis on science process skills help children to discover meaningful information and accumulate knowledge by constructing understanding within and beyond the science classroom. Ward and Roden in Ward et al (2005) mentioned that children’s process skills are limited and unsystematic which are characterized by trial and error exploration. Young children make use of simple individual process skills all the time during their exploration of the world and these individual skills become more important in their formal education later on. Therefore, the teacher should develop the process skills in children. So, when children get older, they will able to approach the exploration of the world in a more systematic, organized and meaningful way. Ward and Roden in Ward et al. (2005) suggested that the teacher should identify individual process skills and provide opportunity to pupils to practise each skill that make up procedural understanding. A Position Paper on Teaching of Science by NCERT (2006) also emphasized that there should be enough time and space for teachers and students to plan experiments, discuss ideas, critically record and analyze observations. It means that there should be enough room for students to have hands-on experiences, recording observations and reflecting on them using process skills.


1. **Sense-making Tools**

   It is argued that frequent and increasingly challenging use of the science process skills support students in developing their efforts and scientific inquiry. The students became less dependent on the teachers, more skilled and confident with science and they start to make connections for themselves.
2. **Supporting Language Development**
   It is mentioned that use of science process skills engage students to discuss with others. They need to communicate well with other students to describe their ideas and what they have observed. They need to use descriptive words and ideas which create the need to find specific and elaborate ways of language.

3. **Creating a Community of Learners**
   The use of process skills by students help them to create a community of learners as they are working with materials using their ideas which they share with others. The process of learning includes exchange of information wherein explanation is ventured and understanding is negotiated. Collective efforts to understand science make the class less dependent on teachers and students participate actively.

4. **Fostering Natural Curiosity**
   It is mentioned that when people are attracted by equipment or an artifact from the natural world, the challenge of motivating them is almost saved. The active use of process skills in learning science will kindle curiosity in students for learning new things and exploration. The students will be motivated when they explore by their own efforts using process skills.

Gregory and Hammerman (2008) mentioned process and thinking skills as sets of behaviours and ways of thinking that students use to construct understanding. The process skills and thinking skills are tools for learning as they engage students both physically and mentally in the learning process. Both the authors further added that instruction rich in sensory input and opportunities to use and develop process and thinking skills and strategies is critical for developing important concepts and principles in science. The students develop clearer understanding. They create new and more elaborative mental modes of knowing when they make sense of what they experience.

It is understood that learning science using process skills has many advantages. Learning becomes more concrete and meaningful. Learners become active and learn the logic behind particular happening in the surrounding. The mental modes of
knowing become more clear and are refined. They also learn the systematic ways of scientists. This promotes not to believe without any evidences. The skills to observe, test, collect the required data, evaluate the evidences and setting the trustworthiness of one’s enquiry are inculcated and nurtured in longer run. Such skills are of utmost importance to eradicate superstition and live in 21st century.

1.3.4 Process Skills in Learning Science
This section deals with the use of science process skills in modifying the existing understanding of students and process of learning science.

Harlen and Elstgeest (2008) explained the role of process skills in development of concepts and indicated that understanding of the world becomes clear when development of concepts occurs. The development of concepts is related with the refinement and extension of the process skills used while learning science. According to Harlen and Elstgeest (2008) how learning takes place in science can be shown in figure 1.

Figure 1 Learning Science and Process Skills as indicated by Harlen and Elstgeest (2008)

Linking

The circles I₁, I₂, and I₃ represent various existing ideas and E represents a new experience. The either of the existing ideas is linked with the new experience due to some perceived similarities. The processes involved may include observation, hypothesizing and communication. The linked idea with the experiences is then tested
against the evidence to see whether it helps in making sense of new experience. If it succeeds in doing so, it will be considered as a more useful idea. Consideration of idea for modification or rejection depends on the way in which the testing processes are carried out. The testing processes include raising questions, predicting, planning and carrying out investigations, interpreting and making inferences, and observing, measuring and communicating. The below mentioned figure 2 shows how learning takes place using the process skills.

The possibilities represented in above diagram are dependent on the existing ideas and the nature of new experience as well as on the extent to which scientific process skills can be used. Here, the attitude has also emerged as a determining factor whether or not available skills would be deployed.

Harlen and Elstgeest (2008) indicated investigating process in science which is mentioned in figure 3. According to Harlen and Elstgeest (2008), there is as such no hierarchy or sequence present in the use of process skills in learning concepts of
science. It means that all the process skills are part of a whole called scientific investigation.

Figure 3 Investigation in Science Using Process Skills as indicated by Harlen and Elstgeest (2008)
1.4 Multiple Intelligences (MI) Based Instructional Strategy For Learning Science

Gardner’s theory of Multiple Intelligences offers unique educational implication for designing learning experiences. The MI theory provides educationists and teachers a wider panoramic view of students’ abilities. The MI theory points out that each one is smart in various ways, and it is not advisable to segregate students on the basis of their performance in paper-pencil test. It also suggests that there can be more than one way to teach the same content so as to sustain and involve students in the learning process. The educational implication of the MI theory clearly indicates that teachers have to shift from one mode of expression in teaching to another mode like singing to talking, talking to organizing group discussion session, from group discussion session to personal reflection, from personal reflection to kinesthetic activities, and from kinesthetic activities to visual imagery or visual presentation. The way the teacher selects the mode of presentation of content in his/her framed instructional strategy, makes classroom interaction filled with higher level of students’ involvement. It, thus, offers teachers various ways to engage the learner in the process of problem solving, working on projects, sharing their views, reflecting their roles and connecting the situation to their lives. The organization of learning experiences perhaps seems difficult, but Chackley (1997) pointed out that the learning experiences should not be like stretching – it – out on the part of learners. Stating more clearly Chackley’s stand, it is apt to engage one or more intelligences of learners depending upon the scope of the content, age and interest level of students. As logical-mathematical intelligence is hallmark of scientists and engineers, architectures and lawyers, it does not mean that a teacher can involve only logical-mathematical intelligence while tailoring learning experiences for learning science. The rest seven intelligences are also used by scientists in solving problems, and to communicate. Science is also understood well by involving various experiences such as visual imagery and presentation, connecting the situation with one’s self, understanding musical patterns, finding the patterns in the natural world, and expressing scientific phenomena by kinesthetic experiences. According to Howard Gardner’s MI theory, all have all intelligences with different strengths and doing something will usually require use of more than one intelligence. According to Gardner (1995), most topics can be powerfully approached in number of
ways but there is no point in assuming that every topic can be effectively approached in at least seven ways, and it is a waste of effort and time to attempt to do this. Hammerman (2006) mentioned that it is important to keep in mind that most students associate with more than one intelligence and exposure to a variety of instructional strategies is more likely to increase learning potential among a group of students.

Thus, various intelligences based science instruction will offer new stimulus to students and will act as motivator. It will help teachers to remove boredom also. Therefore, intelligences which are less valued in particular culture should also be addressed by teacher in teaching. Hence, all intelligences should be targeted by a science teacher effectively.

According to Armstrong (2000), a teacher should follow below mentioned process step by step while designing MI based instructional strategy.

- Formulation of objective.
- Ask how all the intelligences will be addressed.
- As per the scope of addressing all the intelligences, think about what techniques, materials are more suitable? Then, enlist them.
- List the approaches to teaching.
- Select the most suitable methods, media and approach.
- Select appropriate activities.
- Set a plan of action.
- Execute the plan of action.
Table 1 shows MI based teaching strategies mentioned by Armstrong (2000).

**Table 1 MI based Teaching Strategies**

(Compiled from Armstrong (2000))

<table>
<thead>
<tr>
<th>Intelligences</th>
<th>Teaching Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linguistic</td>
<td>Storytelling, Brainstorming, Tape Recording, Journal writing, Publishing</td>
</tr>
<tr>
<td>Logical-Mathematical</td>
<td>Calculations and Quantifications, Classifications and Categorization, Socratic Questioning, Heuristics, Science Thinking</td>
</tr>
<tr>
<td>Visual-spatial</td>
<td>Visualization, Color cues, Picture Metaphors, Idea Sketching, Graphic Symbol</td>
</tr>
<tr>
<td>Bodily-kinesthetic</td>
<td>Body answers, The Class room Theatre, Kinesthetic Concepts, Hands-on thinking, Body Maps</td>
</tr>
<tr>
<td>Musical</td>
<td>Rhythms, Songs, Raps and Chants, Discographies, Supermemory Music, Musical Concepts, Mood music</td>
</tr>
<tr>
<td>Interpersonal</td>
<td>Peer sharing, People Sculptures, Co-operative Groups, Board Games, Simulation</td>
</tr>
<tr>
<td>Intrapersonal</td>
<td>One-minute reflection periods, Personal Connections, Choice Time, Feeling Tone Moments, Goal-setting Sessions</td>
</tr>
<tr>
<td>Naturalist</td>
<td>Nature walks, Windows onto learning, Plants as props, Pet-in-the-classroom, Ecostudy</td>
</tr>
</tbody>
</table>

The science teacher should find ways to locate the scope to teach the content using MI based teaching strategies as mentioned in Table 1. According to Tisher, Power and Endean (1972), a science teacher should provide both direct and vicarious experiences and several modes of communication such as speaking-listening, visualizing-observing and writing-reading mentioned as under.
a. Direct Learning through first-hand experiences: (Immediate sensory contacts with reality), Exhibits, contrived experiences, demonstrations, projects, laboratory work, excursions, field trips and environmental encounters.

b. Vicarious Learning through Audio-visual Materials: (mechanical representation of reality) Charts, graphs, pictures, slides, film-strips, specimens, models, films, and television


Below are the general criteria which should be considered for the selection of intelligence specific learning experiences.

a) **Appropriateness:** It should ensure that whatever experiences are provided should be appropriate to the content and instructional objectives of teaching.

b) **Comprehensiveness:** It should be taken care to offer adequate opportunities to all students to think and to convey what they learn through writing, demonstration and using different process skills when required depending upon the nature of the content and scope of the activity thus tailored.

c) **Variety:** It should offer different intelligences focused learning experiences.

d) **Relevance:** The difficulty level of activities and intelligences focused experiences should be matched with students’ needs, interests and abilities.

e) **Usability from the Teacher’s Perspective:** MI based instructional strategy should be used easily using computer, charts, experiments and simple project works across India.

f) **Cost:** Cost should be minimal so that MI based instructional strategy can be implemented again whenever required.

g) **Demand:** It should assure a high degree of involvement on the part of students by making them use different process skills and a particular intelligence at a time or different intelligences together.
1.4.1 Multiple Intelligences (MI) Based Instructional Strategy for Teaching Science at Elementary Stage of Education

The teacher should develop MI based instructional strategy keeping in mind the nature of content of science and scope of incorporating the combination of multiple intelligences together or sometimes separately. The age specific characteristics of the target group which influence learning of science should also be considered while developing MI based instructional strategy.

Learners of this age are very curious, interested in doing, working with their hands and they tend to explore the surrounding world. They prefer activities rather than simply listening to their teacher’s act. Moreover, their attention span is smaller in comparison to learners of secondary and higher secondary stages. As per Piaget’s theory of cognitive development, students of this age fall under the concrete operational stage. It is the incubation phase of students to develop their higher level mental abilities and understand the scientific phenomena from holistic point of view and also viewing the phenomena from multiple viewpoints. Concrete and simple experiences should be provided to the learner and the difficulty level of learning experiences can be gradually increased to maintain their pace of learning. The learning experiences should offer the opportunity to learners to observe, classify, infer, predict, measure, and conclude so that they can learn to work as scientists do. The challenge is to a science teacher is to find novel but stimulating intelligences specific ways to engage combination of intelligences together or separately as per the scope of the content. Table 2 shows how multiple intelligences of the students can be addressed in teaching of science.
Table 2 Teaching Science in Multiple Intelligences Way

<table>
<thead>
<tr>
<th>Intelligence</th>
<th>Teaching Science in Multiple Intelligences Way</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linguistic</td>
<td>• Instruct students to write brief report on contribution of scientists by referring print and on-line resources.</td>
</tr>
<tr>
<td></td>
<td>• Encouraging students to write sentences, poems, or stories about living and events.</td>
</tr>
<tr>
<td></td>
<td>• Incorporating letter writing activity such as asking permission to zoo, aviary mentioning clear academic purposes.</td>
</tr>
<tr>
<td></td>
<td>• Ask students to solve crossword puzzles on concepts of science.</td>
</tr>
<tr>
<td>Logical-</td>
<td>• Provide scope to learn science by using metric measurements, conversion of measurement unit.</td>
</tr>
<tr>
<td>mathematical</td>
<td>• Using inquiry and problem solving approach.</td>
</tr>
<tr>
<td></td>
<td>• Calculating usage of water and sources of energy and suggesting ways of conservation of the same based on logical reasons.</td>
</tr>
<tr>
<td></td>
<td>• Thought-provoking question–answer sessions.</td>
</tr>
<tr>
<td>Visual-spatial</td>
<td>• Use graphs, drawings, illustrations, maps, and diagrams and encourage students to present their learning in visual presentation including PowerPoint Presentation and using over head projectors.</td>
</tr>
<tr>
<td></td>
<td>• Use graphic organizers.</td>
</tr>
<tr>
<td></td>
<td>• Guide students to construct two/three dimensional models of molecules.</td>
</tr>
<tr>
<td></td>
<td>• Provide opportunity to students to prepare assignments using photographs taken by camera.</td>
</tr>
<tr>
<td></td>
<td>• Provide scope to use microscopes and telescope and ask them to present their learning in the form of images and drawing.</td>
</tr>
<tr>
<td></td>
<td>• Promote thinking in images.</td>
</tr>
<tr>
<td>Musical</td>
<td>• Investigate the nature of sound and the variables that create sounds in the natural environment.</td>
</tr>
<tr>
<td></td>
<td>• Provide opportunity to students to use musical instruments and ask them to explain why different instruments vary in their production of sound in pitch.</td>
</tr>
<tr>
<td></td>
<td>• Encourage students to prepare raps and songs on the topics of science such as energy, universe, instruments and natural world (flora, fauna, living, rock, sources of water, wind)</td>
</tr>
<tr>
<td></td>
<td>• Provide them opportunity to study music affects living. (human being and plants)</td>
</tr>
<tr>
<td>Bodily-kinesthetic</td>
<td>• Incorporate games, dance, drama, experiments, role-play and demonstrations</td>
</tr>
<tr>
<td></td>
<td>• Engage them to learn using puppet shows.</td>
</tr>
<tr>
<td></td>
<td>• Provide opportunity to students to participate in community affairs by working on projects like health and sanitation, AIDS, communicable diseases with the medical professionals, village education committees, Parent Teachers’ Association and people of village.</td>
</tr>
<tr>
<td></td>
<td>• Action research.</td>
</tr>
</tbody>
</table>

(*Table 2 is continued on next page.*)
### Table 2 Teaching Science in Multiple Intelligences Way

<table>
<thead>
<tr>
<th>Intelligence</th>
<th>Teaching Science in Multiple Intelligences Way</th>
</tr>
</thead>
</table>
| **Interpersonal** | • Use cooperative learning strategies such as peers’ assisted learning, learning in groups or allow them to work in pairs for experimentation, assignments, and projects.  
• Use role playing activities.  
• Ask them to prepare group report and ask them to present by means of group discussion and skit.  
• Use collaborative action research projects.  
• Provide them opportunity to interview the scientists, science teachers, parents to learn scientists’ inventions.                                                                 |
| **Intrapersonal** | • Use daily log writing activity so that students can track the record of their behavior and can modify the same.  
• Help them to decide personal goals and ask them to review.  
• Ask students to link science learning with their lives.  
• Ask students to identify their strengths and weaknesses and invite them to prepare plan of action to work in groups or alone.  
• Use exercise of personal reflection.                                                                                                                     |
| **Naturalist** | • Promote students to learn concepts of science using investigation of the natural phenomena.  
• Organize visit to aviary, zoo and sanctuary and ask them to write report on characteristic features of the animals.  
• Bring pets to the class for study.  
• Ask them to show their understanding of the natural world by presenting information in images, photographs of the natural world.  
• Ask them to watch channels TV like Discovery, Animals Planet and provide them opportunity to share what they saw and learnt about different inventions, plant and animal kingdom. |
1.5 Rationale for the Present Study

The review of related literature assisted the researcher to gain insight about studies conducted in the area of MI. It was found that a few studies have been carried out in India and that too at secondary level. Besides this, Multiple Intelligences is completely an exotic idea like others but not utilized in Indian set-up as it should have been. One cannot predict by the IQ measured on traditional intelligence test that particular person might have capacity to become a musician or a dancer. The theory of Multiple Intelligences provides scope to understand each person with different domains of abilities and talents. It also directs educationists to identify learners as per their strengths in multiple intelligences and also to render instructional strategy to allow them to use abilities for learning different subjects, especially science. NKC (National Knowledge Commission) (2008) expressed genuine concern for the enrollment of fewer students in science and mathematics education. It recommended popularization of science among children across India. NKC (2008) advocated that the programme should bring all popular science activities under one umbrella for rapid implementation.

The National Curriculum Framework for School Education- NCF (2000) mentioned that the multiple Intelligence approach offers learners many opportunities for the exploration of significant concepts and topics leading to think about them on their own and to have many ways to make sense of what they find. NCF (2000) also indicated that as MI (Multiple Intelligences) provides a variety of experiences, it helps large number of learners to succeed. It further added that the use of Multiple Intelligence in curriculum provides a variety of experiences which become the entry points into the lesson content and reach the learners in ways they can understand. It denoted that the multiple intelligence education provides a frame work that helps curriculum planners and also teachers to look for varying levels of strengths of their learners, and develop the optimum range of their intelligences. Fischer (1997) found that the use of Gardner's theory enabled educators to create learning environments that enabled all types of students to learn better.
Goodnough (2000) conducted a qualitative case study to explore Howard Gardner’s theory of multiple intelligences and its merit for making science teaching for making science teaching and learning more meaningful. Many positive outcomes resulted from this study on areas such as curriculum development, teacher development, and student learning in science. The researches documented by the researchers of the Schools Using Multiple Intelligences Theory (SUMIT) as mentioned in Kornhaber, Fierros, and Veenema (2004) supported that the application of multiple intelligences theory was found useful in solving academic problems such as score on standardized achievement test, performance of learning of disabled students’ in test, disciplinary problems and parental participation. Davis (2004) found a positive attitude among students about learning in science and the significant improvement in students’ achievement, behavior, and self-esteem. Therefore, based on research evidences and noticing the dearth of multiple intelligences based studies in India, the researcher was led to select the theory of multiple intelligences to design and develop the instructional strategy for teaching science at standard V as the researcher belongs to science background. The Government of Gujarat in the year 2010 - 2011 introduced the concept of theory of multiple intelligences and life skills with the introduction of semester system at secondary education. This suggested timely application of the theory of multiple intelligences at elementary level.

NCF (2005) suggested that curriculum must enable children to find their voices, nurture their curiosity to do things, to ask questions, to pursue investigations, to share and to integrate their experiences with school knowledge rather than their ability to produce textual knowledge. The report of the Education Commission (1964-66) aptly denoted, “In recent year, several countries have been able to raise their GNP (Gross National Product) very rapidly because of their investment in basic science, technology, and education. We are at a crucial stage in the process of development and transformations; and in this context the role of science (using the world in its broadest sense) is of the utmost importance.” This shows the importance of science education and relates it to the development of a nation. It is therefore required to use novel approach and methods in teaching science to enrich the teaching of science so as to maximize the learning to develop scientific attitude right from the beginning and to instill and develop interest towards science. NCERT (1969) mentioned, “Science is
more than a collection of knowledge; it is also the intellectual activity in which scientists are engaged. That is, science is not just a subject— it is also a pattern of methods for solving real problems, large and small, scientific and otherwise.”

It means in present context that science is required to develop the problem solving abilities and skills among young students. The teaching of science should aim to develop logical thinking along with nurturing and developing the interest towards science. It should also develop the creativity and critical thinking as they are inevitable for better living in 21st century. Various experiences such as reading, experimenting, listening, thinking, reflecting, writing and expressing oneself in speech are helpful to understand the concepts of science and retain the scientific understanding. The retaining of scientific understanding is also required as the problem solving ability builds upon small piles of scientific understanding. The conceptual understanding can be developed by engaging students actively in learning process. Active involvement involves exploration, enquiry, questioning, discussion, reflection leading to creation of ideas. Hence, the challenge lies before the teacher is to ensure active involvement of the students. The National Curriculum Framework by NCERT emphasized on active learning. This can be made possible by taking advantage of ICT and working on multiple intelligences models.

In Gujarat, subject specialization in schools is being offered after the 10th class. Primary schooling leaves intangible effects on tender minds of children. This is the most formative period of the development of interest towards science subject as it is the first experience for student to have science textbook in his/her syllabus, to know the miracles of the nature and the laws governing behind it. The success in developing interest of students towards science is largely possible by providing instructions in ways that would appeal to their student’s interest. Moreover, the Government of Gujarat has introduced a new Science and Technology textbook in the year 2007 in standard-V. It is therefore, standard-V was selected for the present study.
1.6 Statement of the Problem
Development of Instructional Strategy for Teaching Science at Standard V Based on the Theory of Multiple Intelligences

1.7 Objectives of the Present Study
(1) To design and implement instructional strategy based on the theory of Multiple Intelligences for teaching science at standard-V.
(2) To study the effectiveness of instructional strategy based on the theory of Multiple Intelligences for teaching science at standard-V in terms of academic achievement.
(3) To study the process of learning science among the standard V experimental group students in relation to process skills.
(4) To study the opinion of experimental group students for implemented instructional strategy for learning science based on the theory of Multiple Intelligences.
(5) To study the Multiple Intelligences profile of standard V students of experimental group with respect to academic achievement of students in science subject.
(6) To develop the guidelines for teaching science at standard V based on the present study.

1.8 Explanation of the Terms
1.8.1 Instructional Strategy
The instructional strategy would comprise of integration of various activities, methods and media for learning concepts of Science at standard-V based on the theory of Multiple Intelligences.

1.8.2 Multiple Intelligences
The Multiple Intelligences theory propounded by Howard Gardner in 1983 and 1999 is considered as a base for the present study. It includes eight different intelligences namely linguistic, logical-mathematical, visual-spatial, musical, bodily-kinesthetic, intrapersonal, interpersonal, and naturalist intelligence. Multiple Intelligences is abbreviated as ‘MI’ in the present study.
1.8.3 Process Skills
Science process skills are the systematic pathways to explore and gain evidence to study particular phenomena under study objectively. This systematic enquiry helps in developing ideas. The science process skills help to test and verify the results. Science process skills such as observation, communication, inference, measurement, classification and prediction were included in the study.

1.9 Operationalization of the Terms

1.9.1 Academic Achievement
The marks scored in pre- and post-tests are considered here as an academic achievement.

1.9.2 Studying the Process of Learning Science in relation to Process Skills
The indicators of science process skills given by Fraser-Abder (2011) were considered to analyze the process of learning science in relation to process skills. It was studied in observation process skill whether the students were able to identify the similarities, dissimilarities, noticeable changes and properties of the objects such as colour, size and shape. In measurement process skill, it was studied whether the students were able to measure the length, and width of the given objects using a standard tool such as ruler or meter tape accurately and precisely. The students’ ability to measure volume of liquid using measuring cylinder was also studied. The students’ abilities to classify given objects/substances based on their similarities were considered here. In inference science process skill, it was studied that whether the students were able to infer based on the acquired understanding through observation, measurement, and classification. It was studied that how students use their prior knowledge systematically and logically to think and predict what will happen for particular phenomena under study. The communication science process skill was studied with reference to how effectively the students were able to communicate their understanding about the scientific phenomena using charts, diagrams, and models, written and verbal modes of expression.
1.10 **Hypothesis of the Study**

There will be no significant difference between control and experimental group students of standard V in terms of academic achievements in science.

1.11 **Delimitation of the Study**

The present study is delimited to

- English medium schools following Science and Technology textbook prescribed by Gujarat State Board of School Textbooks, Gandhinagar.

- The Instructional strategy was developed for chapters - 2 to 7, 9, 11, 12, 14 and 16 of Science and Technology textbook of standard V, Gujarat State Board of School Textbooks, Gandhinagar. The lessons included are: Learn Preparing Groups, Living - Non Living, Let Us Know the Soil, Seed and Its Germination, Water and Its Importance, Observation of Living World, Food and Health, Air, Light and Its Properties, Measurement of Length and Energy.