A Study of Misconceptions in Science among Students of Standard VIII of Ranchi District

A Synopsis
of the Thesis to be submitted to
The Maharaja Sayajirao University of Baroda, Vadodara
for the degree of
Doctor of Philosophy
in
EDUCATION

Guide
Prof. R. C. Patel

Researcher
Ekta Priyadarshini

Department of Education (CASE, IASE & IUCTE)
Faculty of Education and Psychology
The Maharaja Sayajirao University of Baroda
Vadodara – 390002

1.0 Introduction

Education in the largest sense is any act or experience that has a formative effect on the mind, character or physical ability of an individual. It is the process by which society deliberately transmits accumulated knowledge, skills and values from one generation to another. The process of gaining and imparting education is spontaneous and goes on throughout our lives. As per modern conventions, education actually begins in school but in reality, it begins with the day we are born. Education that students get in the schools is through different subjects that are taught in schools. Science is one of the subjects that are compulsorily taught at all levels of schooling and it is also one of the core elements of the school curriculum.

The word science derived from Latin word "Scientia" which means "to know". In this context, science is a human enterprise through which we come to understand the big biological and physical aspects of the world around us. Science is tied to nature. Explanations of nature are always open to questions. Science is built from curiosity, experience, analysis and finally the expression of discovery. Adinarayana (1984) said science is better suited than any other subjects for acquiring the ability to develop scientific attitudes, to distinguish on the fact from opinion. It is important that science is highly creative and dynamic in nature by which man can attempt to search knowledge.

1.1 Meaning and Definition of Science

Science is the term that encompasses many fields or disciplines. The nature, structure and functions have been differently described by various scientists and philosophers. It is not easy to give precise definition of what is science. Science is a way of thinking, reasoning and finding solutions for diverse kinds of problems related to life and natural phenomenon. Scientists believe that all the natural phenomena have some patterns that can be understood through careful and systematic study. Although science does not have a single definition, however, many scientists, researchers and philosophers made attempts to define science. Science is the cumulative and endless series of empirical observations, which results in the formation of concepts and theories, with both concepts and theories being subject to modification in the light of further empirical observations. Science is both a body of

knowledge and the process of acquiring knowledge (Fitzpatric, 1960). According to Conant (1951) “Science is an interconnected series of concepts and conceptual schemes that have developed as a result of experimentation and observation”. Bronowski (1956) considers science as the search for order, regularity and organization as the fundamental aspect of science.

1.2 Importance of Science

Today’s age is the age of science and technology. Right from cradle to grave all our activities are controlled and fashioned by science. Science has entered in our life and daily activities so much that our existence would become impossible without it. Science is a great human enterprise, not only endless and faceless but also stable and fluid. It is a self accumulating, self growing, self-pervading, self accelerating and self-correcting enterprise which originated in the collective curiosity of man since time immemorial.

1.3 Aims of Science Education

According to National Curriculum Framework for School Education (2000, 2005 & 2023) and National Focus Group on Teaching of Science (2005) the broad aims of imparting science education to learners is paraphrased as below:

- To know the facts and principles of science and its applications, consistent with the stages of cognitive development.
- To acquire the skills and understand the methods and processes that lead to generation and validation of scientific knowledge.
- To develop an understanding of how scientific knowledge evolves.
- To develop a historical and developmental perspective of science and to enable the learners to view science as a social enterprise.
- To develop an understanding of the connection between science and other curricular areas.
- To relate to the environmental (natural environment, artifacts and people), local as well as global and appreciate the issues at the interface of science, technology and society.

- To acquire the requisite theoretical knowledge and practical technological skills to enter the world of work.
- To nurture the natural curiosity, aesthetic sense and creativity in science and technology.
- To imbibe the values of honesty, cooperation, concern for life and preparation of environment.
- To cultivate scientific temper, objectivity, critical thinking and freedom from fear, superstition and prejudice.

All the aims of science education are important to develop scientific literacy but the most important is the proper and correct understanding of the facts and principles. It empowers individuals to engage with scientific concepts, make informed decisions and contribute to the progress and well-being of society. Moreover, knowledge of facts and principles of science education is also important because it helps us understand the world, develop critical thinking skills, become scientifically literate, pursue career opportunities, shape public policies, address societal challenges and foster curiosity and wonder.

1.4 Recommendations of Various Commissions on Science Education

While reviewing the recommendations of the various commissions it was found that science education is considered important both before independence as well as after independence. British government also laid the importance of imparting science education to students. The researcher had reviewed the recommendations of Macaulay's Minutes on Education (1835) to Sargent Report (1944) before independence and from Secondary Education Commission (1952-53) to National Policy on Education (2020) after independence. It was found that the major crux of all these commissions was to enhance the quality of science education, development of analytical, critical and creative thinking. It also emphasized on problem solving ability, scientific attitude, decision making skills, proper understanding of scientific concepts and nurturing of science process skills etc. Science is involved in almost all the activities of our day to day life so the learners must have correct understanding of scientific concepts otherwise lack of concept clarity may lead to misconceptions.

1.5 Status of Science Teaching in India

National Focus Group on Teaching of Science (2005) suggests that scientific concepts should be taught mainly through activities, experiments and hands on experiences at all stages whether primary, upper primary, secondary or higher secondary levels. However, some researches such as Padhi (1994), Maitra and Maitra (1997), Malhotra (1998), Umashree (1999), Saxena (2012), Shelat (2013) found that science is taught more through lecture method rather than through demonstration or experiments. Malhotra (1998) observed that teachers often provide lecture and students largely observe the teacher rather than actively participating in the classroom. Umashree (1999) in her study found that students are rarely given opportunities to do things or take initiatives; teachers simply teach science through lecture method**.** Shelat (2013) is of the view that still today science is either taught through lecture method or through "TU PADH" approach. Looking at the contemporary scenario of science education in schools, the issues and challenges are more with regard to instructional method, laboratory and equipments facilities, curriculum materials and evaluation system. Science teaching largely follows lecture method; occasionally demonstration is conducted in the classroom and laboratory. Science teaching is dominated by facts, concepts, principles and generalization. Even today science teaching is focused more on content aspect rather than on process and application aspect. Teachers very rarely conduct experiments and investigations. Science is more about doing rather than cramming. If science is taught more through lecture method rather than demonstration method then students will not be able to understand the abstract concepts correctly and as a result misconceptions are created. The findings of the Public Report on Basic Education (1998 & 2006) revealed that science was taught more through lecture method rather than through demonstration or enquiry method. Students were forced to cram the topics rather than developing proper understanding of the concepts. An endearing story was told about a Standard IV class in progress in a municipal school in central Delhi. Students were mechanically being made to recite a lesson on the properties of air. The researcher visiting the classroom asks the children in a friendly way, 'Air is everywhere. Is it, really? Is there air in your bag?' The response of the students to this question is described as follows: Most deny emphatically, quite possessively confident of the details of their own belongings. However, a few curious and enterprising ones do innocently peep into their school bags to

see if this unknown elusive element somehow entered unnoticed. Programme for International Student Assessment (PISA 2009) was the litmus test for Indian Education System. This test is conducted worldwide every three years to measure the scholastic performance of fifteen year old school pupils in Maths, Science and Reading. The two best performing states of India (Himachal Pradesh and Tamil Nadu) participated first time in PISA (2009) test. In science the result was worst, Himachal Pradesh came in dead last behind Kyrgyzstan while Tamil Nadu inched ahead to finish 72nd out of 74 countries. In 2022 also India planned to participate in PISA but unfortunately we could not make it. This finding revealed a very dismal picture of science education in India.

Science teaching should engage the learner in acquiring methods and processes that will nurture the curiosity and creativity particularly in relation to the environment. It should develop the ability to think logically and the ability for using scientific method of work. Overall there is a need to develop teaching style and strategy to ensure meaningful learning so that correct scientific concepts are developed and misconceptions are avoided.

1.6 Understanding of Scientific Concepts

A concept is a category used to group similar events, ideas, objects or people. Concepts are abstractions and exist only in form of individual examples. Concepts help us to organize vast amounts of information into manageable units. Concepts are the building blocks of knowledge and allow people to organize and categorize information. Everyone has a set of knowledge that can be acquired through beliefs, conceptions, understandings and experiences. They are a part of the models and theories we hold to make sense of the world around us. During early childhood, children actively engage in acquiring fundamental concepts and in learning fundamental process skills. Young children begin to construct many scientific concepts during the pre-primary period. Concepts used in science grow and develop as early as infancy. Babies explore the world with their senses. They look, touch, smell, hear, and taste. They also develop the processes that enable them to apply their newly acquired concepts, expand existing concepts, and develop new ones. As they enter the primary period, children apply their early, basic concepts when exploring more abstract inquiries and concepts in science. Thus when students come to school they already had some established knowledge about the physical, biological, and social world based upon their own

ideas and explanations that may or may not be correct. If the wrong concepts of children are not corrected by school they tend to develop misconceptions in later stages (Charlesworth, 1995).

1.7 Meaning and Definition of Misconception

Concepts can be defined as ideas, objects or events that help individual understand the world around them. Conversely, misconceptions can be described as ideas, objects or events that are not in agreement with our own current understanding of natural science (Barke, 2012). Therefore, a misconception on the other hand can be defined as learning a concept in such a way that does not correspond to currently hold scientific theory (Skelly, 1993).The term "misconception" has many definitions. Wandersee (1985) defined misconception as a concept often used to describe an unaccepted (though not necessarily "incorrect") interpretation of a concept by the learner. Fowler and Jaoude (1987) defined misconception as an inaccurate understanding of a concept, the misuse of a concept name, the incorrect classification of concept examples, confusion between differing concepts, improper hierarchical relationships, or over- or under-generalizing of concepts. Students' incorrect patterns of responses, informal ideas, non-scientific interpretations and conceptions leading to conflict with scientific views are referred to by different terms such as "preconceptions", "misconceptions", "alternative framework" or "alternative conceptions" (cited in Karpudewan, et.al., 2017). Misconception refers to any conceptual idea whose meaning deviates from the one commonly accepted by scientific consensus (Haslam & Treagust, 1987). Misconceptions are stable cognitive structures that affect learners' understanding of scientific concepts and these are highly restricted to change (cited in Karpudewan, etal, 2017). Mc Closkey (1983) defines misconception as a belief or an idea that is not based on correct understanding or correct information. Carey (1985) opines misconception as a wrong belief or wrong opinion as a result of improper understanding of facts. According to Guest (2003), when children hold views that differ from conventional scientific explanations or classifications they are often referred to as misconceptions. The term misconception also refers to the inappropriate understanding of any idea or concept (Peckmez, 2010). Mayer (2011) opines misconception is a conclusion that is wrong because it is based on faulty thinking or facts that are wrong. A number of term such as misunderstanding,

misapprehension, mistake, error, misinterpretation, misbelieve are synonymously used for misconception (Read, 2004). For the present study, the definition given by Narode (1987) is sufficiently comprehensive to provide practical and useful guidelines: “Misconception is a person's conceptualization of a problem or phenomenon that generally is reasonable to themselves but at variance from the conceptualization of an "expert" in the field from which the problem came”. Thus, the term misconception can be simply paraphrased as an idea or an explanation that differs from an accepted scientific concept. Thus, misconceptions among students can be in the form of misunderstanding, mistake, error, improper/partial understanding of facts and concepts.

1.8 How misconceptions are created in children?

Children’s ability to process information, their thinking ability, develops slowly with experiences and interaction and the information processing capability of a particular child will set limits on the complexity of concepts that the child can cope with. We have operations in the workings of our minds, or ways of thinking, which enable us to construct knowledge. This development is not just a matter of becoming faster or more accumulation of knowledge: there are qualitative changes in the way that children process new information as they develop cognitively.

According to NCF 2023, students come to school with their own theories about the world around them. These theories develop as they observe the world around them and seek explanations for what they see. Often, these theories conflict with what is being discussed in the classroom. Their existing notions do not get addressed in the classroom, and there is a separation between ‘home’ and ‘school’ science. As students move to higher grades, the demands on them increase, and the curricular load becomes greater. The need for abstract thinking also increases. It is critical that the students develop the capacities to be able to make the progression. However, the current focus on facts does not build these capacities. Also, the time for understanding each concept is limited, so alternative conceptions may develop that are difficult to address.

According to Von Glasersfied (as cited in Bodner, 1986), the learners construct understanding of concepts on their own. They do not simply mirror and reflect what they are

told or what they read. Learners look for meaning and will try to find regularity and order in the events of the world even in the absence of full or complete information. This can be summarized in a single statement: Knowledge is constructed in the mind of the learner (Bodner, 1986). Constructivist theory views knowledge acquisition as the result of the life-long construction of both formal and informal knowledge. Informal knowledge is gained from interaction with the environment, whereas formal knowledge is gained through the intervention of the school (Bodner, 1986; Pine & West, 1986). Children construct knowledge in order to manage their experiences. An informal knowledge is constructed through interactions with parents, friends, and other influences. This knowledge base is built on everyday-life experience, influencing consideration of any or all explanations by children. Thus, it impacts whatever children will learn subsequently (Bodner, 1986; Butts & Brown, 1989; Driver & Oldham, 1986; Garnett & Stavy, 1992). If what children consider to be reasonable explanations are incorrect, and are provided with this knowledge (either formally or informally) via any media or school system, the incorrect knowledge will be maintained and this led to the creation of misconceptions among students. However, if they are provided with correct knowledge, that is, knowledge approved by consensus opinion, for example, respected scientists, learned teachers etc., and they are engaged in constructing meaning, the children may change their existing knowledge base (Cho, 1988; Inhelder & Piaget, 1958). Thus, Constructivist theory helps to provide explanations why children bring misconceptions to the classroom. Constructivists' perspective holds that misconceptions are incorporated into student cognitive structures.

1.9 Misconceptions in Science

The assessment of students' understanding of scientific concepts has been of interest to researchers and teachers in science education community recently. Various terminologies have evolved to describe students' understandings, which are different from or inconsistent within the consensus of the scientific community. Misconception is one of the various terms used by science education researchers to describe wrong knowledge (Brumby, 1984, Cho, 1988, Driver and Oldham, 1986, Doran, 1972, Fischer, 1985, Garnett and Stavy, 1992, Griffiths & Preston, 1992, Rayla & Rayla, 1938, Treagust, 1988). Others include misunderstanding (Marek, 1986) alternative framework (Betkouski, 1987) and alternative

conception (Abimbola, 1988) preconceptions (Driver and Oldham, 1986, Novak, 1980, Tippet, 2010), and children's science (Gilbert, Osborne, 1983 and Fensham, 1982). NCF (2005) also uses the term "alternative conceptions" or "misunderstanding" to describe improper or partial understanding of scientific concepts by students. In the present study, the term "misconception" is used because of its frequent appearance in research studies. Researchers have given various definitions to describe misconceptions in science. The term misconceptions refer to the students conceptions in different domains of science which are incongruent to the standard conceptions accepted by scientists (Clement, 1982). Duit (1987) stated that "misconceptions are conceptions which are incorrect viewed from the standpoint of science". Misconceptions are often defined as ideas that persons believe to be true but do not necessarily match scientific evidence (Pine & West, 1986). Carey (2000) defines misconception as the inability of the students to apprehend scientific concepts correctly. According to Mondal and Chakraborty (2013) the word misconception implies (a) students' mistaken answer to a particular scientific situation (b) students' ideas which causes mistaken answer about a particular scientific situation (c) students' beliefs about how the world works different than that of the scientists.

Thus on the basis of above meanings and definitions the term "misconception in science" can be simply paraphrased as an idea or an explanation that differs from an accepted scientific concept. It can also be concluded that if the view or the opinion or the concept of an individual is different with what is generally accepted by scientific community the individual may tend to develop misconception. Wrong information, misunderstanding or partial understanding of scientific concepts may lead to misconceptions among students.

Duit and Treagust (1995) suggest that "at all ages students hold conceptions about many phenomenon and concepts before they are presented in the science class. These concepts stem from and are very deeply rooted in daily experiences because they have proved to be helpful and valuable in daily life". These conceptions that students hold are sometimes grounded in scientific truth and other times are conceived through intuitive yet incorrect assumptions. Children develop ideas about natural phenomenon before they are taught science in school. In some instances these ideas are in keeping with the science which is taught. In many cases, however, there are significant differences between children's notions

and school science. For example, a child who believes that the seasons are caused by the distance of the Earth from the Sun during its annual revolution is operating with a misconception. However the correct concept is that the seasons are caused by how Earth is tilted on its axis relative to the Sun.

2.0 Review of the Related Literature

In order to get a clear insight on misconception in science education the researcher has gone through the available sources like books, documents, survey reports, journals, international dissertation abstracts, university news, published and unpublished thesis ERIC, Shodhganga, inflibnet and research works to obtain research findings on the related topic, which provided a clearer insight into the problem and direction for the appropriate methodology. The researcher has examined different literature from book, thesis, survey reports and research works. It involved locating, reading and evaluating reports of research as well as reports of casual observation and opinion that were related to researcher's research work. It helped to obtain a structured outline of what others have done in the area. The researcher developed an insight into various problems of the same field, from suggestions given by other researchers and could also identify the research gaps persisting, which needed to be investigated and further researched upon. It helped the researcher to get advance knowledge in the field of interest. It also enabled the researcher to avoid unnecessary duplication and at the same time to understand different methodologies adopted by other researchers. Review of related literature is an important aspect of any research as it helps the researcher to examine whether the problem selected or any aspects of problem have been dealt with previously. In order to get a clear insight on misconceptions in science the researcher went through some available sources such as documents, survey reports, journals and research works to obtain research findings on the related topic. Review was done from sources available since 1988 till 2018. Both Indian and foreign literatures were explored. A total of hundred and twenty reviews were selected relevant to the topic. The availed reviews can be broadly classified into following categories.

- Studies related to misconceptions in Physics (38 studies)
- Studies related to misconceptions in Chemistry (25 studies)
- Studies related to misconceptions in Biology (34 studies)

- Studies related to misconceptions in other areas (14 studies)
- Studies related to misconceptions in science among teachers (9 studies)

2.1 Implications of the Reviewed Literature for the Present Study

Out of hundred and twenty studies reviewed, hundred and eleven were conducted abroad and only nine studies were conducted in India. Misconceptions interfere with ability of students to understand concepts presented in the classroom (Mestre & Touger, 1989). Halloun and Hestenes (1985) stated that if misconceptions are not corrected early in the course, the student will not only fail to understand much of the material, but worse, he is likely to dress up his misconceptions in scientific jargon, giving the false impression that he has learned something about science. The misconceptions are barriers in teaching learning process as students are emotionally attached to them and bestow up their misconceptions with great efforts. For the success of teaching learning process it is henceforth imperative to identify, acknowledge and breakdown the misconceptions. Before teaching science, the misconceptions about it must be identified and the topics must be planned so as to minimize it, therefore, the need of the present study is felt. The review of the related literature helped the researcher in identifying the research trends in India and abroad related to misconceptions in science. The research studies reviewed gives the knowledge of methodology adopted by various researchers and their findings. On the basis of the review of the related literature the researcher has come to the conclusion that misconceptions in science is prevalent among students in many countries however the number of such studies done on Indian students are very few (only five in last decade) and therefore the urge for the present study is felt.

2.2 Rationale

If we throw a bridge between science and education, using psychology, we arrive at the concept of science education, which, bluntly speaking is an integrated concept. If so, it is then within the realm of possibility to link the most powerful concepts of science to the growing minds of children through active experimental pedagogy. Learning science should never only be about learning to know the natural world. Science education has to be recontextualised in order to be meaningful in school. Findings of Hoshangabad Science

Teaching Project in Madhya Pradesh HSTP (1970-2002) a massive Science teaching programme revealed that "Science teaching is mainly textbook-based rote learning with little emphasis on understanding of concepts or the process of science, students are unfamiliar and far behind in basic process skill". In many classrooms today "teaching" means talking, and Learning means "listening". HSTP is the pioneer in reconceptualising science teaching.

Science is being described as part of everyday life and an understanding and appreciation of science concepts and process is required by all members of society if they are to be active citizens making informed decisions and contributions to debate about relevant issues and events. Various committees from Secondary Education commission (1952-1953) to National Curriculum Framework (2005) have recommended for science to be taught through purposeful, concrete and realistic situations and also talked of improving the quality of science education. In order to strengthen the quality of science education at all levels there seems to be an urgent need to practice learner centered, activity based, competency dependent inquiry approach for teaching science, which will make learning of science an enjoyable experience for children others wise it may lead to misunderstandings and misconceptions.

Students learn the concept of knowledge about the world around them from an education system at schools or informal way according to their experiences, which are frequently used to construct an insight with the student perspectives. Because of that matter, some researches had been held to provide information about student understanding, especially in learning science concepts. Students entering the science classroom have a number of previous experiences, ideas, beliefs and expectations about the natural world. The content taught in the classroom should be interpreted in the light of this prior knowledge. Even after formal instructions, students' spontaneous conceptions often remain at variance with accepted scientific ideas. These have been labelled as alternative conceptions, misconceptions, pre-conceptions or naive conceptions. On the basis of the literature reviewed it has been found that research all over the world has gone into uncovering misconceptions and drawing their implications for learning.

National Research Council (1996) stated that the primary role of misconceptions in science is a barrier for students to learn science because in many cases, misconceptions can detain students to develop correct ideas used as the initial insight for advanced learning. This is

parallel with King (2010) who unveiled that misinterpretations found in the textbook of Earth Science influence students' understanding of a scientific text which makes them difficult to comprehend further information or knowledge as a reader. Besides, teachers may also experience misconception in teaching either physics, chemistry, or biology topics which leads, inevitably, in student misconceptions (Moodley & Gaigher, 2019). In other words, misconception will interfere with the quality and quantity of science learning process and outcomes for both student and teacher.

Students' misconception is a major threat in general teaching-learning process at school level. Students' misunderstandings and misconceptions not only in sciences but also other disciplines at all levels constitute a major problem of concern to science educators, scientific researchers, teachers, and students (Johnstone, 2000, Novick and Nusbaum, 1981). Misconceptions cover a large range of science concepts, so science educators in many countries are paying attention upon students' misconceptions about scientific concepts (Osbome and Wittrock, 1983). Many students have difficulty in learning science because much of their learning tends to involve memorization of facts in which newly learned materials is not related in ways that make sense to the learner (Novak, 1988). However, learning in science is not just adding new concepts to the knowledge, but it often requires realignment in thinking and construction of new ideas that may be in conflict with earlier ideas. Additionally, research studies have consistently shown that students do not come to classroom with blank slates (Posner, et.al., 1982). In fact, students from the moment of birth need to make sense of their world. They construct their own understanding for how and why things behave as they do. So, long before they begin formal schooling, children have made meaning of their everyday observations and, they will construct new knowledge on their previous experience. As accepted by many scientists, when these students' previous conceptions are different from the views of scientists, these differing frameworks affect further learning negatively. In order to remove students' misconceptions, it is necessary to identify the sources of these misconceptions. During learning, the students try to connect new knowledge into his/her cognitive structure. If they hold misconceptions, these misconceptions interfere with subsequent learning. Therefore, new knowledge cannot be connected to their existing structure and misunderstanding of the concepts arises (Nakhleh,

1992). Misconceptions are a serious problem because it prevents learning and creating obstacles to further learning (Canpolat, 2006).

The researcher will carry the present study on eighth standard (upper primary stage) students in Ranchi district of Jharkhand State. The period of eight years (I to VIII std.) is of one of the tremendous cognitive development, shaping reason, intellect and social skills, as well as the skills and attitudes necessary for entering the work force. According to NCF (2005), at the upper primary stage the children are getting their first exposure to science as separate subjects. It is a crucial stage wherein students are expected to learn more scientific concepts correctly. Also eighth standard is the threshold of secondary education and it is also a transition phase between primary and secondary level. In this stage the students should develop a lot of clarity about basic concepts of science. Beard (2007) suggests that science should be taught through experiential learning method such as activity based learning, demonstrations, experiments or through scientific enquiry but (Malhotra, 1998, Umasree, 1999, Ramkumar, 2003 and Shelat 2013) found that lecture method is being commonly used in our classrooms and our students did not get hands on experience. As a result when our students did not understand any of the basic concepts rather than explaining them through experiments or connecting those concepts to their day to day life, the teacher teach the same concepts twice and thrice through lecture method. Because of this the correct concept formation in students does not takes place. As we know that in science most of the concepts are inter-related and if one concept is not understood properly it may lead to improper understanding of other related concepts. It has proved through some researches (Alvermann et al., 1985, Diakidoy & Kendeou, 2001, Diakidoy, +Vosniadou, & Hawks, 1997, Nussbaum & Novak, 1976, Vosniadou & Brewer, 1992, 1994) that if children do not have clear concepts about scientific principles and process they tend to develop misconceptions and one misconception leads to another which sometimes persist throughout their lives.

It is fairly well recognized now that misconceptions cannot be easily replaced by correct scientific ideas. One way of looking at this resistance is to imagine students' conceptions from an interconnected system of beliefs: about the nature of science, of school, of learning and of the world around. Any one of these beliefs cannot simply be treated as a scientifically inaccurate idea that is easily corrected. The idea has to be understood in terms of a more general world-view held by the student, and it has to be also tackled from that perspective

(Novak, 1988). Knowledge is constructed through interaction with the physical as well as the social environment. Misconceptions, therefore, need to be seen in terms of the context of learning, including the socio-cultural and linguistic background of students and its relation to the classroom climate

Therefore, it is of utmost importance that the misconceptions among students must be identified then only proper teaching learning strategies can be developed to minimize it. Hence the researcher has decided to conduct a study on misconceptions in science with the following research questions.

3.0 Research Questions

1. How misconceptions in science can be measured?
2. What leads to the development of misconceptions in science among students?

3.1 Statement of the Problem

"A study of misconceptions in science among students of standard VIII of Ranchi district"

3.2 Objectives of the study

1. To identify misconceptions in science among students of standard VIII.
2. To study the reasons and sources of misconceptions in science among students of standard VIII.
3. To study misconceptions in science with respect to:
    a. Gender
    b. Availability of teaching learning materials.
    c. Availability of science laboratory.
    d. Educational qualifications of teachers.
    e. Professional qualification of teachers.
    f. Experience of teachers.
    g. Educational Qualification of parents

3.3 Hypothesis

The hypotheses for the present study are as follows:

1. There will be no significance difference in the mean score of misconceptions in science between boys and girls of standard VIII.

2. There will be no significance difference between availability and non-availability of teaching learning material on misconceptions in science among students of standard VIII.
3. There will be no significance difference between availability and non-availability of science laboratory on misconceptions in science among students of standard VIII.
4. There will be no significance difference between higher educational qualification and lower educational qualification of teachers on misconceptions in science among students of standard VIII.
5. There will be no significance difference between higher professional qualification and lower professional qualification of teachers on misconceptions in science among students of standard VIII
6. There will be no significance difference between higher experience level and lower experience level of teachers on misconceptions in science among students of standard VIII.
7. There will be no significance difference between higher educational qualification and lower educational qualification of parents on misconceptions in science among students of standard VIII.

3.4 Explanation of the term

Misconception: Misconception refers to any conceptual idea whose meaning deviates from the one commonly accepted by scientific consensus (Haslam & Treagust, 1987). According to Guest (2003), when children hold views that differ from conventional scientific explanations or classifications they are often referred to as misconceptions. For the present study, the definition provided by Narode (1987) is sufficiently comprehensive to provide practical and useful guidelines: Misconception is a person's conceptualization of a problem or phenomenon that generally is reasonable to themselves but at variance from the conceptualization of an "expert" in the field from which the problem came. Thus, the term misconception can be simply paraphrased as an idea or an explanation that differs from an accepted scientific concept.

3.5 Operationalization of the term

1. Misconceptions in Science: For the present study the term misconception refers to the incorrect answer given by the students in Three-Tiered Multiple Choice Science Misconception Test (TTMCSMT). Misconceptions among students can be in the form of misunderstandings, mistakes, errors, improper/partial understanding of the facts and the concepts.

2. Score on Misconceptions in Science: For the present study scores on misconceptions refers to the total achievable scores minus scores obtained by students on Three-Tiered Multiple Choices Science Misconceptions Test.

Score on Misconception = 76 - Score obtained by a student on TTMCSMT

As there were 76 items of one mark each in the test, therefore, maximum achievable score was 76.

Second tier was used to know the probable reasons of misconceptions and third tier was used to know the probable sources of misconceptions.

3.6 Delimitation of the Study

The present study was delimited to schools affiliated to Jharkhand Board of Secondary Education of Ranchi district. The present study was further delimited to standard VIII students enrolled in the academic year 2019-2020. It was also delimited to scientific concepts only.

4.0 Methodology of the Study

A descriptive survey method was used for the present study. According to Creswell (1994), the descriptive research method gathers information about the present condition. The focus of this research was to identify misconceptions in science, and therefore, the descriptive survey method was appropriate.

4.1 Population

The population for the present study consists of all the schools affiliated to Jharkhand Board of Secondary Education of Ranchi district of Jharkhand state. There were a total of 866 schools under Ranchi district. All standard VIII students and teachers teaching science to

these students of the academic year 2019-2020, constituted the population for the present study. *(Source: District Education Office, Ranchi)*

4.2 Sample and Sampling Technique

For the present study the sample was selected from Ranchi District of Jharkhand State. There were a total of 18 blocks in Ranchi district. One school from each block was selected using lottery method. All the students of standard VIII and teachers teaching science to the students of the selected schools constituted the sample for the study. There were a total of 926 students and 18 teachers.

4.3 Tools used for Data Collection

In order to collect the requisite data for any theme of research, one has to devise an appropriate tool. To collect the data on Misconceptions in Science following tools were used.

1. Content analysis of Science and Technology textbook of standard VIII of Jharkhand State Board.
2. Semi-Structured Interview for school teachers.
3. Three-tiered Multiple Choices Science Misconception Test.
4. Information Schedule for school teachers.
5. Observation Schedule for availability of teaching learning material.
6. Observation Schedule for availability of science laboratory.

4.3.1 Content analysis of Science and Technology textbook of standard VIII.

The researcher has done the content analysis of science and technology textbook of standard VIII of Jharkhand State Board. The objective of the text book analysis was to know the content, topics and concepts covered in each chapter. There were a total of 16 chapters in the book. Text book analysis helped the researcher to identify the proper representation of chapters of physical and biological sciences. It also helped the researcher to figure out the inter-linkages between the chapters and its gradual progression from easy to difficult

concepts. The detailed analysis of science and technology text books of standard VIII helped the researcher to establish vertical and horizontal relationship among chapters. The scientific concepts or topics covered in each chapter would become the base for the construction of Three-Tiered Multiple Choice Science Misconception Test.

4.3.2 Semi Structured Interview of School Teachers

The researcher has taken semi structured interview of school teachers who taught science to the students of standard VIII in Jharkhand State Board Schools. The researcher has conducted the interview of 25 teachers teaching science in different schools. Most of the teachers had a minimum of 10-15 years of teaching experience. The objective of this interview was to identify those concepts where students face difficulty in comprehension. During interview discussion was also done related to concepts where teachers face difficulty in making students comprehend in spite of all their efforts.

4.3.3 Principles followed while constructing Three-tiered Multiple Choice Science Misconception Test

On basis of text book analysis, semi structured interview of school teachers and personal teaching experience the researcher has identified one chapter each from physics, chemistry and biology for the construction of Three-Tiered Multiple Choice Science Misconception Test. Prior to the construction of the test the researcher had carefully reviewed the existing research literature, as well as all related instruments that have already been used by other researchers on misconceptions in science. Language used in the tool should be simple and understandable by the students.

4.3.4 Three-tiered Multiple Choice Science Misconception Test

In order to collect the data on misconceptions in science from the selected sample, researcher constructed the Three-tiered Multiple Choice Science Misconception Test for the students of standard eight. This test contained a set of items, each one composed of three parts. The first part or the first tier of the item is multiple choice content questions with a set of true and false responses. The second part or the second tier consists of a set of justifications for the chosen response to the question in the first part. Space is provided for writing an alternative

response. The third part or the third tier consists of set sources of the information. By considering the study objectives, research questions, nature of date required, and student's cognitive level, researcher has constructed the first draft of the three-tiered multiple choice science misconception test.

4.3.5 Expert's Validation

The item pool of Three-tiered Multiple Choice Science Misconception Test was sent to experts in the field of science and technology to ensure its content validity and appropriateness of items. The experts were either working as a science teacher in elementary/secondary/higher secondary schools or assistant professor of science method in teacher education institutes. The minimum qualification of the experts was M. Sc., B.Ed. However, some experts had the qualification M. Sc., M. Ed. while many of them had earned a Ph. D. in Education too. The minimum teaching experience of the experts was five years; however, some experts had a vast experience of 25 years too. The tool was also sent to English and Hindi language experts to examine its language aspects. The comments and suggestions received from the experts were incorporated to formulate the final draft of the test.

4.3.6 Pilot testing

Researcher had personally administered the Three-tiered Multiple Choice Science Misconceptions test on a group of 45 students who were not the part of the sample. The main purpose of pilot testing was to examine the tool of its language aspect and ambiguity of the items. According to Johnson and Christensen (2008) a pilot testing of minimum five to ten pupils is enough to establish the reliability of the tool. Subsequent to completion of pilot test researcher has used "Think aloud Technique" to know strength and weakness of the items. In this technique the participants verbalize their suggestions and perceptions about each item. Think aloud technique is for determining whether participants are interpreting the items the way researcher has intended (Johnson and Christensen, 2008). Instead of using the "Think aloud Technique" on all the 45 students, it was rather used on a small group of 15 students so that the researcher can more accurately figure out whether the students are interpreting the items, the way researcher has intended.

Experts' comments and suggestions during validation of the item pool and the findings of the pilot testing were used to frame the final draft of the test. In the final draft some items were substituted, some were deleted and few were modified.

4.3.7 Information Schedule for School Teachers

The researcher has made an information schedule for the teachers to know about their gender, teaching experiences, educational qualification, professional qualifications, and mode of teaching, use of teaching learning materials in the classroom. This tool was administered on 18 science teachers teaching students of standard VIII in schools of Ranchi district.

4.3.8 Observation Schedule for Availability of Teaching Learning Materials

The researcher has made an observation schedule to check the availability of teaching learning materials in the selected schools. This observation schedule has six items. These items were kept in the tool to assess the availability of books, blackboard along with the presence and use of charts/models/diagrams/posters etc. in the classroom. The researcher has also observed the availability of electricity so that the use of information and communication technology can be assessed. The observation regarding availability and use of teaching learning material in the classroom was noted in the field diary.

4.3.9 Observation Schedule for Availability of Science Laboratory

The researcher has made an observation schedule to check the availability and use of science laboratory for teaching-learning process. The researcher was keen to observe that whether science laboratory was well illuminated and ventilated so that the students feel comfortable and there is no difficulty in performing any experiments. The tool contained items related to the availability and working condition of the scientific equipments. The equipments were in accordance to the needs of the student and whether it was used by teachers only or students were also allowed to manipulate with the equipments. Items related to the proper allocation of equipments to the students as well as the presence of sufficient number of equipments

were also added in the tool. The observation regarding availability and use of science laboratory was noted in the field diary.

4.4 Procedure for Data Collection

First the researcher has taken a permission letter from guide for data collection. Then a forwarding letter was taken from the Dean and Head of The Faculty of Education and Psychology, Department of Education (CASE) The Maharaja Sayajirao University of Baroda. This forwarding letter was presented to the District Superintendent of Education (DSE) of the Ranchi District. Thereafter permission letter was sought from the DSE of Ranchi district to allow the researcher to collect data in the selected schools. The tools used for data collection was also submitted to the office of the District Superintendant of Education and an assurance was given that data collected would be used for research purpose only and would be kept strictly confidential. Students were instructed to fill primary details such as their names, school names, class section, before they started attempting the questions. Following instructions were given to the students before starting of the test.

- It is compulsory to attempt all the questions.
- Each question has three parts.
- Put a tick mark to the most appropriate response from each part.
- Each question has only one correct answer.
- There is no negative marking for incorrect answer.
- Each correct answer carries one mark.
- Do not make any marks in the question paper.
- Return the question paper to the invigilators after completion of the test.

4.5 Data Analysis Techniques

The tools used to gather data for each objective along with the appropriate data analysis techniques employed for each tool is depicted in the table given 1.1

Table_1.1 Tools and Data Analysis Technique

S.N.	Objectives	Tools Used for Data Collection	Data Analysis Technique Employed
1.	To identify misconceptions in science among students of standard VIII.	Three-tiered Multiple Choice Science Misconceptions Test	Percentage
2.	To study the causes and sources of misconceptions in science among students of standard VIII.	Three-tiered Multiple Choice Science Misconceptions Test	Frequency and Percentage
3.	To study misconceptions in science with respect to: a) Gender b) Availability of teaching learning materials c) Availability of science laboratory d) Educational qualifications of teachers e) Professional qualification of teachers f) Experience of teachers g) Educational qualifications of parents	Three-tiered Multiple Choice Science Misconceptions Test for variable **a** & **g**, Observation Schedule for variable **b & c** Information Schedule for teachers for variable **d, e & f.**	t-test, ANOVA

4.6 Major Findings

The major findings of the study are as follows:

1. Majority of students had given incorrect answers of the questions asked in Three-Tiered Multiple Choice Science Misconception Test.
2. Majority of students had given incorrect reasons for their true and false answers of Three- Tiered Multiple Choice Science Misconception Test.
3. Majority of students considered books as their primary source of knowledge.
4. Majority of students of standard VIII had misconceptions in science.
5. It was found that there was no significant difference in the mean score of misconceptions in science between boys and girls.
6. It was found that availability and non availability of teaching learning material has significant difference on misconceptions in science among students. It was found that

higher the number of teaching learning materials lower is the level of misconceptions among students.

8. The significance difference between availability and non-availability of science laboratory on misconceptions in science among students could not be established because science laboratory was available in only one school.
9. It was found that there was no significant difference between higher and lower level of educational qualification of teachers on misconceptions in science among students.
10. It was found that there was a significant difference between higher and lower level of professional qualification of teachers on misconceptions in science among students. It was found that higher the professional qualification of teachers lower is the level of misconceptions among their students.
7. It was found that there was a significant difference between higher and lower experience level of teachers on misconceptions in science among students. It was found that higher the experience of teachers lower is the level of misconceptions among their students.
11. It was found that there was a significant difference between higher and lower level of educational qualification of parents on misconceptions in science among students. It was found that higher the educational qualification of parents lower is the level of misconceptions among their children.

References

Abimbola, I. O. (1988). The problem of terminology in the study of student's conceptions in science. *Science Education*, 72(2), 175-184.

Adinarayana, K. (1984). *Science teaching in primary schools training programme.* An unpublished Doctoral thesis. University College of Education Madurai. In Buch, M.B (Ed.) *Fourth Survey of Research in Education.*

Alvermann, D. E., Smith, L. C., & Readence, J. E. (1985). Prior Knowledge activation and the comprehension of compatible and in compatible test. *Reading Research Quarterly*, 20, 420-436.

Barke, H. D. (2012), Two Ideas of the Redox Reaction : Misconceptions and Their Challenge in Chemistry Education. *African Journal of Chemical Education*, 2, 32-50.

Betkouski, M. B. (1987). *Meaningful learning in elementary science*. Dubuque, IA: Kendall/Hunt.

Bodner, G. M. (1986). Constructivism: A Theory of Knowledge. *Journal of Chemical Education,* 63, 873-877. http://dx.doi.org/10.1021/ed063p873

Bronowski, J. (1956). *Science and Human Values.* New York: Harper and Row.

Brumby, M. N. (1984). Misconceptions about the concept of natural selection by medical biology students. *Science Education,* 68(4), 493-503.

Butts, R. E. & Brown, J. R. (1989). Constructivism and Science: Essays in Recent German Philosophy. New York: Springer.

Canpolat, N. (2006). Turkish undergraduates' misconceptions of evaporation, evaporation rate and vapour pressure. *International Journal of Science Education,* 23, 1757-1770.

Carey, S. (1985). *Conceptual change in childhood.* Canbridge. MA: MIT Press.

Charlesworth, L. (1995). Misconceptions in physics and biological science of the upper secondary school students. (Unpublished Ph.D. thesis). Chulalongkorn University, Thailand.

Cho, J. (1988). *An investigation into fifth and eighth grade Korean students' misconceptions of photosynthesis* (Unpublished Ph.D thesis). Ohio University, Ohio.

Clement, J. (1982). Students' preconcepts in introductory mechanics. *American Journal Physicans,* 50(1), 66-71.

Cresswell, J. W. (1994). *Research Design: Qualitative and Quantitative Approach.* California: SAGE Publications, Inc.

Diakidoy, I. N., & Kendeou, P. (2001). Facilitating conceptual change in astronomy: A comparision of the effectiveness of two instructional approaches. *Learning and Instruction,* 11, 1-20.

Diakidoy, I. N., Vosniadou, S., & Hawks, J. D. (1997). Conceptual change in astronomy: models of earth and the day/night cycle in American Indian children. *European Journal of Psychology of Education,* 12, 159-184.

Doran, R. L. (1972). Misconceptions of selected science concepts held by elementary school students. *Journal of Research in Science Teaching,* 9(2), 127-137.

Driver, R., & Oldham, V. (1986). A constructivist approach to curriculum development in science. *Studies in Science Education,* 13, 105-122.

Duit, R. (1987). Research on students' alternative frameworks in science topics, theoretical framework, consequences for science teaching. *In J. D. Novak (Ed.), Proceedings of the Second International Seminar of Misconceptions and Educational Strategies in Science and Mathematics,* Vol. 1 (pp. 151-162). Ithaca, NY: Cornell University.

Duit, R., & Treagust, D. F. (1995). Conceptual Change: *A powerful framework for improving science teaching and learning. International Journal of Science Education*, 25, 671-688. Doi: 10.1080/09500690305016

Fensham, J. 0. (1982). Superstition and science teaching. *School Science and Mathematics,* 30(3), 277-282.

Fischer, K. M. (1985). A misconception in biology: amino acids and translation. *Journal of Research in Science Teaching*, 22(1), 53-62.

Fitzpatrick, F. C. (1960). *Policies for science education.* Bureau of Publications, Columbia University: New York.

Fowler, T. W., & Jaoude, D. B. (1987). *Using hierarchical concept/proposition maps to plan instruction that addresses existing and potential student misunderstandings in science* (Unpublished Ph.D thesis). Cornell University, New York.

Garnett, P. & Stavy, R. (1992). Conceptual difficulties experienced by senior high school students of electrochemistry: electrochemical (galvanic) and electrolytic cells. *Journal of Research in Science Teaching,* 29(10), 1079-1099.

Gilbert, J. K. (1982). Concepts, misconceptions and alternative concepts: Changing perspective in science education. *Studies in Science Education,* 10, 61-98.

Griffiths, A. K., & Preston, K. R. (1992). Grade-12 students' misconceptions relating to fundamental characteristics of Atoms and molecules. *Journal of Research in Science Teaching,* 29(4), 611-620.

Guest, G. (2003). *Alternative Frameworks and Misconceptions Primary in science.* Retrieved

fromhttp://www.ase.org.uk/scitutors/professional_issues/teaching_teaching/misconceptions.php

Halloun, I. & Hestenes, D. (1985). The Initial Knowledge State of College Physics Student. *American Journal of Physics,* 53(11):1043-1055 DOI:10.1119/1.14030

Haslam, F., & Treagust, D. F. (1987). Diagnosing secondary students' misconceptions of photosynthesis & respiration in plants using a two-tier multiple choice instrument. *Journal of Biological Education,* 21(3), 203-11.

Hoshangabad Science Teaching Project (1977). *Science Today, 12.*

Jhonson, B and Christensen, L. (2008). E*ducational Research (3rd Edition) Qualitative, Quantitative and mixed Method Approaches.* New Delhi, SAGE Publications.

Johnstone, A. H. (2000). Teaching of Chemistry-Logical or Psychological? *Chemistry Education: Research and Practice in Europe,* 1(1), 9-15.

Karpudewan, M., Narulazam, A., Zain, M. & Chandrasegaran, A. L. (2017). *Overcoming Students' Misconceptions in Science,* Singapore: Springer.

King, C. J. H. (2009). An Analysis of Misconceptions in Science Textbooks: Earth science in England and Wales. *International Journal of Science Education,* 32(5), 565-601.

Maitra, K. &, Maitra, A. (1997). To explore the attitudes towards laboratories and other related practical work in science. *School Science.* 24(2). P.44-51

Malhotra, V. K. (1998). *A critical study of the existing facilities of science teaching and construction of evaluation instruments for its supervision in different types of secondary school in Delhi.* (An unpublished Ph.D thesis). CIE, University of Delhi: Delhi.

Marek, E. (1986, December). They misunderstand, but they'll pass. *The Science Teacher,* 32-35.

Mayer, K. (2011). Addressing student's misconceptions about gases, mass and composition. *Journal of Chemistry Education.* 88, 111-115.

Mc Closkey, M. (1983). Naive theories of motion. In D. Gentner & A.L. Stevens (Eds.), *Mental models* (pp. 299-324). Mahwah, NJ: Erlbaum.

Mestre, J., & Touger, J. (1989). Cognitive Research--What is in it for physics teachers? *The Physics Teacher,* 27, 447-456.

Ministry of Education. (1952-53). *Secondary Education Commission. (1952-53).*New Delhi: Government of India.

Mondal, B. C. & Chakraborty, A. (2013). *Misconceptions in Chemistry- Its Identification and Remedial Measures*, Germany: LAP LAMBERT Academic Publishing.

Moodley, K. & Gaigher, E. (2019). Teaching Electrical Circuits: Teachers Perceptions and Learners' Misconceptions. *Research in Science Education*, 49(1) 73-89 DOI-10.1007/s/11165-017-9615-5

Nakhleh. (1992). Why some students' don't learn chemistry. *Journal of Chemical Education,* 69, 191-196.

Narode, R. (1987). *Standardized testing for misconceptions in basic mathematics*. (Unpublished Ph.D thesis). Cornell University, New York.

National Council of Educational Research and Training. (2000). *National Curriculum Framework-2000*. New Delhi: Author.

National Council of Educational Research and Training. (2005). *National Curriculum Framework-2005*. New Delhi: Author.

National Council of Educational Research and Training. (2005). *National Curriculum Framework Review-2005*. New Delhi: Author.

National Council of Educational Research and Training. (2005). *Position Paper: National Focus Group on Teaching of Science*. New Delhi: Author.

National Council of Educational Research and Training. (2020). *National Education Policy - 2020*. New Delhi: NCERT.

National Council of Educational Research and Training. (2023). *National Curriculum Framework for School Education-2023.* New Delhi: Author

National Research Council. (1996). *National Science Education Standards: Observe, interact, change, and learn*. National Committee on Science Education Standards and Assessment. Washington, D.C: National Academy Press.

NCERT. (2005). *National Curriculum Framework-2005*. New Delhi: Author.

Novak, J. D. (1980). *Teacher handbook for the learning how to learn program* (Unpublished manuscript). Cornell University, Ithaca, NY.

Novak, I. D. (1988). Leaming Science and the Science of Learning. *Studies in Science Education,* 15, 77-101

Novick, S. & Nussbaum, J. (1981), Pupils' Understanding of the Particulate Nature of Matter: A Cross-age Study, *Science Education* 65(2), 187-196

Nussbaum, J., & Novak, J. D. (1976). An assessment of children's concepts of the earth utilizing structured interviews. *Science Education,* 60, 535-550.

Organization for Economic Cooperation and Development. (2009) *The Programme for International Student Assessment (PISA).* Paris: Author

Organization for Economic Cooperation and Development. (2023) *The Programme for International Student Assessment (PISA).* Paris: Author

Osbome and Wittrock, (1983), Learning Science: A Generative Process. *Science Education,* 67, 489-508.

Osborne, R. J. & Cosgrove, M. M. (1983). Children's Conceptions of Changes of State of Water. *Journal of Research in Science Teaching,* 20(9), 825-838.

Padhi, J. S. (1994). High school students' science classroom environment and their attitude towards science. *School Science,* 32(3) 32-37.

Pekmez, E.S. (2010). Using Analogies to Prevent Misconceptions about Chemical Equilibrium. *Asia-Pacific Forum on Science Learning and Teaching.* 11(2).

Pine, A. L., & West, L. H. T. (1986). Conceptual understanding and science learning: An interpretation of research within a sources-of-knowledge framework. *Science Education,* 70(5), 582-603.

Posner, G. J., Strike, K. A., Hewson, P. W., and Gertzog, W. A. (1982). Accommodation of a Scientific Conception: Toward a Theory of Conceptual Change. *Science Education,* 66, 211-227.

The PROBE Team (1996, 1998). *Public Report on Basic Education in India.* New Delhi: Oxford University Press.

Ramkumar, N. (2003). *Acquisition of process skills by IV standard pupils through an instructional programme in environmental studies.* (Unpublished Ph.D thesis) CASE, M.S University of Baroda, Vadodara.

Ralya, L. L., & Ralya, L. L. (1938). Some misconceptions in science held by prospective elementary teachers. *Science Education,* 22(5), 244-251.

Read, J. R. (2004). *Children's misconceptions and conceptual change in science education*. Retrieved from http://acell.chem.usyd.edu.au/conceptual-change.cfm

Saxena, A. (2012). A critical study of the teaching styles of science teachers in different types of secondary school in Delhi. (Unpublished Ph.D thesis). CIE, University of Delhi: Delhi.

Shelat, P. (2013). *Instructional strategy and studying its effectiveness for comprehension in science among class VII students.* (An unpublished Ph. D. thesis). CASE, M.S University of Baroda: Vadodara.

Tippett, C. D. (2010). Refutation text in science education: A review of two decades of research. *International Journal of Science and Mathematics Education*, 8, 951-970. doi:10.1007/s107633010392033

Treagust, D. F. (1988). Development and use of diagnostic tests to evaluate students' misconceptions in science. *International Journal of Science Education*, 10(2), 159-169.

Umashree, P. S. (1999). *Science curriculum and its transaction: An exploratory study in the secondary schools of Vadodara Gujarat*. (An unpublished Ph.D. thesis). CASE, M.S University of Baroda: Vadodara.

Unal, G. & Ergin, O. (2006) Science Education and Models. *National Education Journal*, 171, 188-196.

Vosniadou, S., & Brewer, W. F. (1992). Mental models of the earth and study of conceptual change in childhood. *Cognitive Psychology*, 20, 535-585.

Vosniadou, S., & Brewer, W. F. (1994). Mental models of the day and night cycle. *Cognitive Science*, 18, 123-183.

Wandersee, J. H. (1985). Can the history of science help science educator anticipate students' misconception? Journal of Research in Science Teaching, 23, 581-587.

William, C. P. (1993) A survey of eighth grade Earth science students' misconceptions about fundamental Earth science ideas and their teachers' perceptions about their students' knowledge of these fundamental ideas. (Doctoral Dissertation, University of Maryland college Park, 1988). *Dissertation Abstract International,* (54)1, 137A.