CHAPTER II

REVIEW OF RELATED LITERATURE

2.0 Introduction

This chapter deals with review of related literature. It is an important aspect of any investigation. It helps the researcher to gather up-to-date information about what has been already done in the particular area from which he or she intends to take up a problem of research. Thus it is very necessary to review the studies before selecting any research work. Best and Kahn (2009) opined, " since effective research is based upon past knowledge, review of related literature helps to eliminate the duplication of what has been done and provides useful hypotheses and helpful suggestions for significant investigation. This step also helps to sharpen and define understanding of existing knowledge in the problem area and provides a background for the research project." Review of related literature is an essential aspect of any research. The purpose of the review is to expand the context and background of the study, to help further in defining the research problem and also to provide an empirical basis for the subsequent development of the research objectives. It is an extremely important part of any research as it shows what other researchers have already done and what other researchers are doing contemporarily. In other words, it basically helps the researcher to find various research gaps. It provides insight to investigate about use of methodology. Thus, it provides a critical review and appraisal of the related studies and shows how the related studies contribute towards advancing the present knowledge regarding the specific area under investigation. By doing reviews the repetition of the already done studies can also be avoided.

Review of the related literature helped the researcher to understand and familiarise the past and present studies conducted in different areas. It stimulates the researcher deep into the knowledge on the selected topic. 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like books, documents, survey reports, journals, international dissertation abstracts, university news, published and unpublished thesis ERIC, Shodhganga, inflibnet and research works to obtain research findings on the related topic, which provided a clearer insight into the problem and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 need to be investigated and further researched upon. It helped the researcher to get advance knowledge in the field of interest and also enabled the researcher to avoid unnecessary duplication and at the same time to understand different methodologies adopted by other researchers. Thus 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 Studies Related to Misconceptions in Physics

Fredette and Clement (1981) interviewed the students for the topic of electricity. They noticed the short circuit misconceptions in the interviews. Afterwards, they followed three steps to probe their investigation. First, they administered the written questionnaire; second, the researchers conducted twelve additional interviews to obtain more insight into the depth of the conceptual difficulty; third, the researchers administered another but similar written test to ten engineering students who had completed a course in electricity and magnetism to observe if the misconceptions had been overcome after the course. It was concluded that it is difficult to overcome the misconceptions for some students even after the course.

Engel Clough and Driver (1986) conducted a study of consistency in the use of students' conceptual frameworks across different task contexts. The researchers found the misconceptions among students for the concepts of pressure, heat and inheritance. The findings showed that students were using different alternative frameworks in response to the parallel questions and it was concluded that in many cases, students do not apply their conceptions in a way which a scientist would consider to be consistent.

Elizabeth (1988) in her study A comparison of the effectiveness of demonstrations, verbal statements and hands-on experience on correcting the misconceptions of the first graders regarding magnets compared the relative effectiveness of five instructional interventions which were designed to correct size-related misconception in the group of first graders. The particular misconception chosen for the study is the belief that the larger magnets are always of greater strength than the smaller magnets. These interventions consisted of (a) a demonstration lesson (b) a hands-on lesson (c) a verbal statement lesson (d) a demonstration plus verbal statement lesson (e) a hands-on plus verbal statement lesson. Subjects were tested three days before the treatment, one day after the treatment to determine the change of knowledge effect, then six weeks after treatment as to check the knowledge retention. It was found that the treatments consisting of a demonstration plus verbal statement lesson and hands-on plus verbal statement lesson were more effective in achieving correction of the size related misconception than the treatments consisting of a hands-on treatment alone and verbal statement alone.

James (1989) conducted a study on misconceptions in the Earth and Space Sciences. A questionnaire containing several possible Earth and Space Sciences misconceptions were administered to 1213 students in a cross-age study in north-west Indiana. The sample included a mixture of white, black and Hispanic participants who were either students in 5^{th}, 8^{th}, or 11^{th} grades or were enrolled in local universities or a trade school. Data from this study have verified that misconceptions in Earth and Space Sciences are widespread. Six primary misconceptions were identified as were fourteen secondary misconceptions. One functional misconception is suspected to be common among subgroups.

Kesidou and Duit (1993) conducted a study on student's conceptions of the second law of thermodynamics an interpretive study. The researchers had conducted clinical

interviews with 10th class students. The main misconception was that heat transfer starts and does not stop at once when temperatures have equalized. The main reasons for this kind of thinking was- these ideas were based on everyday experiences and not on a scientific basis as taught in schools.

Mark (1993) studied the effect of formal reasoning ability and grouping in cooperative study groups upon the alleviation of misconceptions in high school physics. The study was quasi-experimental pre test-post test control group design. The statistical procedure used in the study was Pearson Product Moment Correlation Coefficient and analysis of covariance with the physical pre-test serving as the covariant. The Lawson Classroom Test of Formal Reasoning Ability was used to classify students as high or low formal thinkers. Heterogeneous cooperative study groups were formed in the experimental group by pairing a high formal thinker with a low formal thinker in the three of the five intact high school physics classes. The remaining two classes comprised the control group in which students work individually. All students completed a mechanics conception outline designed to initiate cognitive conflict between their common sense intuition and the scientific theory involved in Newtonian mechanics. Students in the experimental group work cooperatively in the completion of the mechanics outlines. A conceptual physics post-test was administered at the end of the semester following the completion of 23 mechanics conceptions outlines. There was a significant correlation between the students' formal reasoning ability and their scores on the conceptual physics pre-test, indicating that students with higher formal reasoning ability tended to have fewer pre-course misconceptions than students with lower formal reasoning ability. Students classified as high formal thinkers achieved significantly higher scores on the conceptual physics post-test than low formal thinkers, indicating that students with high formal reasoning ability had significantly fewer end-of-course misconceptions than students with low formal reasoning ability.

William (1993) has conducted 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. This study contains a description of the knowledge 360 Delaware eighth grade Earth science students have about twenty-five fundamental Earth science ideas, by total population and gender, the misconceptions associated with the ideas are described and the teachers' perception about the frequency with which the student would select the ideas are reported. The

misconceptions associated with the fourteen of the fundamental ideas were previously reported in the literature while the remaining eleven evolved from the study. Results from the two surveys developed for this study indicated that the students scored a mean of 40.6 % in identifying the fundamental ideas. When evaluated for gender differences male significantly outscored females. It was also found that 50 % of the sixteen Earth science teachers' were able to significantly predict their classes mean score for each item.

Fuller (1994) studied the effect of concept mapping on misconceptions about light in fifth graders. The role of misconception in acquisition of science concepts has been widely studied. The researcher compared three groups of students. Trained teachers taught three consecutive lessons about the nature of light. Each group received lesson that had varying levels of misconception activation. One group utilized the written, schematic tool of concept mapping to activate their misconceptions. The analyzed data sets indicate that there was no significant difference between the pre-test and post-test scores on the unit test between the groups. Overall, the students showed progress in their test performance, although there was no indication of concept change regarding the nature of light. Speculations and recommendations about the use of concept mapping with elementary students conclude this investigation.

Saxena (1994) had done a study on identification of misconceptions related to work and energy among students. It was found that students were not able to establish relationship between work and energy. Previous knowledge of the students played a major role in creating misconceptions among them.

Sopapun (1994) conducted a study on the "development of a two-tiered multiple choice test to measure misconceptions in physics among elementary school students in Thailand". The objectives of this study were to (a) construct and develop a two-tiered multiple choice test for the measurement of student misconceptions in optics at the level of secondary education in Thailand (b) to investigate the effects of gender, grade level and type of schools upon levels of student misconceptions. Misconceptions were measured by the development of the Two-Tiered Optics Misconceptions (TTOM) test instrument developed for the study. The TTOM was administered to 932 elementary school subjects from randomly selected all male, all female and co-educational schools in Bangkok, Thailand. Some of the major findings were (1) a paper-pencil test based

upon a pattern of two-tiered multiple choice questions and reasons developed for this study provided a valid and reliable measure of students' misconceptions in optics at the level of elementary education in Thailand (2) gender, grade level and type of school did not had significant effect upon subject misconception score among Thai elementary school students (3) when fixed grade levels were considered for type of school there were significant differences in misconceptions among 8th grade students from different types of school.

Hardt and Paula (1997) examined understanding of electrical circuits among students. The tools used for the study were multiple choice test and interview. The samples of the study were high school students and university students. The results showed that both high school students and university students had misconceptions about direct current resistive electric circuits. Students tended to confuse terms especially current to voltage and/or for resistance.

Sanger (1997) has done a study on identifying, attributing and dispelling student misconceptions in electrochemistry. The researcher had modified the questions asked by Garnett and Treagust for galvanic and electrolytic cell, however, the questions related to concentration cell was same. The tool was administered to 16 chemistry student who were studying at the introductory college. The common misconceptions identified were (i) in order to complete the electric circuit the flow of electron is through salt bridge and electrolyte solutions. (ii) The net electronic charges are denoted by the plus and minus signs assigned to the electrons. Many students who displayed misconceptions were still proficient at calculating cell potentials accurately. This aligns with prior research indicating that students who can solve quantitative exam questions may lack a deep comprehension of the fundamental concepts. These misconceptions likely stemmed from students not realizing the relative nature of electrochemical potentials and the presence of misleading or incorrect information in chemistry textbooks.

Palmer (1998) conducted "a study on measuring contextual error in the diagnosis of alternative conceptions in science". The tool used was a test entitled "Force in Sport" containing 10 multiple choice questions. The test was administered to 567, Year 10 students (15-16 year olds) in four secondary schools in a regional city in South Eastern Australia. The schools were located in different parts of the city and represented a variety of educational practices: co-educational and single sex school (of both types)

with classes either streamed or un-streamed. All the students had studied forces at high school although some more recently than others. The present study has indicated that contextual error does occur and that it was a factor which resulted in inaccurate diagnoses of alternative conceptions in about 17% of the students

Neset (2001) conducted a study with an objective to investigate the effect of a web based physics software programme on the students' achievement and misconceptions in force and motion concepts. Through convenient sampling a total of 125 students from two public high schools in Brevard County, Florida were selected. It was the quasi experimental study where MANCOVA was used to analyse the data. Out of six hypotheses only hypothesis 2 which examined differences in group misconception score was rejected. One of the major finding was that incorporating web-based physics program with traditional lecturing did have a significant effect on dispelling students' physics misconceptions about force and motion concepts.

Abdelhaleem (2002) examined the impact of the guided constructivist teaching method on students' misconceptions about concepts of Newtonian Physics. A quasi-experimental design of non-randomised, non-equivalent control and experimental groups was employed. The experimental group was exposed to the Guided Constructivist teaching method, while the control group was taught using the Traditional Expository teaching approach. The data collection instruments included the Force Concept Inventory Test (FCI), the Mechanics Baseline Test (MBT), and the Maryland Physics Expectation Survey (MPEX). The finding showed that the Guided Constructivist Group had significantly higher means than the Traditional Expository Group on the criterion variables of (1) conceptions of Newtonian physics (2) achievement in Newtonian physics (3) belief about the content of physics knowledge, beliefs about the role of Mathematics in learning physics and overall beliefs about learning/teaching/appropriate roles of learners and teachers/nature of physics.

Eryilmaz and Surmeli (2002) conducted a study on identifying student's misconceptions on heat and temperature. The tool used for the present study was a three tier test to measure misconceptions related to the topic of heat and temperature. The finding of the study revealed that the errors committed by students were due to mistakes. Lack of knowledge was one of the probable reasons for error committed by

students. Incomplete or partial understanding of concepts leads to misconceptions among students.

McWilliam (2002) examined misconceptions particularly in the area of force and motion. Structured interview templates, containing concept and parallel questions and predicted responses, were designed covering frequently misunderstood area of force and motion. The results revealed common misconceptions but more importantly indicated critical moments, the points where a student realizes that their apparent understanding is flawed, prior to conceptual change.

Senear and Eryilmaz (2004) conducted a study on factors mediating the effect of gender on ninth grade Turkish students' misconceptions concerning electric circuit. The researchers had developed a two-tier test to diagnose the misconceptions concerning electric circuits among students. It was analyzed that most of the students had many misconceptions. In addition, it was found that females had more misconceptions as compared to males.

Demirci (2005) conducted an experimental study titled "A study about students' misconceptions in force and motion concepts by incorporating a web-assisted physics programme". The web-based physics program was incorporated with the traditional lecture. Specifically, 30% of class time was allocated for using this tutorial program, and 70% of class time was used for normal lecture. The Force Concept Inventory (FCI) was used as pre and post-test. Although there were not any significant results between FCI post test scores and group memberships, and gain scores and group membership ($F1, 123=2.023, p>0.05$);relative to FCI pre and post-test mean difference scores, group membership (being control and treatment groups)was statistically significant at .05 ($F1,123=4.307, p<0.05$).

Haki (2005) conducted a study for the purpose of assessing misconceptions of ninth grade students about simple electric circuits. A three-tier test was developed and administered to students. Students gave a lot of wrong answers because of lack of knowledge but mostly due to misconceptions. Parallel circuit misconception was the most common misconception prevalent among ninth grade students.

Kutluay (2005) developed a three-tier test for assessing misconceptions among students about geometric optics. The proportion of false positives and false negatives was

estimated to be 28.2% and 3.4% respectively. The results showed that the proportions of misconceptions were observed to lessen gradually as the tiers of the tests increased one by one, due to mistakes and lack of knowledge while the proportions of the correct responses were observed to lessen gradually as the tiers of the tests were increased one by one, and were due to false positives and lack of knowledge.

Gray (2007) had studied Gender differences in science misconceptions in eighth grade astronomy. This study attempted to ascertain if there were significant differences between genders in the number and types of science misconceptions eighth grade science students had. The specific misconceptions used in this investigation concern gravity, seasons and the phases of moon. It remains a serious problem in science education that girls are being inadequately trained to question and reflect on their science understandings. It has been suggested that girls may have more problems with misconceptions that do boys. Through this study the researcher tried to explore the ability of students to understand theoretical and conceptual principles of science. The data for this study was obtained using the methodology of a multiple choice survey which contains common misconceptions and the correct answers as choices. This survey was administered to eighth grade students in a large suburban school district by their science teachers. Interviews of a randomly selected sample group of 20 (10 boys and 10 girls) were conducted by the researcher. The findings of the survey showed that there was a statistically significant difference between the means for the two groups indicating a gender difference in knowledge of astronomy concepts. The results of the interviews also showed a difference in astronomy knowledge and background information. In addition the interviews showed that the girls were very unsure of their answers while boys defend their answers even when they were incorrect.

Kucukozer and Kocakulah (2007) revealed secondary school student's misconceptions about simple electric circuits. Data was obtained with a conceptual understanding test for simple electric circuits and semi structured interviews. The most important findings appeared in the study were the misconceptions, which emphasized the idea of "no bulb lights on if the switch is off" due to everyday language and the idea of "bulbs connected in parallel give better light than those connected in series" due to prior teachings.

King (2009) An Analysis of Misconceptions in Science Textbooks: Earth science in England and Wales. The 29 science textbooks or textbook series surveyed (51 texts in all) showed poor coverage of National Curriculum earth science and contained a mean level of one earth science error/misconception per page. Science syllabuses and examinations surveyed also showed errors/misconceptions. More than 500 instances of misconception were identified through the surveys. These were analysed for frequency, indicating that those areas of the earth science curriculum most prone to misconception are sedimentary processes/rocks, earthquakes/Earth's structure, and plate tectonics. For the 15 most frequent misconceptions, examples of quotes from the textbooks are given, together with the scientific consensus view, a discussion, and an example of a misconception of similar significance in another area of science. The misconceptions identified in the surveys are compared with those described in the literature. This indicates that the misconceptions found in college students and pre-service/practising science teachers are often also found in published materials, and therefore are likely to reinforce the misconceptions in teachers and their students. The analysis may also reflect the prevalence earth science misconceptions in the UK secondary (high school) science teaching population.

Beer (2010) in his study How do pre-service teachers picture various phenomenon? A qualitative study of pre-service teachers' conceptual understanding of fundamental electromagnetic interaction analysed the nature of pre-service teachers' conceptual models of various electromagnetic phenomena, specifically electrical current electrical resistance and light/matter interaction. This is achieved through the students answering the three questions on electromagnetism using a free response approach including both verbal and pictorial representation. The students' responses are then analysed qualitatively and quantitatively. These analyses include epistemological representation, misconceptions, correct conceptions and the impact of high school physics exposure on students' conceptions. This study is unique in three primary respects, the free response questionnaire approach, a subject group that consists of pre-service teachers and a primarily female demographic.

Oglesby (2010) in his study efficacy of changing physics misconceptions held by ninth grade students at varying levels through teacher addition to make a prediction phase to the learning cycle. The major objective of the study was to examine the efficacy in correcting student's misconceptions about science concepts by using the pedagogical

method of asking students to make a prediction in science laboratory lessons for students within pre-operational, transitional or formal stages of cognitive development. The sample consisted of 250 students of ninth grade. Students were pre and post tested using a 40 questions instrument based on the Force Concept Inventory augmented with questions on the concepts taught during the period of the study. Students were also tested using the Test of Scientific Reasoning to determine their cognitive developmental level. Result showed 182 students to be cognitively pre-formal, 50 to be transitional and only 3 to be formal.

Sahin and Cepni (2011) conducted a study on development of a two tiered test for determining differentiation in conceptual structure related to floating-sinking, buoyancy and pressure concepts. The sample of the study consisted of 78 8^{th} grade students from two different primary schools in Giresun. The researchers found that the two-tiered test helps to build relationships between the cause and the result of the knowledge and is a powerful tool to remove misconceptions among students.

Radhakrishnan (2013) conducted a study on astronomical misconceptions prevalent among high school students of Kerala. The researcher has adopted survey method for her study. Astronomical Misconception Inventory (AMI) containing 32 items was prepared by the researcher. AMI was given to a sample of 300 students studying in different high schools of Kerala. The data obtained was subjected to percentage analysis. From her study it was found that majority of the high school students of Kerala have misconceptions related to astronomy. The researcher through the study tried to orient the curriculum planners to give more importance to astronomy in the school curriculum.

Akhilesh (2014) conducted a study on identification of misconceptions in physics and testing of effectiveness of certain instructional programmes on remediation of the misconcepts among VIII standard students in Kerala. It was a survey cum experimental study. A total of 467 students from eight schools situated in Malappuram, Kozhikode and Kasargod districts of Kerala was selected using stratified sampling technique with due representation to the sub-groups based on gender of the pupils and locality of the schools. The objectives of the study were (1) to find out the percentage of error committed in each of the selected concepts of physics viz. Matter, solar system, density, velocity, mass, gravity, work energy, light, sound, electricity, magnetism, pressure and

force by the secondary school students in the total sample. (2) to identify the major concepts in physics and the minor concepts involved with each of them in which there exists significant difference in the percentage of error between boys and girls, rural and urban among VIII standard students of Kerala. (3) to find out the effectiveness of a range of selected experimental instructional strategies in remediation of the identified misconceptions in physics among VIII standard students of Kerala. The researcher has used Misconception Identification Test (MIT), interview guide along with different strategies such as conceptual change approach, ideational confrontation, hands on activities were used as tool for data collection. The collected data was analysed using SPSS and one way ANOVA. The major findings of the research were (1) all the students possess high rate of misconceptions in all the major concepts of physics. (2) It was also found that irrespective of the locale and gender of the students they possess around fifty percent of misconceptions in all the concept area of the study. (3) The instructional strategy was found to be very effective in remediation of physics AMONG VIII standard students of Kerala.

Temiz & Yavuz (2014) studied students' misconceptions about Newton's second law in outer space. A set of questions in which students are asked to solve two similar Newton's second law problems, one of which is on the Earth and the other in outer space, was administered to 116 undergraduate students followed by an interview. The findings indicate that there is a significant difference between students' epistemic game preferences and race-type (outer space or frictional surface) question. So students who used Newton's second law on the ground did not apply this law and used primitive reasoning when it came to space. Among these students, voluntary interviews were conducted with 18 students. Result showed that: (1) the term 'space' causes spontaneity among students that prevents the use of the law; (2) students hesitate to apply Newton's second law in space due to the lack of a condition—the friction; (3) students feel that Newton's second law is not valid in space for a variety of reasons, but mostly for the fact that the body in space is not in contact with a surface.

Howe (2015) conducted a study on misconceptions, intuitions and elementary physics: harnessing everyday understanding in learning environmental design. Children's conceptions of physical events have been extensively discussed. Philosophers from Aristotle to Kant speculated about their form, and Einstein was sufficiently intrigued to persuade Piaget to initiate research. Amongst physics educators, it has been recognised

for many years that the difficulties children experience in mastering the discipline stem, in part at least, from the conceptual challenge that the material implies. Thus, charting the relation between children's conceptions and the received wisdoms of physics has become a significant field of research. A range of methodologies has been used, but one of the most popular involves presenting scenarios and asking children to predict outcomes, e.g. anticipate whether 'float' or 'sink' will occur when heavy and light objects are immersed in water. Regardless of topic area, results indicate marked divergence from received conceptions, which often continues through the adult years. Nevertheless, no matter how scientifically unorthodox notions are when used in prediction, there must be a substrate of orthodoxy that allows children to recognise when events do or do not unfold in the normal fashion. Studies are reported where students make predictions (engaging misconceptions) and view simulations as feedback (engaging intuitions). The encouraging, albeit preliminary, results as regards student knowledge mean that the approach can be regarded as a step towards using intuitions in learning environment design.

Nik, et. al., (2015) presented a survey of existing literature related to misconceptions and challenges encountered by high school and university students in introductory physics. This paper outlines and explains misconceptions and challenges in the field of mechanics drawing from previous research in science education. Additionally, it discusses how these misconceptions impact the teaching and learning of physics and their role in driving conceptual changes.

Derya, et. al., (2016) conducted a study examining the misconceptions and conceptual challenges of pre-physical teachers regarding geometrical optics, particularly in the contexts of plane mirrors, spherical mirrors and lenses. Data were gathered through extended interviews and open-ended tests. The study's results revealed that teachers held common misconceptions related to the concept of geometrical optics.

Tamkavas, et. al., (2016) conducted a study on misconceptions about heat and temperature in Turkey between 2005 and 2015: A content analysis. The studies found in the literature conducted on misconceptions about heat and temperature between the years 2005-2015 were examined. Document analyses were used as the method of study. The data were analyzed by content analysis method. The study was limited to the studies originated in Turkey and found in the databases of "EBSCO", "Tübitak Journalpark", and "National Thesis Centre" between the years of 2005-2015. The

review focused on the detected misconceptions and the methods for detecting these misconceptions. It was found that there were differences in the methods for detecting these misconceptions between the periods of 2005-2009 and 2010-2015. A total of one hundred twenty-one misconceptions were identified. In fifty-six of the misconceptions, the concept of temperature was misused, in fourty-four of them, the concept of heat was misused, and in twenty-one of them, the concepts of heat and temperature were mistakenly used together.

Khandagale & Chavan (2017) conducted a study on identification of misconceptions for gravity, moon and inertia among secondary students. The study was descriptive in nature. One hundred forty (N=140) Ninth standard Semi-English secondary school students of Kolhapur city were selected by purposive sampling method. The researchers identify three concepts of Physics i.e. Gravity, Motion, Inertia. The tool was constructed and data was collected from the Ninth standard students of schools affiliated to State Board of Kolhapur city. The misconceptions found were 'gravitational force just act on only heavy object', 'gravity does not affect object in water', 'a continuous force is needed for continuous motion' 'speed and motion' are same and 'inertia is the force that keep objects in motion' among the students.

Zajkov, et. al., (2017) conducted a study on textbook caused misconceptions in consistencies and experimental safety risks of grade 8 physics textbook. A physics textbook for the 8^{th} grade was analysed in particular the section on the interaction between electric current and magnetic field. The textbook is written in the Macedonian language, but is translated also in Albanian, Serbian, and Turkish which provide an opportunity to influence a larger population of children, in a large ethnic area. Errors are found from both a didactic as well as from a physical point of view. The researchers created many sources of misconceptions. It was found that the questions at the end of the chapter are of the low level, according to Bloom's taxonomy. They are of the first and second level mostly. In very rare cases third level questions can be found. The proposed experimental activities do not follow the safety precautions and are dangerous to perform. Risk assessment of the laboratory activities is proposed by the researchers.

Anjarsari (2018) conducted a study on the common science misconceptions in Indonesia junior high school students. The main purpose of this study was to analyse some publications about common science misconceptions in some science topics in

junior high schools. The misconceptions identification in this research is based on the descriptive research using some journal publications in Indonesia University which is held science education study program. It was found in this study that the concept of photosynthesis, respiration, the relationship of photosynthesis and respirations, force (action and reaction forces), and Newton laws are most frequently investigated as misconceptions of science students' interest and learning environments are some reasons of students' misconceptions.

Irwansyah, et. al., (2018) conducted a study on the analysis profile of student misconceptions on the concept of fluid based instrument three-tier test. The purpose of this study was to analyse the misconception profile of eleventh senior high school students about the concept of fluid. The sample of this research was the eleventh students of science class Karanganyar state Senior High School I and Gondangrejo state Senior High School of Religion with 98 students. The analysis of students' misconceptions profile used the instrument of three-tier-concept-based test. The items consisted of 28 items that consist of three level of completion stage, the first level was multiple choice questions, the second level was a description of the reasons of the student's answer to the first level questions, as well as the third level was the students' level of confidence on the answers that have been given. The results showed that 27, 58% of students understood the concept of fluid, 45, 29% of students don't understand the concept of fluid, 24, 74% of students showed misconceptions and 2, 36% of students had errors. The highest misconceptions were in the concept of Pascal with average 13, 96%. Therefore, it was concluded that the three-tier can be used to identify misconceptions as well as the causes of the misconceptions, such as false positives, false negatives to lack of knowledge.

Widiyatmoko and Shimizu (2018) has conducted a study on literature review of factors contributing to students' misconceptions in light and optical instruments. This study was conducted in Japan with an aim to explore the factors that contribute to student's misconceptions in light and optical instruments concept. The researchers found that misconceptions impede the students' conceptual understanding of science learning. It was also found that misconceptions are considered to have occurred if the students' understanding of a concept differs from what is understood by the scientific community. An analysis of the literature reveals that everyday experiences, language used, teachers and textbooks are the main factors contributing to students'

misconceptions of light and optical instruments in science learning. by analysing these factors, it would make sense to minimise the contributing factors that might help promote the students to achieve conceptual understanding in light and optical instruments concept.

2.1.1 Observations on the Literature Reviewed (Physics)

The researcher has reviewed a total of 38 studies of physics. It has been bcserved that magnets, light, optics, force, pressure, motion, work and energy, electromagnetic interaction, electricity, electric circuits, heat and resistance, geometrical optics, gravity and inertia, Newton's laws and Newtonian mechanics are the areas in physics where most of the were conducted. Most of the researchers had used written questions, interviews, concept mapping, concept inventories, multiple choice test, web assisted programmes along with two or three-tiered multiple choice test. Most of the researchers had either conducted experimental studies or surveys, however, one survey cum experimental study was also found. The studies were conducted at all levels strating from grade one to elementary level, secondary, higher secondary and upto university level. One study was related to misconceptions among engineering studes.

2.2 Studies Related to Misconceptions in Chemistry

Osborne and Cosgrove (1983) also investigated children's misconceptions specifically in relation to phenomena associated with the water and particularly children's conceptions of the changes of the state of water. A series of events involving ice melting, water boiling, evaporating, and condensing were shown to children in an individual interview situation. For each of the events, children were asked to describe and explain what was happening and explain what had happened. The analysis of the interviews showed that children bring to science lessons „strongly held views" which relate to their experiences. These views appear as logical and sensible to them. Children have ideas about the changes of the state of water, but these ideas are quite different from the views of scientists and they can be influenced in unintended ways by science teaching.

Treagust (1988) developed Diagnostic tests in Chemistry and Biology to evaluate students' misconceptions and errors committed in Science. Analysis of the results of the

tests revealed that Diagnostic tests were very much effective for identification of errors and misconceptions of both teachers and students in Chemistry and Biology.

Kathleen (1994) in her study the development and validation of a categorization of misconceptions in the learning of chemistry studied that misconceptions in the learning of chemistry are due to some aspect of the instructional process. The purpose of the study was to validate a categorization of the sources of error in concept formation in chemistry, based on the review of the literature. The proposed classification system divides error sources into two types, Experimental and Instructional. Instructional misconceptions are further divided into seven categories (a) Languages (b) Prior knowledge of the learner (c) Overtaxing of the Short-term memory (d) Mismatch of the subject matters demands and the cognitive developmental level of the learner (e) choice of the inappropriate mental strategy and (f) low standards of the epistemology. Category 3 to 6 was merged into 1 category called Other Cognitive Factors to improve reliability. The experimental design utilized five weekly interviews to monitor the learning of 12 subjects which matched controls as they proceed through a unit of study on chemical equilibrium. These interviews were transcribed verbatim and coded for errors by two rater followed by consensus sessions. Some of the major findings were (1) the frequency of occurrence of error categories showed the overall error distribution to be approximately equally divided among the major categories of Instructional Misconceptions, with 37 % of the error attributable to language related difficulties, 32 % to the Prior knowledge of the student and 30 % to other cognitive factors. Notably only 1 % of the errors were due to Experiential Misconceptions. (2) the proposed classification of the error sources provided an accurate and complete description of student error for the unit of Chemistry studied.

Ladage (1995) had done a study on identifying students' misconcepts and learning barriers in chemistry and designing and evaluating appropriate remedial measures. The results of the study indicated that the two-tier Diagnostic instrument provided a feasible approach for evaluating students' understanding and for identifying misconceptions and misunderstanding in the Chemistry.

Douglas & Rao (1997) conducted a diagnostic study of the common errors committed by students in writing and solving of chemical equations. The necessary data were collected by administering a diagnostic test in chemical symbols, formulae and

equations. The study revealed that the nature and extent of errors committed by the students in the learning of chemical symbols, formulae and equations is influenced by certain selected socio-personal factors.

Bradley & Mosimege (1998) conducted a study on misconceptions in acids and bases: a comparative study of student teachers with different chemistry background. The misconceptions were explored through the use of a twenty item questionnaire divided into twelve multiple choice items and eight discussion items. The findings of the study reveal that the student teachers who had done more chemistry at both university and college of education performed better on average than those who had done less chemistry, and the student teachers at the university performed, on average, better than the student teachers at the college.

Tyson, et. al., (1999) conducted a study on the complexity of teaching and learning chemical equilibrium. The researcher had used a two-tier test, coupled with interviews from a case study, to explore student's understanding of what happens when reaction mixtures at equilibrium are disturbed. According to the findings, language turned out to be a key factor, causing misinterpretations by students.

Voska and Heikkinen (2000) developed a ten-item pencil and paper test, two-tier diagnostic instrument, and used it to identify and quantify chemistry conceptions students' use when solving chemical-equilibrium problems. Eleven prevalent misconceptions about chemical equilibrium were identified with the help of the test.

Tan, et. al., (2002) developed a two-tier multiple choice diagnostic instrument to access understanding of high school students' inorganic chemistry. The study showed that the grade ten students had difficulty in understanding the reactions involved in the identification of cations and anions, for example, double decomposition reactions and reactions of complex salts and thermal decomposition.

Chandrasegaran, et. al., (2008) developed a two-tier multiple choice diagnostic instrument to evaluate the secondary school student's ability to describe and explain chemical reactions using multiple levels of representations. Despite the emphasis on multiple levels of representation during instruction, fourteen conceptions were identified that indicated confusion between macroscopic and sub microscopic representations, a tendency to extrapolate bulk macroscopic properties of substances to

the sub microscopic level and limited understanding of the symbolic representational system.

Secken Nilgun (2010) conducted a study on identifying student's misconceptions about SALT. A total of 121students, who were aged between 18 and 23 and had studied the basic chemistry course at Universities in Turkey, participated in the study. A test was prepared which are consisted of open-ended and multiple choice questions to determine possible misconceptions about "salts" by benefiting from various chemistry books. The result showed that students have misconceptions about "salts" in basic level. The researcher has given some suggestions to eliminate these misconceptions by determining the reasons.

Cynthia (2011) in her study development and application of an instrument to identify students' misconceptions: Diffusion and Osmosis found that large number of undergraduate students had naive understanding about the process of diffusion and osmosis. Sample constituted 19 undergraduate science students at a Midwest University. Samples were asked to complete a short answer (fill in the blanks) test followed by an interview. Descriptive and co relational data was used in the analysis of the study. Evidence from this study demonstrated that students had very strong misconceptions about diffusion and osmosis.

Smolleck and Hershberger (2011) conducted a study on playing with science: an investigation of young children's science conceptions and misconceptions. The purpose of this study was to investigate the conceptions and misconceptions of young children related to science concepts, skills and phenomena. Qualitative data was collected from 63 children from three separate early childhood educational sites in an attempt to investigate the conceptions and misconceptions of young children. Out of the 63 participants, 65% were male and 35% were female. For her study the researcher has created multiple inquiry-based science units for areas of matter, magnetism, density and air. Findings of this study reveal the most common conceptions related to matter, magnetism, density and air. The common conceptions that children held related to matter included "a brick is a solid". Regarding magnet is that "it stick to all metals"

Bayrak (2013) identified primary students' conceptual understanding and alternative conceptions in acid base. For this reason, a 15 items two-tier multiple choice test administered to 56 eighth grade students in spring semester 2009-2010. Data for this

study were collected using a conceptual understanding scale prepared to include the concepts used in the subject of "Acids and Bases", which is a part of the unit "Structure and Properties of Matter" taught in the eighth grade Science and Technology course. The conceptual understanding scale was developed by the researchers to identify the alternative conceptions students might have concerning this subject. The scale consists of diagnostic tests (n=15) designed to measure levels of understanding among students concerning the subject of acids and bases, and to identify their ways of thinking and rationales. Data were first analyzed by tabulating students' answers to the first tier of each question, and the percentages of the reasons they selected for their answers. Analysis of results showed that students find difficulty about conceptual understanding and they have some alternative conceptions related to acid-base.

Lemma (2013) conducted a diagnostic assessment of eighth grade students' and their teachers' misconceptions about basic chemical concepts. The main objective of this study was to diagnose both teachers' and students' misconceptions about five basic chemistry concepts. Survey method was employed for the study. A multi-tier chemistry misconception test (MTCMT) and an interview was used as tools for data collection. Purposive sampling of 192 students and 6 teachers were done. As a result, many set of suspected and new misconceptions were found, and finally from the Pearson's correlation, it was found that 90% of students' misconceptions has a significant correlation with teachers misconceptions implying that teachers are responsible for most (90%) of their students' misconceptions**.**

Potvin (2014) explored the effect of the Predict-Observe-Explain (POE) strategy on learners' misconceptions about dissolved salts. Grade 10 Physical Sciences were selected as sample. A quasi-experimental design was employed for collecting data. A t-test and Analysis of Co- variance (ANCOVA) were used to analyse the data. The results show that learners in the experimental group (EG) taught using POE performed better in the post-test than their counterparts in the control group (CG) taught using traditional methods. Also, two new misconceptions were identified, namely: 1) salts dissolve in water when it is in 'fine' grains; and, 2) solid sodium chloride is not an ionic compound. These results highlight the need for educators and curriculum developers to include various elements of POE in the curriculum as a model for conceptual change in teaching science.

Dharan (2015) conducted a study on identification and remediation of misconception about chemical kinetics among secondary school students. It was an experimental study using pretest-posttest design. A total of 768 students of standard IX were selected from Kollam district of Kerala using stratified random sampling technique with due representation of boys, girls, government, aided, Malayalam and English medium schools. The objectives of the study were (1) to find out the misconcepts of senior secondary students in the topic of chemical kinetics in the following content area such as temperature, concentration, rate of reaction, collision, catalyst, surface area, photochemical reaction. (2) to compare the effect of conceptual change approach to alleviate the misconception of secondary school students in chemical kinetics. (3) to identify the major contributing factors of misconceptions among secondary school students on the topic of chemical kinetics. The researcher has used misconception identification test, interview schedule along with different strategies such as conceptual change approach, ideation confirmation as a tool for data collection. The collected data was analysed using SPSS, t-test and one way ANOVA. Some of the major findings of the study were: (1) majority of the students have misconceptions in different concepts of chemical kinetics, (2) the students of rural and Malayalam medium have more misconceptions than the students of the urban and English medium. (3) it was also found that conceptual change approach was very effective in the remediation of misconceptions in chemical kinetics.

Milenkovic, et. al., (2016) conducted a study on identification of misconceptions through multiple choice tasks at municipal chemistry competition test. In their paper, the level of conceptual understanding of chemical contents among seventh grade students who in the municipal Chemistry competition in Novi Sad, Serbia, in 2013 have been examined. Tests for the municipal chemistry competition were used as a measuring instrument, wherein only multiple choice tasks were considered and analyzed. Determination of the level of conceptual understanding of the tested chemical contents was based on the calculation of the frequency of choosing the correct answers. Thereby, identification of areas of satisfactory conceptual understanding, areas of roughly adequate performance, areas of inadequate performance, and areas of quite inadequate performance have been conducted. On the other hand, the analysis of misconceptions was based on the analysis of distractors. The results showed that satisfactory level of conceptual understanding and roughly adequate performance

characterize majority of contents, which was expected since only the best students who took part in the contest were surveyed. However, this analysis identified a large number of misunderstandings, as well. In most of the cases, these misconceptions were related to the inability to distinguish elements, compounds, homogeneous and heterogeneous mixtures. Besides, it is shown that students are not familiar with crystal structure of the diamond, and with metric prefixes. The obtained results indicate insufficient visualization of the sub microscopic level in school textbooks, the imprecise use of chemical language by teachers and imprecise use of language in chemistry textbooks.

Heng & Karpudewan (2017) conducted a study on facilitating primary school students' understanding of water cycle through guided inquiry based learning. Due to the ineffective teaching in introducing the water cycle, students have developed various misconceptions about the water cycle. In this study, an attempt was made to elucidate primary students' misconceptions about the water cycle using drawings and the guided inquiry-based learning approach was used to reduce the incidence of misconceptions. A quasi-experimental design involving randomly assigned comparison and experimental groups was used in this study to measure the effectiveness of the guided inquiry learning in reducing students' misconceptions about the water cycle. Pre- and post-comparisons of the drawings show that the experimental group students who were taught using the guided inquiry approach significantly reduced their misconceptions as opposed to students in the comparison group who were taught using a more conventional approach. The findings suggest that guided inquiry-based learning would be one possible method to improve students' understanding about the water cycle.

Bayuni, et. al., (2018) conducted a study on Identification Misconception of Primary School Teacher Education Students in Changes of Matters using a Five-tier-diagnostic test. This research was conducted on third grade students (III) semester six, with sample number 84 respondents. The method used in this research was descriptive method. A five tier diagnostic test was used as research instrument, a question adapted to three chemical representations accompanied by an open reason and a level of confidence in the choice of answers. The categorization of the five tier diagnostic test scoring was divided into four namely, understand the concept, lack of concept, misconception and not understand the concept. Questionnaire in the form of a closed questionnaire was used to determine the factors that cause misconception. The data obtained was, misconception has the highest percentage on the concept of substance properties and

changes in its form. It was found that the highest incidence of misconceptions was due to self-factors. It was concluded that five tier diagnostic tests can be used to uncover misconceptions of elementary school teachers and assist teachers in presenting lesson material tailored to the chemical representation so that students can understand the concept of the nature of matter and change its form well.

Koomson and Fordjour (2018) conducted a study on misconceptions of senior high school science students on evaporation and water cycle. Science educators agreed that everyday activities enable children o learn some science even before entering preschool education and those children's ideas are part of the classroom. Some of these ideas will not be completely correct. Misconceptions refer to children's incorrect or incomplete ideas. This study was conducted based on student's drawings and interviews. It was held with the aim of determining the misconceptions of science students receiving education in Senior High Schools in Ghana about evaporation and water cycle. The researchers had used a number of techniques to indicate misconceptions of students. These techniques included open ended questions, two-stage diagnostic tests, concept maps, word association and interviews. In addition, science educators have started to use drawing methods in order to ensure that students understand science and to obtain knowledge about their misconceptions. As a result of analysis of drawings and interviews, it was seen that more than half of that students had comprehensively or partially conceptual knowledge, but approximately one fourth of students had misconceptions about this subject. It is recommended that science education should focus on studying natural cycles in context of their effects on daily lives of humans instead of separating these cycles into specific scientific fields. This would provide fundamental instruments for students to appreciate that these concepts deal without ecology and environment.

Ilyas and Saeed (2018) conducted a study on exploring teachers' understanding about misconceptions of secondary grade students. The sample included 15 chemistry teachers who were purposively selected. Semi-structured interview was used as a tool for data gathering. The interview transcripts were transcribed after thematic description. The results revealed that most of the teachers understand the terminology of misconceptions. However, they do not possess the knowledge about the sources of these misconceptions and techniques to rectify them. In addition, the teachers do not consider the possible misconceptions that could generate from their teachings. On the basis of the findings, it

is recommended to incorporate the techniques required for the mediation of misconceptions in the curriculum for teacher educators. It was also found that it is necessary to equip teachers with essential capabilities of continuously identifying their students' misconceptions and implementing remedial instructional strategies.

Lamichhane, et. al., (2018) have conducted a study on undergraduate chemistry students' misconceptions about reaction coordinate diagrams. According to authors misconceptions are "the old, the bad, and the ugly" prior knowledge, ideas or conceptions that the learners have that hinders their further learning in science. Several types of misconceptions that undergraduate students hold about reaction coordinate diagrams and energy diagrams were highlighted by this research. The rationale of 223 students were coded based on their responses to a multiple-choice question on the topic and interviews (n=10) were used to delve deeper into the students' knowledge structures. The results of the open coding of the rationale and the interviews were used in developing an instrument which was administered to 57 students. Through this research the researchers had come across some alternate conceptions that students had regarding energy diagrams which were not reported earlier.

Satriana, et. al., (2018) conducted a study on student's profile of misconceptions in chemical equilibrium. The aim of this study was to analyse the student's misconceptions of chemical equilibrium. The topic of chemical equilibrium concept consists of three subtopics there are dynamic equilibrium and equilibrium constants, Le Chatelier principles and interpreting the experimental results in equilibrium state. The participants consists of six students, two students from high, two from the medium and two from low ranked school category. The instrument used to identify student's profile misconceptions was the computerised Two Tier Multiple Choice Test (CTTMC). There was subtopic on the concept of chemical equilibrium that most likely causes misconception that was the interpretation of the experimental results in the equilibrium state.

Wiji & Mulyani (2018) conducted a study on Student's mental model, misconceptions, troublesome knowledge, and threshold concept on thermo-chemistry with DToM-POE. The purpose of this study was to obtain a profile of students' mental models, misconceptions, troublesome knowledge, and threshold concept on thermo-chemistry. The subjects in this study were 35 students. The method used in this research was

descriptive method with instruments Diagnostic Test of Mental Model - Prediction, Observation, and Explanation (DToM-POE). The results showed that the students' ability to predict, observe, and explain ΔH of neutralization reaction of NaOH with HCl was still lacking. Most students tended to memorize chemical concepts related to symbolic level and they did not understand the meaning of the symbols used. Furthermore, most students were unable to connect the results of observations at the macroscopic level with the symbolic level to determine ΔH of neutralization reaction of NaOH with HCl. Then, most students tended to give an explanation by a net ionic equation or a chemical reaction equation at the symbolic level when explaining ΔH of neutralization reaction at the sub-microscopic level. In addition, there are seven misconceptions, three troublesome knowledge, and three threshold concepts held by students on thermo-chemistry.

2.2.1 Observations on the Literature Reviewed (Chemistry)

The resrarcher has reviewed a total of 25 studies in chemistry. The studies were conducted in the field of errors in concept formation, states of water, water cycle, evaporation, diffusion, osmosis, chemical symbols, formulae and equations, chemical reactions, chemical equilibrium, matter, density, thermo-chemistry. Potvin (2014) found a very interesting misconception among standard X students regarding solubility of salts that salts dissolve in water when it is in fine grains. The resrarchers had used questionnaires both open-ended as well as close-ended to identify and measure misconceptions in chemistry. Many of the researchers had used two-tiered, three-tiered, five-tiered and multi-tiered test. Structured as well as semi-structured interviews along with concept maps and word association test were also used as a tool to measure misconceptions in chemistry. Studies were conducted at all grade level starting from grade three upto university levels. Couple of studies was conducted to identify misconceptions among teachers. Both survey and experimental studies were conducted to identify misconceptions in chemistry.

2.3 Studies Related to Misconceptions in Biology

Longden (1982) conducted a study on Genetics-are there inherent learning difficulties? Through the present study the researcher had identified sources of misconceptions and learning difficulties by interviewing academically sound students who were having

difficulty with genetics. The results indicated that misconceptions were related to nature of concepts used in genetics, such as frequent representation of meiosis by fixed inanimate stage diagrams and to instructional strategies.

Barrass (1984) conducted a study on some misconceptions and misunderstandings perpetuated by teachers and text books of biology. The results showed a list of commonly encountered misconceptions in biology related to the concepts of acellular and multi cellular, respiration and photosynthesis, egestion and excretion and homeostasis and homeothermy.

Cho, et al., (1985) conducted an investigation of high school biology text books as sources of misconceptions and difficulties in genetics. The researchers had done a detailed analysis of three most commonly used biology textbooks. It was found that misconceptions were commonly related to four major factors. First, sequence of topics taught. Second was the relationship between meiosis and genetics. Third was a set of relationships among the concepts which are basic to understanding meiosis and genetics. Fourth was the use of terms and mathematical elements in genetics. It was also found that most commonly misused term in textbooks were allele, genes and mutation.

Trowbridge and Mintezs (1985) conducted a study to determine students' alternative conceptions of animals and animal classification. The concepts examined were animal, vertebrates, invertebrates, fishes, amphibians, reptiles, birds and mammals. The comparison of the responses revealed that misclassification is consistent across the grade levels.

Haslam and Treagust (1987) conducted a study on diagnosing secondary students' misconceptions of photo synthesis and respiration in plants. The tool used for the present study was a two-tiered multiple choice test regarding "what do you know about photosynthesis and respiration in plants". Two-tiered multiple choice test contained 15 items. The finding of the result showed a very high percentage of students were found to have misconceptions regarding plant physiology. Majority of the students were not able to differentiate between photosynthesis and respiration.

Treagust (1988) conducted a study on the development and use of diagnostic tests to evaluate students' misconceptions in science. The researcher had used diagnostic tests for chemistry and biology developed by Peterson (1986) and Haslam (1987). The tool

“covalent banding and structure” and “what do you know about photosynthesis and respiration in plants” were two tiered multiple choice test containing 13 and 15 items respectively. The data related to chemistry was collected from responses of four groups of students. Groups 1 and 2 are composite grade 11 and 12 chemistry students, respectively, in South Australia. Groups 3 and 4 (aged 18—19 years) are first year tertiary chemistry students from two institutions in Western Australia. The majority of students in all groups (87%, 97%, 100% and 89%) responded correctly that intermolecular forces account for the difference in state of hydrogen sulphide and water at room temperature. Almost all these chemistry students were aware of the relationship which exists between the strength of the inter-molecular forces and the melting point/boiling point of a substance. However, only 11%, 33%, 19% and 18%, respectively, correctly understood why this relationship exists. Whereas the data related to biology was collected from responses of students in grades (8-10) in one school and from students in grades 11 and 12 in three schools from comparative socioeconomic areas. The results indicate that this sample of students does not have a clear understanding of the process of respiration. When the first part of the item only is taken into consideration (end column), the results show that there is generally an increasingly correct response choice from grades 8-12 (39%, 44%, 41%, 65%, 88%) about which gas in taken in large amounts by green plants when there is no light energy at all. However, when students' reasoning for their choice in the first part of the item is taken into consideration, the correct response is much lower (9%, 11%, 7%, 28%, 65%). This study can be included in both chemistry and biology.

Mahapatra (1989) conducted a study on four dimensions of teaching and learning of science: characteristics and implication. The researcher has observed that children made a great deal of conceptualization on the basis of their observation of the day to day happenings in the environment and home situations. In this process they formulated alternative concepts about things, objects and events. These alternative conceptions are hard to refute. As a result many of the students hold misconceptions, which teachers find difficult to correct.

Ansari (1998) studied misconceptions concerning genetics and evolution in biology at high school level in relation to formal reasoning ability, cognitive development and achievement. The study reported that performance on achievement was inversely related

to the number of misconceptions held by IX standard students studying biology in two government schools of Bhopal. It was also found that reasoning ability and cognitive development do create misconceptions among students and affect their achievement.

Dreyfus and Jungwirth (1989) conducted a study on the pupil and living cell: a taxonomy of dysfunctional ideas about abstract ideas. The tools used by the researcher were a two-tier questionnaire followed by a series of interviews with tenth grade (age 16) pupils who had been taught about 'the living cell' the previous year. The questionnaire was based on the normative curricular expectations of the 'establishment' (including the views of practising teachers). Pupils' responses during the interviews permitted a multi-dimensional categorization according to the type(s) of knowledge possessed by them, its functionality, the degree of ego-involvement with such knowledge, and their readiness for conceptual (ex) change and hence the chance for survival of out-of-school acquired misconceptions about 'the living cell'. The researchers had found that many misconceptions survived because they were socially, but not scientifically, functional in the classroom situation. The prevalence of these misconceptions was because they had remained undetected by the teachers or were even regarded as acceptable analogies by teachers. The researchers had suggested an early diagnosis of such misconceptions as imperative in order to prevent their survival and possible reinforcement. Furthermore, the introduction of concepts by teachers, which cannot become meaningful to pupils because of the non-functionality of previously acquired knowledge (prerequisites for concept-formation) or complete lack of such knowledge, was seen to lead inevitably to the formation of erroneous ideas—misconceptions. It was also suggested that, in order to avoid the rise of such misconceptions and their survival, a teaching approach be adopted by which a concept can be described by means of meaningful attributes, and linked to other, related concepts.

Pearson and Hughes (1988) conducted a study on problems with the use of terminology in genetics education. The researchers had examined the technical vocabulary of genetics as a possible source of error and confusion among students. The researchers had also reported misuse of many terms in textbooks of science and genetics in Great Britain.

Amir and Tamir (1990) conducted a study to define misconceptions about photosynthesis. The purpose of this research was to carefully select and define

misconceptions about photosynthesis needing remedial efforts. To achieve this, a specially designed paper-and-pencil test was administered to 285 students in grades 11 and 12 who had previously completed a study of photosynthesis just prior to the test. The researcher had analysed the results of the limiting factor activities, and items which tested the concept of the relationship between photosynthesis and respiration. It was found that even though the sampled students were familiar with the concept of limiting factors, they had trouble applying it in everyday life. It was found that the students' understanding of the latter concept was as a gas exchange rather than as a biochemical process. The researcher had recommendations for the production of remedial materials.

Tangmongkollert (1994) has done a study on development and use of instruments to measure students' misconceptions of selected science concepts at the elementary school level in Thailand. A 17-item two-tier test for measuring Thai student misconceptions in the area of photosynthesis and respiration at the elementary level was developed by the researcher. The instrument was administrated to 4,346 fourth, fifth, and sixth-grade students. Some of the major findings of the study was a) Both plants and animals can produce their own food by using light b) Animals with green colour photosynthesize since the green colour is from chlorophyll c) Light is not a factor in making the green colour of the plants. It was also found that school location and parents' educational levels were related to understanding of the selected concepts. Students who were studying in schools located in urban areas scored higher than those who were studying in schools located in suburban/rural areas. Students whose parents had completed college education scored significantly higher than those whose parents had completed lower educational levels.

Odom, et. al., (1995) developed a two-tier diagnostic test to measure understanding of diffusion and osmosis of college biology students. Three general steps were used: defining the content boundaries, collecting information on students' misconceptions and instrument development. The results showed the misconceptions related to diffusion among students.

Hill (1997) examined the conceptual change through the use of student generated analogies of photosynthesis and respiration. There were eleven items and a three tier multiple choice instrument was designed to assess the common misconceptions. There was no significant change in performance between the pre-test and post test

administration. But the confidence in their responses about the two concepts had increased.

Tekkaya (2002) conducted a study on misconceptions as barrier to understand Biology. In this study the researcher has focussed on literature in biology education concerned with students' understanding of biological concepts. Characteristics and possible sources of misconceptions were discussed and examples of some common misconceptions such as 1) Behaviour and habitat are criteria for classification 2) community is same as population 3) population is the area where living thing occur 4) population is an area where living thing occur 5) population is the number of people /organisms 6) genes contain alleles 7) alleles contain genes 8) DNA replication occur in prophase 9) chromosomes and DNA present separately in nucleus 10) serum is the storage form of plasma 11) the thick and elastic wall of arteries helps prevent heat loss 12) low blood velocity in capillaries is due to their smaller diameter. The researcher has also discussed the issue of how teachers best addresses students' misconceptions and also provided some suggestions for its remediation.

Graham (2003) studied the effect of student-centred and teacher-centred with and without conceptual advocacy (CA) on biology students' misconceptions (MIS), achievement (ACH), attitudes towards science (ATS) and cognitive retention (CR). Students of ninth grade were purposively selected using intact classes assigned to one of four treatment groups (i.e., student-centred instruction without CA, student-centred instruction with CA) a modified quasi-experimental design was used in which students were not matched in the conventional sense but instead, groups were shown to be equivalent on the dependent measure via a pre-test. A five day treatment implementation period addressed science conception under investigation. The treatment period was based on the number of class periods teachers at the target school actually spend teaching the biological concepts under investigation using traditional instruction. At the end of the treatment period, students were post-tested using the concepts in biology instrument and science questionnaire. Eight weeks after the post-test these instruments were administered again as a delayed post-test to determine cognitive retention of the correct biological conceptions and attitude towards science. MANCOVA and follow up univariate ANCOVA results indicated that students-centred instructions without CA (i.e. Group 1) did not have significant effect on students' MIS, ACH and ATT. On the other hand students-centred instruction with CA (i.e. Group 2)

had a significant effect on students' MIS, ACH but did not on ATT. Teacher centred instruction with CA (i.e. Group 3) had a significant effect on students MIS in favour of Group 4 (i.e. control group) did not have significant effect on students' MIS, ACH and ATT.

Lin (2004) conducted a study on development and application of a two-tiered diagnostic test for high school students' understanding of flowering plant growth and development. The instrument development procedure had three general steps: defining the content boundaries of the test, collecting information on students' misconceptions, and instrument development. Misconception data were collected from interviews and multiple-choice questions with open response answers. The data were used to develop 13 two-tier multiple-choice items. The conceptual knowledge examined was flowering plant life cycles, reproduction, precondition of germination, plant nutrition, and mechanism for growth and development. The diagnostic instrument was administered to 477 high school students. The correlation coefficient of test-retest was 0.75. Difficulty indices ranged from 0.24 to 0.82, and discrimination indices ranged from 0.32 to 0.65. Results of the Flowering Plant Growth and Development Diagnostic Test suggested that students did not acquire a satisfactory understanding of plant growth and development concepts. Nineteen misconceptions were identified through analysis of the items that could inform biology instruction and resource.

Nguyen and Rosengren (2004) Children's misconceptions about five specific biological concepts—life, aging, reproduction, illness, and death—were investigated using a parent survey. Parents of 3- to 4-year-olds (**N** = 125) and parents of 5- to 6-year-olds (**N** = 145) completed a questionnaire about their child's knowledge and misconceptions involving these concepts. Parents reported that misconceptions were common among 3- to 6-year-olds, particularly for reproduction and death. Parents reported a greater reluctance to talk with their children about death and reproduction and also thought their children should learn about these concepts at a later age than other biological concepts. One third of the misconceptions reported by parents occurred at the boundary between different domains, where information from another domain (i.e., physics or psychology) was incorrectly associated with the biological domain. Parents of 5- to 6-year-olds reported fewer misconceptions than parents of 3- to 4-year-

olds, suggesting that these misconceptions are open to change and are eventually replaced by accurate biological knowledge.

Yen, et. al., (2004) examined alternative conceptions of reptiles and amphibians and the extent to which these conceptions remain intact through the elementary, junior and high school students. A multiple choice and free response instrument was administered to assess various levels of students' understanding of amphibians and reptiles. The results showed that most of the students were able to classify snakes as reptiles but few students classified sea turtles as reptiles, majority of the students' classified sea turtles as amphibians. More students were able to correctly classify frogs as amphibians than toads. In most instances, students correctly classified "Prototypical" representatives of two animal classes more readily than less exemplary representatives.

Baweja (2008) developed a three-tier test to examine prevalence of errors and misconceptions in Ecology at secondary school stage. The sample comprised of 912 students of 9th standard of Punjab. The interviews and Scientific Attitude Scale were also used as a tool to assess errors and misconceptions amongst the secondary school students. It was reported that percentage of students having misconceptions decreased as the tier of the test increased. The females, rural, low achievers and secondary school students' having low favourable attitude towards science showed more errors and misconceptions as compared to males, urban, high achievers and students having high favourable attitude towards science.

Klymkowsky and Gravin (2008) developed Biology Concept Inventory. Results indicated a striking lack of understanding on two questions related to randomness, even after three major's courses in molecular, cell and developmental biology at the University of Colorado at Boulder.

Soyiba (2008) conducted a study on review of some sources of student's misconception in Biology. It is now widely acknowledged that students' misconceptions in science impede their meaningful understanding of and good performance in the subject. A search in the literature reveals that textbooks, reference books, teachers, language, cultural beliefs and practices are some principal sources of high school students' misconceptions of many science concepts in biology. In this paper, some misconceptions students hold in biology, which originate from each of these sources,

are reviewed using cognate studies and published documents. The implications of the conclusions from the review for biology education are addressed.

Cardak (2009) conducted a study on science students' misconceptions about birds. The aim of this study was to determine the misconceptions of science students attending the university on the classification and behaviour of birds, and their interaction with people. For this purpose, open questions, interviews and drawing methods were directed at 110 university science students. As a result of the analysis of data obtained, it was determined that the science students surveyed had various misconceptions with regard to the classification and behaviour of birds, and their interaction with people. Some of these misconceptions are described for the first time (the gizzard in their maw provides the digestion).

Taylor, et. al., (2011) designed implicit-confidence tests, a simple modification of the multiple-choice test, could be used as a strategy for recognizing student misconceptions. The test was administered to students (both majors and non-majors) in MCDB 1111: Bio fundamentals at the University of Colorado at Boulder. It was examined that at a statistically significant level (> 95%), there was no difference between women and men regardless of whether their answers were confidently correct or incorrect, suggesting that such two dimensional tests were a gender neutral tool.

Deshmukh (2012) conducted a study of students' misconceptions in biology at the secondary school level. The objective was to study the students' misconceptions in biology with respect to life processes, which is the syllabus at secondary school. An open-ended questionnaire was administered to the students of class IX. A total of 110 secondary school students were selected through random sampling technique. Research shows that misconceptions about processes of respiration, photosynthesis, circulation persist among students. It has been found that there is an urgent need for research based material to rectify students' misconceptions.

Yiebekal (2014) studied conceptions and misconceptions of Students about Photosynthesis and Cellular Respiration in Plants. A randomly selected 220 (M=140 & F=80) grade 10 students were the participants of the study. Interviews, questionnaires, classroom observations, document analysis and Two-tier diagnostic test (TTDT) of Photosynthesis and Respiration in Plants were the tools of data collection. Data were analyzed by using both qualitative and quantitative methods. The results of the analysis

showed that the major sources of misconceptions related to photosynthesis and respiration in plants were: (i) students' prior knowledge and concept about photosynthesis and respiration in plants (ii) competence of and methods of instruction practiced by biology teachers (such as mainly depending on lectures (iii) lack of practical parts (both field and lab) in teaching photosynthesis and respiration in plants and, (iv). teachers' prior knowledge and conception about photosynthesis and respiration in plants.

Deshmukh (2015) conducted a study on why do school students have misconceptions about life processes. Biology helps students to understand the environment and expects students to develop awareness, positive attitudes, scientific temper, values and skills. From life processes, students develop an understanding of basic structure and functions and their interrelationship. Much research on students' understanding of biological concepts has shown that students possess misconceptions of many concepts that are basic to a thorough knowledge of biology and leave secondary school with a distorted view of biological objects and events. In this research, students and teachers' ideas about life processes were collected via an open-ended questionnaire, interviews and textbook analysis. The data were used to develop the Concept-Based Objective Test. The author analysed the rationale behind the misconceptions in life processes among students and teachers and found that misconceptions in life processes among students and teachers vary in nature, consequence and tenacity. The most important reason determined for these difficulties is the close relationship of various biology concepts and sub-concepts with each other. The author found that in the textbook analysed, the explanation of these concepts was abstract, complex, incomplete, ill-structured and erroneously interpreted. The study also found that the various biological processes are taught independently and that there is a need to help students to understand the interrelationship among the concepts and sub-concepts. Therefore, in the teaching and learning of biology, it's essential to provide effective, complete and accurate understanding of sub-concepts and concepts.

Glavin, et. al., (2015) conducted a study on identification of misconceptions in the teaching of Biology: a pedagogical cycle of recognition, reduction and removal. In the present study the researchers has investigated the use of one diagnostic testing approach to the identification of misconceptions in the teaching of respiration and photosynthesis. The sample consisted of 139 secondary school students and 43 pre-service teachers in

the republic of Ireland. Photosynthesis and respiration was chosen by the researchers as they are prevalent biology topics that students find conceptually challenging. The study used test items to elicit the extent of misconceptions among this cohort-a paper pencil test for students and a survey instrument for pre-service teachers. The findings of the study showed unacceptably high level of misconceptions among all pre-service teachers and students. The researchers have suggested that diagnostic tests of this type can be a useful entry point to a pedagogical cycle for the recognition, reduction and removal of misconceptions. The findings have wider implications than this small scale study and are primarily directed towards new understandings in relation to more effective models of biology teaching and teacher education.

Hasiloglu and Eminoglu (2017) conducted a study on identifying cell-related misconceptions among fifth graders and removing misconceptions using a microscope. The aim of the study was to identify cell-related misconceptions among fifth graders attending middle schools in Turkey and examine the impact of microscopy on the elimination of these misconceptions. This study was conducted with the participation of 87 fifth grade students attending a middle school in Agri province of Turkey in the academic year 2015-2016. The research was designed as a case study and data were collected using a test with 4 diagnostic and drawing items. Data analysis showed that the students had cell-related misconceptions. Prior to instruction with a microscope, most students thought an onion cell was shaped like an onion and it was a cooking ingredient their mothers used. The students further said that a leaf cell was shaped like a leaf and described it as a leaf on a tree. They described bacteria as living things with organs and limbs, like animals. They drew and described bread mold as a loaf of bread. Most of these misconceptions were found to disappear after learning with a microscope.

Subari (2017) conducted a study on improving understanding and reducing matriculation students' misconceptions in immunity using the flipped classroom approach. This study focuses on determining the effectiveness of the flipped classroom as a way of reducing misconceptions in immunity among a group of biology students in Penang Matriculation College. For this purpose, a one-group pre-test-post-test research design was conducted with 35 biology students. A two-tier instrument was used in both the pre-test and post-test. The instrument comprised of part A and part B. Part A consisted of five multiple-choice questions, while part B required true or false responses. Each item in both parts required written explanations to accompany the

students' choice of answer in tier 1. The data collected were analysed using paired samples t-test analysis to determine the difference of the mean scores for both tests. The results showed that there was a significant difference between the pre-test and post-test mean scores, suggesting that the flipped classroom is potentially effective in reducing misconceptions of the matriculation students on the topic of immunity.

Fuchs and Arsenault (2017) conducted a test using data to find misconceptions in secondary science. Students as well as teachers, often learn what makes sense to them, even when it is wrong. These misconceptions are a problem. The author sought a quick, quantitative way of identifying student misconception in secondary science. The authors have used Toronto's National Biology Competition test data. Through this research the authors presented a method of quickly identifying misconceptions that agree with many facets of the extant misconception literature (ubiquity across subject areas, pervasiveness regardless of question difficulty and distractive power). Seeking student's most common wrong answer on a multiple-choice test is found to be a fast, reliable and data-driven way to identify misconceptions.

Hala, et. at., (2018) conducted a study on identification of misconceptions on cell concepts among biology teachers by using CRI method. The objectives of the study was (i) to assess the levels of understanding and misconceptions of biology teachers in Makassar regarding cell concepts, (ii) to identify the basic competence in which the teachers pose misconceptions, and (iii) to identify the factors causing misconceptions on cell concepts among biology teachers in Makassar. This study was a descriptive study which implements Certainty of Response Index (CRI) as the method to identify teachers' misconception. Participants of the study (n=22) were selected through purposive sampling based on the representativeness of the schools in Makassar area. The result of data analysis showed that there were teachers who possess misconceptions (40.30%), scientifically accepted conceptions (49.10%), and transitional conceptions (10.77%). The misconceptions were found in 6 basic competences of the cell concepts. The highest misconceptions (55.68%) on basic competence 3.2 which requires participants to distinguish transport mechanism on the (diffusion, osmosis, active transport, endocytosis and exocytosis) based on observation. There were several factors which cause the occurrence of misconceptions among the participants in this study, including low level of reasoning ability, low retention of knowledge obtained in

undergraduate, lack of learning resources, incomprehensible terms, and low interests of Biology teachers on cell concepts.

Halim, et.al., (2018) conducted a study on Identifying and Remediating Student Misconceptions in introductory Biology via Writing-to-Learn Assignments and Peer Review. It was found that student misconceptions are an obstacle in science, technology, engineering and mathematics courses and unless remediated may continue causing difficulties in learning as students advance in their studies. This study took place at a large, Midwestern university in an introductory level cell and molecular biology course intended for first year students. The course was taught by two professors. The sample constitute of 36 students who were enrolled for the course. This study involved the analysis of qualitative data consisting of student-generated responses to four writing assignment and corresponding peer feedback. Analysis of these data provided that research team with insight into the misconceptions present in students' responses and the types of peer interactions that occurred during the WTL process. These data were quantitatively transformed to investigate the prevalence of certain misconceptions and to analyze the changes between initial and revised drafts of each assignment and the relationship of these changes to peer review.

Kumandas and Ateskan (2018) conducted a study on misconceptions in biology: a meta-synthesis study of research, 2000-2014. In this study the researchers opined that the teachers need to be aware of biology misconceptions in their classrooms and how to address them. In response, researchers and science educators have suggested and examined effective practices to prevent and ameliorate misconceptions. An extensive review of the literature gives researchers and educators insights into trends, practices and gaps in the misconceptions research and helps decide which issues to address and why. The current study the researchers shared how researches in Turkey conduct a content analysis of published misconception research in Turkey by using a form. The analysis resulted in a meta-synthesis (thematic content analysis) that inventoried and compared the purposes, research methods, data collection instruments, and findings of the selected publications. Biology educators in other regions of world can inform their practice by using this instrument and research methods to learn about trends and patterns in misconceptions research. Through this study the researchers will gain insight into effective methods that have been used to examine misconceptions and will be able

to identify biology misconceptions that have been under-investigated and need further analysis.

2.3.1 Observations on the Literature Reviewed (Biology)

The researcher had reviewed 34 studies related to misconceptions in biology. The studies were conducted in the field of genetics, characteristics of animals, respiration and photosynthesis, egestion and excretion, homeostasisand homeothermy, meiosis, respiration, genes and alleles, flowering plants, growth and development, reptiles and amphibians, molecular cell and development biology, birds, life processes and ecology. Two-tiered test, multiple choice test, concept based test and interviews were the tools used to measure misconceptions in biology. Baweja (2008) has used an attitude scale to measure misconceptions related to ecology. Studies were conducted at all grade levels from primary till university level. Both students and teachers were the foci of the study.

2.4 Studies Related to Misconceptions in Other Areas

Eaton, et. al., (1984) has done a study on Student's Misconceptions Interfere with Science Learning: Case Studies of Fifth Grade Students. The study was part of the Elementary Science Project, focused on the science teaching of 14 teachers and the data was collected through observations and audio-recorder lessons on the unit of light. Is worth mentioning that before the light and seeing unit was taught, children took a pre-test and after the unit they took the same test again, which was the basic source of information about children's conceptions. The results showed that students had difficulties in learning about light because neither their text nor their teachers adequately dealt with their misconceptions. Experiences and common sense can sometimes lead to inaccurate or incomplete conceptions that can prevent a student from learning.

Leher & Littlefield (1991) in their study misconceptions and errors in LOGO and animated science: the role of instruction tested the influences of different instructional practices on second and fourth grade children's acquisition of LOGO graphics commands as well as animated science commands. Twenty four fourth graded children were randomly selected for the study. In a less mediated context, students received instruction about LOGO and then worked on whatever they wished in LOGO. In another, more-mediated context, students received instruction about LOGO and

animated science and then used software designed to encourage reflection about the meaning and consequences of various LOGO commands. Results suggested that the incidence of certain misconceptions and errors was significantly reduced by the mediated instructions.

Pine, et.al., (2001) carried out research on Children's Misconceptions in Primary Science: A Survey of Teacher's Views. Their analysis revealed that children have a lot of misconceptions about science topics and these misconceptions are of considerable importance and cannot be ignored in the learning process, since they are bases upon which knowledge in built. Teachers described a range of methods used to find out what children know but it was not clear if finding out what children know "involves searching for their correct notions about topics or actively probing for misconceptions". The results also indicated that teachers may think misconceptions get in the way of the teaching process, and are best ignored or squashed as quickly as possible. However, teachers need to place as much emphasis on children's incorrect ideas as on their correct ones if they want to accomplish conceptual change in science.

Kendeou & Broek (2005) studied the effects of readers' misconceptions on comprehension of scientific text. College students with misconceptions in science were asked to read and recall a text that contradicted their misconceptions. Students with no misconception served as the control group. Both online (think-aloud, reading times) and offline (recall) measures were obtained. The results suggest that readers' misconceptions often do not affect the online processes themselves but do influence the content of those processes and consequently the offline memory representation for the text after reading is completed.

Bethard, et. al., (2006) conducted a research on identifying science concepts and students misconceptions in an interactive essay writing tutor. The authors had developed an interactive essay writing tutor that tries to address the challenges of misconceptions in science. For this study the researchers had identified 30 core concepts of plate tectonic. A cohort of middle school and high school students were selected as the sample for the study. The researchers were able to identify lots of misconceptions prevalent among middle and high school students.

Rowell, et. al., (2006) conducted a study on changing misconceptions: a challenge to science educators. In their paper the researchers examined misconceptions as personal

explanatory knowledge judged by experts in the field to be in error. To those who have constructed them, misconceptions are not recognizable as different from any other explanatory knowledge: they are formed by the same process, take part in the generation of new knowledge and consequently are difficult to replace. As with construction, replacement involves the process of equilibration. To date, educational strategies promoting equilibrium in the classroom have attempted this through co-operative debate that is more teacher centered and report on a comparative empirical test of the educational potential of the two strategies.

Thompson and Logue (2006) had done a study on exploration of common student misconceptions in science. The objectives of the study were to define three scientific concepts and identify for each some of the misconceptions that students commonly have. Six students, representing three distinct age groups were interviewed, using a predetermined set of questions and activities for each concept. Student responses were recorded and evaluated in an attempt to understand what misconceptions were held by the students, how they acquired them. The study showed that the level of misconceptions varied between concepts. There appeared to be some patterns in the level and type of misconceptions between the three age groups, suggesting that a more rigorous study in this area would be of value.

Don (2011) had done a study on exploring American Indian students' perceptions, attitudes and misconceptions of scientists and the nature of science. 133 high school students constituted the sample for the study. Views on Science-Technology-Society (VOSTS), Draw –A-Science-Test-Checklist (DAST-C) and Views of Nature Science Questionnaire (VNOS) were used for data collection. The result showed that there were no significant difference in Students' DAST-C scores between gender and different school grades. The result also revealed that there were no significant relationship between school grade and any of the VOSTS positions, which implies that school grade did impact naive position, merit position and informed position of American Indian students.

Mary, et. al., (2014) conducted a study on Misconceptions yesterday, today and tomorrow. It was found that biology education researchers are being criticised for the use of term misconceptions and recommended that in order to be up-to-date with education research, biology education researchers should use alternative terms for

students' incorrect ideas in science. The researchers counter that criticism by reviewing the continued use and the meaning of misconceptions in education research today and described two key debates that account for the controversy surrounding the term. The researchers then identify and describe two areas of research that have real implications for tomorrow's biology education research and biology instruction: 1) hypotheses about the structure of student knowledge (coherent vs. fragmented) that give rise to misconceptions; and 2) the "warming trend" that considers the effects of students' motivation, beliefs about the nature of knowledge and learning (their epistemic beliefs), and learning strategies (their cognitive and metacognitive skills) on their ability to change their misconceptions in science. They concluded with a description of the proposed future work in biology education research related to misconceptions.

Tam (2015) conducted a study on the identification of students' misconceptions in a two tier item. The two-tier item format has gained some popularity in use by science educators worldwide, including those from Taiwan. Despite its broad applications, there are relatively few studies that focused themselves on extending the present methodology in analyzing this particular item format. As a result, there are still uncertainties concerning how the result in the data table from a two-tier item should be analyzed and interpreted, especially with respect to the identification of potential misconceptions held by the participating students. The usual practice in this area of research is to assume that if more than 10 % of the respondents picked a wrong combination of options across the two tiers, then that combination can be regarded as reflecting the presence of a misconception of some sort. This study argues against the use of the 10 % rule, on the ground that it is, among other reasons, subjective and lacks substantive support based on the subject matters. Instead, it is suggested that correspondence analysis can be performed in a three-stage manner. Potential types of misconceptions as held by the participating students could then be identified by means of interpreting the clusters of categories across the two tiers in the correspondence plot. This study reflects the kind of interest from local researchers on methodological issues surrounding the two-tier item format.

Marleen, et. al., (2016) conducted a study on Uncovering Students' Misconceptions by Assessment of their written Questions. It was an exploratory study. The study was conducted on 242 students of bio medical bachelor course. This study demonstrates that misconceptions can be uncovered in students' written questions. The occurrence of

these misconceptions was negatively associated with the formal examination score. Identification of misconceptions creates an opportunity to repair them during the remaining course sessions, in advance of the formal examinations.

Oberoi (2017) has done a review of literature on student's misconceptions in science. Misconceptions are an obstacle to comprehend scientific phenomena. Since misconceptions are a significant problem at all levels of education, studies have been increasing in the field of biology education. The aim of his paper was to explore the patterns of the researches about science misconceptions. In his paper, a brief, critical review of major published studies relating to research on causes and identification of misconceptions in science by various researchers over the past nearly forty years was reviewed. The sources of errors and misconceptions must be identified for effective conceptual learning. Many researchers found various causes of misconceptions among students. Some studies revealed that misconceptions were related to the nature of concepts or the lack of knowledge of the concepts, text books, confusion, language and overgeneralization etc. An array of tools viz. interviews, multiple-choice questions, concept mapping, drawings, two-tier and three-tier diagnostic tests were used to assess the existence of errors and misconceptions in conceptual learning which are discussed briefly. This paper will be helpful to teachers and future researchers to identify the misconceptions and enhance the probability of effective learning and high achievement of students.

Yasin (2017) in his study aimed to investigate and review the articles about misconceptions in mathematics and for this reason conceptual review method was conducted. Within the scope of the study 21 articles published between 2004 and 2015 were selected through pre-determined criteria. Findings of the review revealed that the number of studies on mathematical misconceptions has increased in the last 5 years. In addition, most of the studies were conducted with primary, elementary and high school students. In these studies researchers generally used multiple choice or open-ended achievement tests. Moreover, most of the studies were conducted for the purpose of determining misconceptions, not eliminating misconceptions. Lastly some recommendations are provided related to findings of the study.

Sirakaya and Cakmak (2018) conducted a study on the effect of augmented reality use on achievement, misconception and course engagement. Augmented reality is defined

as a technology in which real world and virtual objects are combined with a simultaneous interaction. A (matched) quasi-experimental research design with both pre-test and post-test control group was used for the study. The sample of the study consisted of 118 seventh grade students receiving education in six different classes. The students in the experimental group took their lessons with an augmented reality learning material, while the students in the control group continued using their traditional course materials. An achievement test, a misconception test and the student course engagement questionnaire were used as data collection tools. As a result of a seven week implementation, the researcher found that augmented reality technology increased the achievement level of students and eliminated their misconceptions. However, the researcher also found that augmented reality technology did not affect the course engagement of students.

2.4.1 Observations on the Literature Reviewed (Other Areas)

The researcher has reviewed 14 studies in this category. Misconceptions interfere with science learning, elementary science project, and children's misconceptions in primary science, comprehension of scientific texts; plate tectonic and nature of science are the topics where studies are conducted. Wriiten questions, essay writing, two-tiered tests, three-tiered tests, were some of the tools used by the researchers. Studies were conducted from fifth grade till university level. Both students and teachers were the foci of the study.

2.5 Studies Related to Misconceptions in Science among Teachers

Wadih (1993) in his study exploration of factors that may determine what misconceptions prospective elementary teachers at Wayne State University have in some concepts of physical science identified misconceptions in elementary physical science through scores obtained from pre-service elementary teachers on the test of Misconceptions in physics science (TMPS). Two hypotheses were tested. First, the number of college credits hours earned in physical or life science, either singly or in combination with cognitive development controlled for, predict scores on the TMPS. Second, the number of semesters of physical or life sciences, either singly or in combination, predicts scores on the TMPS. Subjects participating in the study were pre-service teachers of Wayne State University who were sophomores, juniors, seniors and

graduates. Multiple regressions were used to analyse the data. The analysis of the data revealed: (1) the number of credit hours in life sciences earned at the college level is the significant prediction of the score on the TMPS, but not the number of credit hours in physical science earned in the college level. This relation was still significant even after factoring out the cognitive development score. (2) the combined number of semesters of physical and life sciences taken individually at both the college and middle school level and/or the high school level is not a significant predictor of the score on the TMPS. The results implies that the only way of reducing misconceptions among pre-service teachers is by requiring them to take more science courses at the college level.

Anne (1999) investigated teachers' understanding and diagnosis of students' preconceptions in the secondary classroom. Four experienced science teachers were studied in depth. They were interviewed three times and classroom observations were conducted for nine weeks. The teachers' classroom practices, questioning techniques, understanding of students' preconceptions and assessment of students understanding were all analyzed. In this study the teachers did not use any formal strategies for diagnosing students' preconceptions such as concept mapping, interview, journals or writing prompts. The teachers studied claimed that it was important to conduct diagnosis but only one teacher was actually seen to do so. The major findings of the study were that (1) the teachers did not have a complete understanding of the concepts of diagnosing students' preconceptions in order to use that information to attempt conceptual change. (2) the teachers beliefs were not consistent with their practices in this situation; they may have had certain constraints on them that inhibited the transaction of their beliefs into practice.

Tahsin (2001) studied pre-service elementary teachers' misconceptions with respect to three environmental issues. The objective of the study was to (1) identify and describe the pre-service elementary teachers' misconceptions regarding the greenhouse effect, ozone depletion and acid precipitation (2) to compare the knowledge level of the students with a science concentration to students with a non-science concentration. 119 junior or senior level elementary education majors enrolled in a science teaching methods course at a large Mid-western university constitute the sample. Out of 119, 26 students had science as their area of concentration. A 29 statement survey questionnaire was used to collect data. Interviews were also conducted. Some of the major findings of the study were: (a) there were no statistically significant difference found in the

knowledge levels of the science and non-science students (b) the majority of the pre-service elementary teachers' posses an array of incorrect ideas about the nature, causes and effects of the greenhouse effect, ozone depletion and the acid rain.

Quick (2003) had done an investigation of the relationship between middle school science teachers' knowledge and beliefs regarding the coherence and connections among science concepts and their classroom practices. This phenomenological investigation used an inductive qualitative research approach with multiple instruments and processing including a survey, interviews, classroom observations, concepts maps and their classroom practice. The results suggest that middle school science teachers' ability to teach science in a connected and coherent fashion may be tied to their mental scheme for organizing science ideas, curriculum materials and the reflections on what they are teaching and why? It was also found that if the teachers had misconceptions about certain concepts then they had transacted the same misconceptions to their learners.

Elanie (2007) had done a study on evaluation of model for confronting science content misconceptions: A case study report. Professional development for practising science teachers often emphasises specific instructional strategies. However, these strategies are of questionable benefit to students of teachers who share content misconceptions relative to the topic being addressed in their science classes. This descriptive multiple embedded case study assessed the efficacy of employing a specific learning cycle strategy to help elementary teachers uncover and address their own science content misconceptions. The sample involved a group of teachers from an urban school district. All but one of the teachers shared a common misconception and moved toward a more scientifically accepted model. One of the major finding was that the professional development strategy, the couple-inquiry cycle for conceptual change could conceivably be utilized to increase science teacher content knowledge and to help teachers become more attuned to the tenacity of the misconceptions their students bring to the science classroom.

Cepeda (2010) studied the effects of participation in inquiry science workshops and follow-up activities on middle school science teachers' content knowledge, teacher held misconceptions and classroom practices. The main objective of the study was to help science teachers increase their science content knowledge, identify and resolve

misconceptions/errors they may have and assist them in their teaching by providing strategies for inquiry based teaching, science laboratory exercises and science equipment. Teachers enrolled in the biology course offered by the Rocky Mountain Middle School Math and Science Partnership constituted the sample for this study. The major findings of the study were (1) science teachers can increase their science content knowledge by attending high-quality professional development courses designed to help increase basic science content knowledge on science content. (2) teachers held numerous misconceptions as shown by the assessments and classroom observations. (3) some misconceptions were resolved, some appeared to be resolved at the time of the post-test reappeared again on the follow up test and some were not resolved.

Kambouri (2010) has conducted a study on Teachers' and Children's Misconceptions in Science. Mixed method research approach was used for the study. The tools used were questionnaires, observations, interviews and focus groups and the research was constituted in three phases. The sample was randomly selected and it consisted of qualified teachers from all schools of south Cyprus working with three to six year old children. SPSS was used for data analysis. The results indicate that often teachers do not acknowledge the existence of these misconceptions and this is likely to be an obstacle for children's learning.

Pine, et. al., (2010) in their study Children's Misconceptions in Primary Science: A survey of teachers' view found that young children hold naive theories about the world around them, but how do these mediate science learning in primary school? This paper considers the process of conceptual change and describes empirical studies into children's naive theories of physics concepts. The Representational Re-description model is invoked to explain how naive theories are a feature of conceptual change. Data are presented from a survey of 122 teachers of primary science in England. The teachers rated almost one-third of the topics sampled from the primary curriculum as being of above average difficulty for the children, particularly abstract concepts like electricity and forces. In addition, the teachers identified 130 misconceptions (such as 'Stones grow' or ' taller people are older than shorter people') which children bring to the science class. These data provide a starting point for considering how children's naive theories may mediate their ability to learn and implications for science teaching are discussed.

Lederman & Lederman (2014) conducted a research on science teacher education: myths and misconceptions. A survey was conducted. A sample of 125 teachers was selected. Questionnaire and interview was used for data collection. The data were analyzed and it was found that teachers had a lot of myths and misconceptions regarding even the simple concepts of science. They did not even have an accurate understanding of the differences and similarities between scientific inquiry and science practices.

Mesutoglu and Birgili (2017) conducted a research on awareness of misconceptions in Science and Mathematics Education: perception and experiences of pre-service teachers. To what extent pre-service teachers are aware of students' misconceptions and what they experience about identifying and working with misconceptions were of interest for this study. Semi-structured interviews were conducted with 11 pre-service teachers from elementary science education and mathematics education programs. The results revealed that the pre-service teachers had awareness on nature of misconceptions while having difficulties in providing more concise definitions of misconceptions. The misconceptions were mostly realised giving additional examples compared to students' explanation during teaching learning process. Another finding showed pre-service teachers believed that misconceptions might leads to academic underachievement, can have impact on other topics; can create negative symptoms of psychology and classroom management problems. The findings were further structured into a SWOT analysis framework that can help future researchers.

2.5.1 Observations on the Literature Reviewed (Teachers)

The researcher has reviewed nine studies under this category. The studies were conducted on topics relaqted to what misconceptions prospective teachers have, the teachers' classroom practices, questioning techniques, teacher's misconceptions on environmental issues, teacher's knowledge and beliefs redarding the coherence and connections among science concepts and their classroom practices as well as model for confronting science misconceptions. The tools used were tests of misconceptions in physics science, classroom observations, concept mapping, interviews, journals and writing prompts. Studies were conducted on both pre-service and in-service teachers. Surveys, case studies and phenomenological studies were done.

2.6 Observations on the Literature Reviewed (Overall)

The researcher has made the following observations while reviewing the literatures. William (1993) and Gray (2007) in their studies on misconceptions in science among standard eighth students found that males outscored females in identifying fundamental ideas related to misconceptions. But contrary to this Sopapun (1994) in his study on misconceptions in science among elementary students found that gender difference did not have significant effect on students' misconceptions. The researcher however, found that there was significant difference in misconceptions among eighth standard students from different types of schools.

It has been found that studies related to misconceptions are conducted in almost all streams of science but more number of studies is conducted related to misconception in physics such as studies conducted by Elizabeth (1988), Mark (1993), Fuller (1994), Sopapun (1994), Saxena (1994), Neset (2001), Abdelhaleem (2002), Beer (2010), Oglesby (2010), Temiz & Yavuz (2014), Howe (2015), Tamkavas, Kiray, Kocak & Kocak (2016), Zajkova, Zajkova & Mitrevski. Magnets, light, optics, force, motion, work and energy, electromagnetic interaction, Newton's laws and Newtonian mechanics are the areas in physics where studies were conducted. Kathleen (1994), Douglas & Rao (1997) Cynthia (2011), Lemma (2013) Potvin (2014), Heng & Karpudewan (2017) studied misconceptions related to chemistry. They conducted their studies on errors in concept formation, diffusion, osmosis, chemical symbols, formulae and equations. Potvin (2014) found a very interesting misconception among standard X students regarding solubility of salts that salts dissolve in water when it is in fine grains. Ansari (1998), Graham (2003), Soyiba (2008), Cepeda (2010), Deshmukh (2012), Yiebekal (2014), Deshmukh (2015) Subari (2017) studied misconceptions in Biology and James (1989), William (1993), King (2009), Don (2011) studied misconceptions related to earth science and Tahsin (2001) studied misconceptions related to environmental issues. It has also been observed that a higher percentage of students had misconceptions related to the concepts of physics, followed by biology and chemistry.

A lot of variations have been found among grades and levels at which studies related to misconceptions were conducted. Some studies were done at primary level like those of Elizabeth (1988), Leher & Littlefield (1991) and Fuller (1994) .William (1993), Tahsin (2001), Graham (2003), Sopapun (1994), Quick (2003), Gray (2007), Cepeda (2010)

and Lemma (2013) had done study at middle school level. Mark (1993), Anne (1999), Neset (2001), Oglesby (2010), Don (2011), Yiebekal (2014) had done study at high school level where as James (1989) has done a cross-age study in which students from 5^{th}, 8^{th}, 11^{th} or students enrolled in local university or trade school were selected as sample. Kendeou & Broek (2005), Cynthia (2011), Temiz & Yavuz (2014) had done study at college level. Wadih (1993), Tahsin (2001) and Beer (2010) conducted study on pre-service teachers where as Quick (2003) and Cepeda (2010) studied about in-service teachers' misconceptions.

Mark (1993) found that there was a significant correlation between the students' formal reasoning ability and their scores on the conceptual physics pre-test, indicating that students with higher formal reasoning ability tended to have fewer pre-course misconceptions than students with lower formal reasoning ability. Students classified as high formal thinkers achieved significantly higher scores on the conceptual physics post-test than low formal thinkers, indicating that students with high formal reasoning ability had significantly fewer end-of-course misconceptions than students with low formal reasoning ability. Kathleen (1994) conducted a study on categorization of misconceptions in learning of chemistry found that 30 % of the misconceptions prevalent among students can be attributed to their cognitive development. Ansari (1998) also found that reasoning ability and cognitive development do create misconceptions among students and affect their achievement.

Quick (2003) had done an investigation of the relationship between middle school science teachers' knowledge and beliefs regarding the coherence and connections among science concepts and their classroom practices found that if teachers had misconceptions about certain concepts then they had transacted the same misconceptions to their students. Lemma (2013) also found that 90% of the students' misconceptions have a significant correlation with teachers' misconceptions.

About the role of previous knowledge in creating misconceptions among students Saxena (1994) and Yiebekal (2014) found that prior knowledge of students tend to develop misconception among them. Kathleen (1994) conducted a study on categorization of misconceptions found that 32 % of the misconceptions in students are due to their prior knowledge.

Review of the literature reveals that textbooks, reference books, teachers, language, pedagogical methods, prior knowledge, cultural beliefs, and practices are some of the principal sources of misconceptions among students. Both teachers and students were the foci in different studies related to misconceptions, however, teachers were less often studied as compared to students. It has been found that more number of studies was of experimental type, however, few surveys, case studies and phenomenological investigation was also done.

The researcher has found some research gaps while reviewing the literature, these gaps are as follows:

- More number of studies have been conducted on physics and a comparatively less on chemistry and biology
- Most of the studies have been conducted exclusively either on physics, chemistry or biology but none/very few studies have been conducted on science as a complete subject comprising of contents from physics, chemistry and biology.
- In chemistry most of the observed studies were on chemical formulae, symbols and equations but areas like acid, base & salt, chemical and physical properties of metals and metallurgy has still been unexplored.
- In biology most of the studies has been done on photosynthesis, respiration, but less number of studies have been done on birds and cell and its organelles.
- Less number of studies has been conducted in India, so this area of research has still been unexplored.
- So far only nine studies have been conducted in India.

2.7 Implications of the Reviewed Literature for the Present Study

For the present study, hundred and twenty studies were reviewed on misconceptions in science in India and Abroad. Out of hundred and twenty, hundred and eleven studies 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 minimise 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 but less studies have been conducted in India. It was also observed that most of the studies conducted on misconceptions were experimental studies and less survey has been done. Therefore, the researcher through present study wanted to know the status of misconceptions in science among Indian students. Moreover, the researcher has not come across any study on misconceptions in science in India except five in the past decade so the urge for the present study is felt.

This chapter described in detail with regard to research trends in India and abroad related to Misconceptions in Science. The research studies presented in this chapter also gives the knowledge of methodology adopted by various researchers and their findings. Based on that, implications were derived for the present study. Next chapter deals with the methodology adopted for the present study.