Chapter II

REVIEW OF RELATED LITERATURE

- CONCEPTS, MISCONCEPTS AND THEIR DEVELOPMENT
  - TYPES OF CONCEPTS
  - MISCONCEPTIONS
- CONCEPTUAL CHANGE
- STUDIES ON MISCONCEPTS IN PHYSICS
- EFFECTIVENESS OF CONCEPTUAL CHANGE STRATEGIES
- CONCLUSION
The way students make sense of the world and their knowledge is an important issue for improving science education. Consequently, research involving students understanding of scientific concepts has been more prevalent within educational communities. Students non-scientific performance in specific subject matter domains has been described by many terms, including misconceptions (Eaton & Smith 1983), preconceptions (Clement, 1982), Alternative Conceptions (Gilbert & Swift, 1985) and alternative frameworks (Driver and Easley, 1978).

While student misunderstandings across the curriculum is a very popular topic in the staff rooms as well as in more academic settings, science teachers especially have many unanswered questions about misconceptions. What is a misconception? Is it merely a misunderstanding? Is a misconception different from a preconception? How does a student develop misconceptions and how can teachers help students overcome their misconceptions? Are there teacher needs to know all these answers to be an effective teacher. This literature survey will answer many of the questions listed above with examples from student misconceptions literature.

**Concepts, Misconcepts and their Development**

**Nature of Concepts**

A concept is the basic unit of all types of learning. Human beings from the infancy to old age, learn new concepts and age-old concepts in new situation of their daily life (Lawson & Renner, 1975). Concept is assumed to be as set of specific objects, symbols or events which share common characteristics (critical attributes) and can be defined by a particular name or symbol. Concept learning thus is regarded as the identification of the concept attributes, which can be generalized to newly encountered examples and to discriminate examples from
non example. Concepts can be thought as information about objects, events and process that allow us to-

1. Differentiate various things or classes.
2. To know relationship between objects.
3. Generalize about events, things and processes.

Which are common to a large number of objects and associate these with a symbol, thereafter may be applied to other similar objects.

The word concept is used to designate both mental constructs of individual as well as identifiable public entities that comprise part of the substance of the various disciplines.

**Definition of Concepts**

In simple term, we may define that concept is an idea or understanding of what a thing is. Logically, a concept refers to phenomenon in a given field that is grouped together because of their common characteristics. There are various definitions for concepts some of them are given below according to their relevance in this context.

Flavell (1970) has indicated that a formal definition of concept in terms of its defining attributes is useful in specifying what concepts are and not, and in understanding the great variability among concepts of a variety of objects.

Kagan (1966) emphasizing the importance of concepts in life says, “Concepts are fundamental agents to intellectual work.” The theoretical significance of cognitive concepts in psychological theory parallels the seminal role of valence in chemistry, gene in biology or energy in physics.

According to Pella (1966), a concept may be viewed as 'a summary of essential characteristics of a group of ideas and/or facts that epitomize important common features or factors from a large number of ideas'. This definition
includes the concepts which have entities as well as those learned as principles. (Examples of physics concepts are mass, weight, force, velocity, acceleration, addition of vectors, subtraction of vectors).

**Development of the Concept**

Concept formation is the process of classifying information into meaningful categories. At its most basic, concept formation is based on experience with positive and negative instances (examples that belong, or do not belong to the concept class).

Bruner makes a difference between concept formation and concept attainment. The process of primitive categorization of objects is called concept formation, in the concept attainment the number of dimensions or specific attribute value are known to the subject before hand and hence he is properly set to find out the definite attributes of a concept.

According to Piaget’s theory, scientific knowledge, concepts and conceptual systems are generated through the use of various reasoning strategies which develop continuously through a process of assimilation and accommodation (Inhelder & Piagets, 1958). Much of the conceptual change literature is built up on the Piagetian concepts of assimilation, accommodation, and a lesser degree cognitive disequilibrium. Assimilation is commonly used as the process where by the learner is able to gain new knowledge by fitting new information into existing knowledge structure schema (Tao & Gunstone, 1999). Accommodation however requires changes in structure before the new information can become part of the learner’s knowledge or in other words a change in conception (Dykstra, Boyle & Monarch, 1992; Posner, Strike, Hewson & Gertog, 1982). For accommodation to occur usually the learner enters a state of cognitive dis-equilibrium where the learner encounters information or an event that does not fit with existing beliefs (Dykstra, Boyle & Monarch,1992; Posner, Strike, Hewson & Gertog,1982).
The necessary conditions for conceptual change are disequilibrium, assimilation and accommodation, terms introduced by Piaget (1950). Assimilation refers to the recognition of a physical or mental event that fits an existing conception. When an event could not be assimilated under already held conceptions, then accommodation occurs. It is a change in a conception. For accommodation to occur, a student must enter a state of cognitive disequilibrium. If the result of an event does not fit the student’s existing conceptions, this situation disequilibrates the student with respect to his current concept. If students can assimilate the concepts presented, then there is no disequilibrium and no conceptual change. Conceptual change can be achieved by disequilibrium, which is the result of an unexpected event. Therefore, instruction should aim to disequilibrates students for conceptual change (Dykstra, 1992).

It has been shown that the concepts involving second degree relationships require formal reasoning strategies. Concrete thinkers can have an intuitive understanding of such concepts, but do not (yet) have the intellectual skills needed to grasp their formal nature. It has also been found that a student can use his formal operational abilities to solve one problem, but cannot solve a different one. The format of the problem and the student's familiarity with the content must also be taken into account (Lovell 1978, Linn and Levine 1978). This familiarity aspect can indeed play an important role in the unfolding of the strategies of formal operation thought, but it can also have a negative effect if preconceptions or misconceptions are present. It must also be recognized that concepts learning can happen at different depths. A student can show abilities which require only his understanding (comprehension) of a concept or he can become also successful in transferring (applying) his knowledge to different contexts (Bloom 1956).

Science teaching should have a conceptual framework which promotes conceptual change. Different researchers used different terms for conceptual change such as weak and strong restructuring (Carey, 1985), branch jumping and
tree switching (Thagard, 1991), conceptual capture and conceptual exchange (Hewson & Hewson, 1992), differentiation and reconceptualization (Dykstra, 1992) and enrichment and revision (Vosniadou, 1994). Each of the theoreticians has developed their own terminology, but there is common ground between the various perspectives of conceptual change. Conceptual change involves changes in students’ assumptions about the world and knowing.

One of the most accepted conceptual change theory is posed by Posner et. al. (1982). In order for conceptual change to take place, Posner et. al. (1982) suggested four conditions: (1) students must become dissatisfied with their existing conceptions (dissatisfaction); (2) the new concept must be clear and understandable for students (intelligibility); (3) the current problem should be solved by using the new concept (plausibility); (4) similar future problems can be solved by using the new concept (fruitfulness). Therefore, teachers should develop strategies to create cognitive conflict in students, organize instruction to diagnose errors in students’ thinking, and help students translate from one mode of representation to another. Conceptual change is not static but is a dynamic process that occurs over a period of time (Chi, 1992). These conditions can be referred to as conceptual change conditions.

Types of Concepts

According to Posner et. al., 1982 there are mainly three types of concepts which are described as follows:

**Conjunctive concepts.**

Conjunctive concepts are defined by the presence of two or more features. In other words, an item must have “this features and this feature and this feature” for example, a motorcycle must have two wheels and an engine and handle bar.

**Disjunctive concepts.**

Disjunctive concepts must have at least one of several possible features. These are either for “concept “.to belongs to the category, an item must have
“this features or that feature or another feature”. For example In base ball, a strike is either a swing and a miss or a pitch over the plate or a foul ball. The either/or equality of disjunctive concepts makes them hard to learn.

Relational concepts.

Relational concepts are based on how an object relates to something else or how its features relate to another. All of the following are relational concepts: Larger, above, north, and upside down.

Nature of Concept in Science

Several authors (Lawson and Renner 1975; Lawson and Nordland 1977; Karplus 1977; Lovell 1978) have already pointed out the strong correlation between students' formal reasoning abilities and their understanding of concepts at different levels of abstraction. The distinction used by Lovell is between physics concepts which relate to concrete references of 'first hand' reality, and those which involve functional relationships, relations between relations and reference models. The former depend on 'first degree relationships', whilst the latter depend on 'second degree relationships' (at the second or third level of abstraction). Likewise, Karplus distinguishes between concrete and formal concepts.

In science context there are mainly two types of concepts Herron (1977) and they are listed below.

Concrete concepts.

According to Herron et. al. (1977), concrete concepts’ are those concepts which name classes of entities for which there are numerous perceptible instances defining attributes which are easily perceived'. Examples of concrete concepts are: table, chair, thermal degree on the thermometer, force when perceived as a pull by a string.
Formal concepts.

According to Herron, Cantu, Ward and Srinvisan (1977), formal concepts 'are those concepts that do not have perceptible instances, or have defining attributes which are not perceptible', formal concepts are: acceleration, element, density, temperature when defined as the mean kinetic energy of the molecules.

The results of this review show that the comprehension of concrete concepts is significantly dependant on students' cognitive level. Regardless of sex, the higher the cognitive level the better the comprehension of concrete concepts. This finding, although it supports the results of Cantu and Herron (1977), is interesting in that it might have been assumed that once a person had reached the highest level in concrete thought, the acquisition of skills at a higher cognitive level would not make any contribution to the understanding of concrete concepts. This is evidently not a justified assumption. Two explanations may be offered for this:

(1) Formal operations may help in the understanding of concrete concepts by enabling the student to use an expanded frame of reference that helps in accounting for both concrete and formal concepts. This expanded frame of reference may allow the learner to see relationships involving concrete objects, situations, or events previously unrecognized, and consequently, it may bring deeper meaning to concrete as well as formal concepts.

(2) The teaching procedures used in the classrooms are largely expository; consequently, students seldom are confronted with first-hand concrete experiences with any aspect of the discipline. This procedure hinders the student from comprehending concrete concepts until he enters the formal stage.

Misconceptions

Student’s non scientific knowledge about subject areas in physics such as false concept about scientific terms, definitions, and phenomena’s have been described by many terms including misconceptions (Eatan & Smith; 1983),
Preconception (Clement, 1982), Alternative conceptions (Gilbert & Smith, 1985) and Alternative frameworks (Driver & Easly, 1978).

There are several definitions given by many researchers. Some of the valid definitions in this context are given below.

Fisher (1983) defined misconceptions in science as ideas that are at a variance with accepted views.

Odom & Barrow (1995) use the term misconception to refer to students’ ideas that are different from the ones generally accepted by scientists.

According to Black & Lucas (1993) people develop ideas about a variety of science topics before they confront the exact theories and concepts about those topics. These ideas tend to remain persistent despite efforts to teach scientifically accepted theories and concepts.

The topic misconceptions are at the heart of the learning and learning process, students need to understand the science content as best, they can in order to make sense of their natural world. Helping students overcome any misconceptions they may be able to only expedite this process.

Students can have misconceptions about scientific facts and Theories (Brows and Clement, 1987). Such misconceptions are an important part of children’s culture and significant component of children’s science (Renner & Mark 1990). Terry Jones and Herford (1985) found that misconceptions could occur in a students understanding of the scientific method or in the manner in which scientific knowledge is organized (Committee on undergraduate Education 1996, Hammer 1989). Considering the following; if a students learning of a particular concept is dependent upon a lab exercise based on expertise prior to that students mastery of the scientific process or method Their obviously the learning process can be seriously hindered Linder (1993). Gordon (1996) reminds us that if the structure of the knowledge to be learned cannot be aligned to the existing structures within the learner’s knowledge there cannot assimilate the new knowledge.
Common types of misconceptions.

There are several types of misconceptions in the learning of science (Tobias, 1987). Distinguishing between types of misconceptions will help the science teacher in identifying their students’ difficulties (Eclestein & Shemesh, 1993).

Preconceived notions or preconceptions of the natural world are popular conceptions rooted in everyday experience. For example, people observing moving objects slowing (decelerating) mistakenly believe that the force responsible for the motion is getting “used up” (Marioni, 1989). Such misconceptions are very common because they are rooted in the most common activity of young children’s, unstructured play. When children are exploring their surroundings, they will naturally attempt to explain some of the phenomena they encounter in their own terms and share their explanations (Terry & Hurford, 1985; Kyle & Shymansky, 1989). When children have an incorrect assumption these preconceptions are also misconceptions.

Factual misconceptions are falsities often learned at an early age and retained unchallenged into adulthood. For example, the idea that “lightning never strikes twice in the same place” is clearly false, but that notion is commonly buried within the teachers and students belief systems (Committee on undergraduate Science Education, 1996, Dysktra & Monarch, 1992).

Vernacular misconceptions arrive from the use of words that mean one thing in everyday life and another in a scientific context. For example, the term “work” in the physics classroom refers to the result of multiplying a force measured in Newton’s by the straight line distance moved in meters. The introduction of the definition of work in a physics class can present many challenges to the teacher (Clement 1989). The power (change in energy per unit time) concept is a similar example (committee on undergraduate Education, 1996).
Conceptual misunderstandings are when students are taught scientific information in a manner that does not encourage them to settle any cognitive disequilibrium (Dykstra & Monarch, 1992). In order to deal with their confusion, students construct weak understandings and consequently are very insecure about these constructed concepts. An example of this is very common “force as a property of an object misconception (Brown, 1989). Forces are dependent upon and related to objects but are not properties of them, yet students continually perceive forces are intrinsic to the object (Maloney, 1990; Marioni, 1989).

**Some sources of misconceptions.**

There are numerous ways that misconceptions can occur. Scientific data are constantly changing. No one person can stay current on all of the new research findings. As a teacher, we are supposed to be teaching the newest and best of scientific information, but by time text books are written and published, much of the information is old. This inability to stay on top of constant change causes misinformation. We also deal with conflicting information into a completely new concept. Parents and teachers relay their misconceptions to the children they teach with little challenge of ideas. Often adults have no idea that they “know” is actually a misconception.

Another way of misconception occurs is by over-simplification of scientific information, either by the media or parents. Trained in science or by teachers and parents in trying to make scientific material understandable, many times the information’s are overly simplified, causing an inaccurate view. The media also tend to have an agenda that slants scientific information to their point of view. One of the worst causes of misconception is cognitive overload. This occur when too much information is presented at one time causing people to shut down all processing because they are over-whelmed with information (University of Massachusetts, 2000). This is detrimental because it can cause children to lose interest in science as a result of the “fear of failure “or “fear of peer group ridicule”. The loss of interest in science during school years can also
eliminate the possibility of pursuing a science related career because of the way it is taught (Mcclomas, 1996).

Misconceptions can result from deficiencies of curricula and methodologies that do not provide the students with suitable experiences to assimilate the new concept (Ivowi & Oludotun, 1987). It is rarely that misconceptions result from the lack of reasoning abilities that are necessary to assimilate the new concept (Renner & Marek, 1990). Although vernacular and factual misconceptions can often be easily corrected, even by the students themselves, it is not effective for a teacher simply to insist that the learner dismiss preconceived notions and ingrained nonscientific believes (Hammer, 1989). Recent research on student’s conceptual misunderstandings of natural phenomena indicates that new concepts cannot be learned if alternative models that explain a phenomenon already exist in the learners mind (Tao & Gunstone, 1999).

Early misconceptions can stunt a student’s science learning until the misconceptions is confronted and overcome (Brown & Clement 1987; Hewson & Hewson, 1983). Students can become confused in physics and mislearn because of many number of factors, Language usage, everyday experience, analogies, metaphors, examination papers and textbooks (Ivow & Oludotun, 1987) can cause students difficulty in forming acceptable understanding of physics concepts, Theories and laws (Brown and Clement1987) Somewhat surprisingly textbooks have been found to be the most significant source of misconceptions in physics classroom. This is unfortunate as an American study shows a huge dependence on the textbook by high school science teachers (Renner & Marek, 1990). Textbook can mislead students because of poor writing and/ or poor editing.

Often misconceptions are incredibly durable. Many studies have shown students to hold believes in contradiction of those used to correctly solve problems (Hammer 1989; Clement and Brown 1987). The tenaciousness of such
misconceptions is not due to the difficulty in acquiring a new concept, but rather the learner’s reluctance to relinquish the old familiar misconceptions (Terry & Hurford, 1985). These old concepts are so near and dear to the learner as they developed over time through personal observations of the learner’s environment and have grown from firm intuitive beliefs (Kyle & Shymaysky, 1989). These intuitions may be not even be consciously held but still exert a great influence on the learner (Shultz & Murrey, 1987). Confidence in the misconceptions increases over time and becomes more entrenched despite instruction to the contrary. Unfortunately traditional instruction has little impact on removing deeply rooted misconceptions (Brown & Clement, 1987).

Misconceptions often reflect a basic lack of understanding. Hidden beneath the ability to use equations to solve problems (Sandanand & Kess, 1990) many students get through traditional assessments of scientific understandings by merely correctly identifying the known and unknown variables from the problem and then plugging them into the correct formula, which generated the correct answer.

Newtons third law is often misconceived by students in high school and beyond (Brown 1989). This is partially due to the textbook design, as opposed to misconceptions being included in the text or images of the books (Maloney, 1990; Roach, 1992). Traditionally textbooks skim over the third law in terms of examples and resources when compared to the pages allotted to the first two laws. Some texts even confuse the third law with momentum (Roach, 1992). The third law needs to be treated in greater detail as it is key to understanding the qualitative aspects of force with Newtonian mechanics.

The persistence of misconception gives us clues to counter them. Teachers and parents often are not aware of children’s incorrect scientific ideas. As a result, adults are unable to challenge students thinking. Misconceptions also persist in children because they are not taught critical thinking skills in school.
Instead, children are taught to memorize facts and to take multiple-choice tests. As a result, when presented with incomplete information, many students do not ask questions otherwise challenge the new information, causing misconceptions to take root and flourish (Podoner, 2000).

Once we know where the students stand, student thinking can be challenged by structuring experience and the learning environment so that there are opportunities for students to “test out” their ideas and prove the correct concepts to themselves (Simanek) while students are testing their ideas, they also need to resolve any conflicts between them during the testing (Podolner, 2000). When finished with activity the teacher must debrief the class, checking for student questions and understanding of the new concepts learned (Podolner, 2000).

**Children’s Science**

Research studies have shown that children have beliefs about how things happen and expectations that enable them to predict future events (Clement 1977; Nussbaum & Novak 2006; Driver & Easley, 1978). Based on their everyday experiences of the world, they hold these beliefs and expectations very strongly. Moreover, children have clear meanings for words that are used both in everyday language and in formal science (Gilbert, Watts & Osborne, 1980). Such views of the word and meanings for words, held by children are not simply isolated ideas (Champagne, Klopfer & Anderson, 1979) but rather they are part of conceptual structures that provide sensible and coherent understanding of the world from the child’s point of view. These structures may be termed children’s science. Ideas of children’s science may become stepping-stones as well as barriers in the physics learning process. So children’s science concepts must be addressed with due consideration while planning teaching strategies for physics classroom learning.
Role of Pre-conceptions and Misconceptions in learning process.

Even young students have well developed ideas of how the world works. These pre-conceptions can hinder their learning in science. Five decades ago, Ausubel (1968) pointed out that these preconceptions are amazingly tenacious and resilient to extinction. Later on, it was found that student preconceptions are so strong that, in some cases they are preserved in the face of obvious and contradictory evidence (Osborne & Freyberg, 1985). Some students accept the teachers’ science for the duration of the topic being studied and revert to their intuitive ideas following instruction. In other instances students construct separate schema to accommodate the lesson content without altering their preconceived views. Both preconceptions and learned misconceptions resist conceptual change (Nussbaum & Novick, 1982). Some teachers find this as worrying. However, the strength of student conceptions means that acceptable conceptions, once learned, are robust and lasting. As learned misconceptions and preconceptions may arise as barriers in learning, replacing them with scientific ones is possible only through conceptual change. Franco et. al (2011) investigated the role of epistemic beliefs and knowledge representations in cognitive and metacognitive processing when learning about physics concepts through text, they manipulated the representation of physics concepts in texts about Newtonian mechanics and explored how these texts interacted with individuals’ epistemic beliefs to facilitate or constrain learning. Results revealed that when individuals’ epistemic beliefs were consistent with the knowledge representations in their assigned texts, they performed better on various measures of learning (use of processing strategies, text recall, and changes in misconceptions) than when their epistemic beliefs were inconsistent with the knowledge representations.

Martin-blas (2010) studied to detect systematic errors about the concept of force among freshmen students. The researchers analysed the results of the
Force Concept Inventory test, which was administered to two different groups of students. The results show that, although there were significant performance variations between the two groups, they, nonetheless, shared common incorrect answers that were consistently triggered by the same misconceptions.

**Conceptual Change**

The root of conceptual change approach to learning can be found in Thomas Kuhn’s works on ‘Theory change in the philosophy and history of science’ (1962). Kuhn proposed that normal science operates within set of shared beliefs, assumptions, commitments and practices that constitute paradigms. Over time, discoveries emerge that cannot be accommodated within the existing paradigms. When those anomalies accumulate, science enters a period of crisis that is eventually resolved by revolutionary change in paradigms, a paradigm shift happens. According to Kuhn, different paradigms are incommensurable; scientific knowledge grows as we move from one to another paradigm, but it is no longer possible to imagine the results of scientific revolutions as a cumulative linear progression. Kuhn claimed that concepts are embedded in theoretical frameworks i.e., paradigms- from which they obtain their meaning. When there is a paradigm shift, there is conceptual change. That is, the meanings of concepts in the new paradigm, even when they keep the name they had in the old paradigm are markedly different from the old ones. Such conceptual changes are part of evolution and development of science as a whole. Adopting an evolutionary and genetic epistemological stance, such paradigmatic shifts are part of development of concepts in individual learners as well.

**Conceptual Change in the Science Classrooms**

Learning in science classrooms can occur under at least three different conditions of prior knowledge. In first condition, a student may have no prior knowledge or information about the ‘to be learned concepts’, although they may have some related knowledge. In this case, prior knowledge is missing, and learning consists of adding new knowledge. In second condition, a student may
have some correct prior knowledge about to be learned concepts, but that knowledge is incomplete. In this case, learning can be conceived of as gap filling. In both missing and incomplete knowledge conditions, knowledge acquisition is of the enriching kind (Carey, 1991). In a third condition, a student may have acquired ideas, either in school or from everyday experience that are in conflict with to be learned concepts (Vosniadou, 2004). Knowledge acquisition in this third case is of conceptual change kind. It is assumed that the prior knowledge is incorrect or misconceived and to be learned information is correct. Thus, learning in this third condition is not adding new knowledge or gap filling incomplete knowledge. Rather, learning is changing prior misconceived knowledge to correct knowledge. This is termed as conceptual change or process of conceptual change.

**Classical Approach of Conceptual Change.**

According to White and Gunstone in the 1970’s researchers started paying greater attention to student’s ideas and explanation of physical phenomena. They started to realize that students held various preconceptions, misconceptions or alternative beliefs, some of which proved to be very persistent and robust (Viennot, 1979; Driver & Easley, 1978; McCloskey, 1983). In some cases, these misconceptions appeared be very similar to earlier theories in the history of science.

Based on the above, Posner et.al (1982) formed an analogy between the kinds of changes needed to be made by students learning in science and Kuhn’s explanations of theory change in science. They claimed that students need to undergo radical conceptual change when it comes to understanding scientific concepts like force or heat energy. They need to replace their preconceptions or misconceptions with the new scientific concepts through instruction. Combining Kuhn’s ideas with Piaget’s, Posner et.al (1982) derived an instructional theory according to which there are four fundamental conditions that need to be fulfilled before conceptual change happen in science,
There must be dissatisfaction with existing conceptions.
There must be a new conception that is intelligible.
The new conception must appear to be plausible.
The new concept should suggest the possibility of a fruitful program.

This theoretical structure known as the classical approach to conceptual change became the leading paradigm that guides research and instructional practice in science education for many years. According to the classical conceptual change approach, the student is like a scientist, the process of (science) learning is a rational process of theory of replacement. Conceptual change is like a gestalt shift that happens over a short period. Accordingly, cognitive conflict is the major instructional strategy for promoting conceptual change.

One of the most controversial claims in Kuhn’s (1962) original explanation of theory change in science, which was adopted by the classical approach, is that the change from one theoretical framework to the other is an abrupt and sudden change that takes place in a short period. It appears that Gestalt psychology influenced Kuhn and this shift in terms of the gestalt ideas of re-structuring is produced by insight. Although it is possible that such abrupt re-structuring may happen in individual cases during the learning process, this does not appear to be the usual road to conceptual change.

The empirical evidence so far has shown that the course of conceptual change is conservative and slow process. Even when researchers claim that radical conceptual changes are happening in the long run; these are usually the end-state of a slow and gradual process and not of a sudden and radical gestalt type of shift (Caravita & Hullden, 1994). Hence, teaching-learning processes have to be devised to facilitate conceptual changes in science.
Important Teaching Strategies Based on Conceptual Change Process

Research findings in conceptual change have started to use in instructional practice but there is a vast gap between our theoretical and empirical knowledge and classroom practices. Teachers are not well informed about conceptual issues and do not use the recommended instructional strategies for promoting conceptual change in the classroom (Duit, et.al, 2008). Hewson and Hewson (1982) commented on traditional instruction as simply introducing new information without paying attention to students existing ways of making sense of ideas related to the concepts.

According to Scott et.al (1992), pedagogical decisions should be made at three levels while planning for conceptual change teaching. Firstly, teacher needs to foster a learning environment that will support conceptual change learning. This can be via providing opportunities for discussion and consideration of alternative viewpoints and arguments. A second level of decision-making involves the selection of teaching strategies. Lastly, consideration must be given to the choice of specific learning tasks. The learning task must address the demand of the particular science domain under consideration.

While selecting specific teaching strategies, four factors may need to be taken into consideration:

1. Students’ prior conceptions and attitudes
2. The nature of intended learning outcomes
3. Cognitive level or intellectual demand of the learner
4. Possible teaching strategies

Two distinct groups of strategies promote conceptual change. The first group is based on cognitive conflict and resolution of conflicting perspectives. The second set of strategies bases on learners existing ideas.
Strategies Based on Cognitive Conflict

Cognitive conflict has been used as the base of developing a number of teaching strategies. Such strategies involve promoting situations where the students’ existing ideas about some phenomenon are made explicit and are then challenged to create cognitive conflict.

**Strategy based on Piaget’s theory of concept learning.**

Nussbaum and Novick (1982) suggest a teaching sequence that draws upon the Piagetian notion of accommodation. It includes four main elements.

a. *Initial exposure of student preconceptions* through their responses to an exposing event

b. *Sharpening student awareness* of own and other students’ frameworks

c. *Creating conceptual conflict* by attempting to explain a discrepant event

d. *Encouraging and guiding* accommodation and invention of a new conceptual model consistent with the accepted science view

**Conflict between ideas.**

Sahin, (2010) studied the impact of problem-based learning on freshmen engineering students’ beliefs about physics and physics learning (referred to as epistemological beliefs) and conceptual understanding of physics. The multiple-choice test of energy and momentum concepts and The analyses showed that the PBL group obtained significantly higher conceptual learning gains than the traditional group and the change (improvement) in the PBL group students’ beliefs from the pre- to post test were significantly larger than that of the traditional group. The results revealed that beliefs were correlated with conceptual understanding. Suggestions are presented regarding the implementation of the approach.

Stavy (1991) draw attention to two types of framing of conflict between ideas. They are,
a. A conflict between a child’s cognitive structures related to a certain physical reality and the actual physical reality.

b. A conflict between two different cognitive structures related to the same reality. They made use of second type of conflict in developing teaching strategy.

**Generative learning model.**

Generative learning model of teaching (Cosgrove and Osborne, 1985) has the following four steps.

a. *Preliminary phase:* teacher needs to understand the scientists view, the children’s view, his or her own view.

b. *Focus phase:* opportunity for pupils to explore the content of the concept, preferably within a real everyday situation such that learners to engage in clarification of own views

c. *Challenging phase:* learners debate the pros and cons of their current views with each other and the teacher introduces the science view

d. *Application phase:* opportunities for application of new ideas across a range of contexts

**Dialogue based strategy.**

Dialogue based strategy (Champagne, Gunstone & Klopfer, 1985) otherwise described as ideational confrontation is specifically designed to alter student’s declarative knowledge with in a particular domain. It involves following steps.

a. *Students make explicit the notions* they use to explain, or make predictions about a common physical situation.

b. Each *student develops an analysis* that supports his or her predictions and presents it to the class.
c. Students’ attempt to *convince each other of the validity* of their ideas, discussions and argument result in each student becoming explicitly aware of his or her ideas in that content.

d. The *instructor demonstrates* the physical situation and presents a theoretical explanation using science concepts.

e. Further discussions allow *students to compare their analyses with the scientific one*.

**Resolution between ideas.**

Rowell and Dawson (1985) proposed a strategy in which resolution between students’ prior ideas and new conceptions occurs after new conceptions have been introduced. The strategy that draws upon a perspective from the history and philosophy of science and equilibration theory (Piaget, 1977) is based upon the following two premises. 1) A theory is only replaced by a better theory and not discarded based on contradictory evidences, and 2) The construction of a better theory need not involve an immediate confrontation with the knowledge that an individual spontaneously considers relevant.

Although cognitive change involves both strategic and meta-strategic knowledge (Kuhn, 1963), they need not be constructed together. The teaching approach involves six steps.

a. *The ideas which student consider* relevant to the problem situation are established.

b. *Discussion and their ideas are retained in a ‘paper memory’* for subsequent consideration.

c. *Students are told that a theory is introduced* to them which may solve the problem and that their help will be required both in its construction and later in its evaluation against the alternatives they have proposed.

d. *The new theory is presented* by linking it to basic knowledge already available to the class.
e. *Students apply the new theory* to problem solution, in order to indicate its construction by individuals. Written work must a part of this procedure to provide a second paper memory for each student.

f. *Each student compares the memories from step 1 and step 5* and the quality of the ideas is examined.

### Teaching Strategies Build on Pupils Existing Ideas

**Analogy based teaching strategy.**

Analogical teaching strategy (Clement, Brown, & Zietsman, 1989) constitutes four steps.

a. The student’s *misconception* relating to the topic under consideration is made *explicit by using a target question*.

b. The instructor suggests a case which he or she views as analogous and which will appeal to the students intuitions. This case is termed as *anchoring example* or simply an anchor.

c. The instructor asks the student to make an *explicit comparison between the anchor and target cases* in an attempt to establish the analogy relation.

d. If the student does not accept the analogy, the instructor then attempts to find a *bridging analogy* or a series of bridging analogies.

**Method which scientists use.**

Niedderer (1987) put forwarded an approach based on the philosophy of science outlined by Brown (1977). It aims not to replace students’ theories by scientific theory but allow them to arrive at a conscious knowledge of both. Solomon (1983) also has suggested learning scientific concepts by difference.

The strategy consists of six steps:

a. *Preparation:* The teaching process that precedes the intervention, and may contain tools and concepts that may be drawn on.
b. **Initiation**: an open-ended problem is posed

c. **Performance** in following sequence. formulating questions or hypothesis, planning and performing experiments, making observations, theoretical discussions, and formulation of findings

d. **Discussion of findings**: in a class forum

e. **Comparison with science**: class findings are compared with similar historical theories or modern ideas. Differences are stated and possible reasons for those differences are discussed

f. **Reflection**: students are encouraged to look back on the process of performance and to consider particular questions or difficulties which have arisen.

Keeping pupils alternative frame works in mind Driver (1978) suggested three points to be considered while planning classroom practice. 1) Curriculum development in physics needs to pay as much attention to the structure of thought of the child as it has recently paid to the structure of the discipline in organizing learning experiments. Currently scientist’s concerns for the structure of thought of the child have been focused on Piagetian operations. It is argued that the content as much as the process of thought requires our attention. 2) Teaching programs need to be structured in keeping with the developmental path in understanding important scientific ideas. The logical order of teaching a topic may not correspond with the psychological order in learning. This is a word of caution for those who are enthusiastic about structured learning programmes that involve such hierarchies. 3) Activities in physics may need to include those that enable pupils to disprove alternative interpretations as well as affirm accepted ones.

**Common Conceptual Change Strategies**

Since the mid - 1980’s a number of researchers have focused on determining methods for changing students alternative conceptions in science. Some of these reviewed a number of studies in the field (Guzetti, Synder, Glass
& Gamar 1993; Wandersee, Mntzel & Worak, 1994; Duit & Treagust 2003) and published a meta-analysis (Guzzetti et. al., 1993) that has documented effectiveness of various conceptual change strategies at all grade levels. The strategies mentioned in this metal-analysis are: conceptual change text, refutation texts, concept maps, bridging analysis, computer simulation, demonstration, and computer aided instruction, and field trips.

**Conceptual change texts.**

One of the common conceptual change strategies in this field is the use of conceptual change texts. (Wang & Andre 1991; Chambers & Andre, 1997; Tekkaya & Geban, 2001; Cakir, Uzuntryaki & Geban, 2002; and Tekkaya 2003).

Conceptual change texts are one of the strategies used to remove misconceptions. The conceptual change text strategy is designed in accord with a model of conceptual change to remediate misconceptions they are designed to make readers aware of the inadequacy of their intuitive ideas and create conceptual conflict described as a necessary requisite for conceptual change. They also help students understand and apply the target scientific concepts through the use of explanations and examples. The meaning of conceptual change oriented textual information is not derived wholly from the reading of the text but from the interaction of the reader with the textual information. The construction of meaning occurs when the textual information is concerned with and modifies the students existing knowledge. The modified prior knowledge is then used to direct subsequent learning. The textual information for causing better acquisition of scientific conceptions should enable students to progress at their own pace and force them to use their thinking ability.

Conceptual text was first proposed by Roth (1985). In Roth’s model, the first step is to identify common misconceptions. Next a situation is presented to students to activate misconceptions. Then student’s misconceptions are challenged by introducing common misconceptions followed by evidence that they are wrong. Finally, the correct scientific explanation is presented. Roth
(1985) reported that students using conceptual change texts performed better than those who receive traditional teaching approach.

Chambers and Andre (1997) listed steps for application of conceptual change texts in classrooms. They are

(a) The instructional designer or teacher first identifies common alternative conceptions.
(b) Students are asked to predict what would happen in a situation before they present the inconsistency between common non-scientific and scientific conceptions.
(c) Common alternative conceptions are introduced with evidence that they are wrong and
(d) Instruction presents the correct scientific explanation.

Bigozzi, (2014) studied a progressive-learning approach to physics, based on knowledge-building pedagogy, was compared to a content-centered approach in which explanations, experiments, and discussions are centered on the transmission of knowledge. The main conclusion achieved by this study is that the teaching of physics should be slow, cyclic, and developmentally appropriate for the context.

Armagan et. al (2010) conducted a study to determine the overall effectiveness of conceptual change texts on academic achievement and to find out if effectiveness was related to some characteristics of the study. It was found that conceptual change texts have been quite successful in promoting the students’ academic success.

Sackes (2012) develop an instrument to assess college students’ efficacy beliefs for conceptual change and to examine the psychometric properties of the instrument. The study reveals that the questionnaire appears to produce valid and reliable scores for college students. With the use of the questionnaire, conceptual
change researchers might be able to better assess the relationship between students’ efficacy beliefs and the change in their conceptual understandings of various science concepts.

**Refutational text.**

The refutational text approach has developed by Hynd and Alverman (1986) based on the conceptual change model for Posner *et. al* (1982). According to the researchers refutational texts are materials written to challenge and change students common non-scientific conceptions.

In this design common alternative conceptions are contrasted with scientific conceptions. However students are not asked to predict a common situation before refutation, in other words, the major difference between refutational text and conceptual change text is whether students are asked to predict a situation (Hynd, 2001).

Refutations involve analyzing statements about scientific ideas, process, or procedures that contain both accurate and incorrect information. Students make corrections to the statements so they are scientifically accurate and justify why they mad the changes.

Refutation can be used prior to instruction to grab the learners attention and identify where students have strong or weak factual and conceptual knowledge related to a topic. This strategy can also be used to monitor student learning through instruction.

Commonly held ideas, including specific misconceptions, can be included in a refutation to help teachers identify students who may have similar ideas. If the teacher sees that these ideas go unnoticed in the refutation, this information can be used to design learning experiences that will confront students with their ideas and move them toward the scientifically accepted view. Justifications and corrections students make to the incorrect statement provide information to the
teacher on how students think about the content or procedures. Teachers may
determine the need to revisit basic ideas and build upon them so that students
develop understandings at a level of sophistication appropriate for their grade or
developmental level.

Refutations are designed to address science content knowledge or
procedures and results from a classroom inquiry – based investigations. They can
be written as a story, article, or textbook-like passage. Refutations should be a
reasonable length for both the content and the grade level of the students.
Students can underline or highlight the areas of text they think need correcting,
revise as necessary (individually or in groups), and justify their revisions. Engage
the class in a whole-group discussion in which they justify why they think a
statement is incorrect and what they would do to correct it.

**Scientists ideas comparison.**

With scientists ideas comparison students are given a summary sheet of
scientists’ ideas, including appropriate terminology, related to a topic they have
been studying. Students compare their existing ideas to the scientists, looking for
differences and similarities.

Scientist’s ideas comparison is used to help students make connections
between the ideas they developed through a sequence of instruction and the
formal, accepted scientific ideas. It provides a meta-cognitive opportunity for
students to examine their thinking to see how close their ideas match the
scientific ideas.

In this method prepare a summary list or paragraph of scientist’s ideas.
The scientists ideas are formal, scientific explanation of the concept or
phenomenon written at a level students can understand at their grade level. Ask
students to list their ideas about the concept or phenomena before giving them
the scientist’s ideas. Encourage students to list ideas that were developed during
their discussions or class activities, citing where their ideas came from, or discuss
their ideas in response to an assessment probe. Alternatively keep a record of the class ideas noted throughout the instructional sequence, including class discussions, and provide students with this list. Use a valid reference source, teacher background information from instructional materials and explanations from the teacher notes, or consult with a scientist or science – content specialists to develop the scientist’s ideas. Provide students with the scientist’s ideas. Have students discussed in pairs or small groups how close they think their own ideas are to the scientists ideas. Engage students in a discussion about what they think it would take to help them more toward the scientist’s ideas. Use the feedback to design targeted learning opportunities that will more students closer to the scientific view or would improve opportunities to learn the next time the same lessons are used.

Mantyla (2012) studied the way to use the cognitive-historical approach for didactical purposes is introduced. In this application, the cognitive processes in the history of physics are combined with current physics knowledge in order to create a cognitive-historical reconstruction of a certain quantity or law for the needs of physics teacher education. The initial and final reports of twenty-four students were analyzed through a qualitative categorization of students’ justifications of knowledge. The results show a conceptual development in the students’ explanations and justifications of how the electromagnetic induction law can be formed.

Eshach (2010) the conceptual flow processes occurring in whole-class dialogic discussions with a high level of interanimation; in a high school class learning about image creation on plane mirrors. This model might help teachers to prepare and conduct efficient whole-class discussions which accord with the social constructivist perspective of learning.

**Analogies**

The importance of analogies in science, mathematics, social studies, technology and literature lies in the ability to explain abstract ideas in familiar
terms. Teachers often say that an artery or vein is like a hose or tube; the earth is round like a ball; the eye works like a camera; and plants, animals and microorganisms are classified into functional groups, like the separate sections of fresh foods, canned foods, stationary and cleaning supplies in a sugar market. It is easy to see why analogies and models are important ways to describe and explain objects and processes, especially those that cannot be seen, like atoms and molecules.

In an analogy the everyday object, event or story that is well understood is called the analog, and the science concept to which it is compared is called the target. This terminology is itself a metaphor, like an analogy, because we all aim to reach targets; if we hit the target, we have succeeded. Explanations have aims so that when we understand the target it means you have achieved our aim.

The structural or functional links that can be made between the analog and the target are called ‘mappings’. Mapping can be

Positive: Having shared attributes – ways in which the target is like the analog.

Negative: having unshared attributes – ways in which the target is not like the analog.

Neutral: When it is not clear whether the target is or is not like the analog.

Teachers should always be sure of all the shared and unshared attributes for the analogies they plan to use with their students. Of course students can suggest their own analogies, and when this happens, some of the mappings are neutral and the challenge is to work out whether they are shared, unshared, or irrelevant. Many teachers skip this step saying that they short of time, but it’s important to help students make sense of their original ideas. These are the moments when students think creatively and such moments can be high points in their learning.
Most analogy researchers agree that analogies promote learning through a constructivist pathway (Duit, 1991). Constructivism claims that people have rich mental environments that are made up of familiar experiences and knowledge; interests, events, and stories; and their own ideas of what counts as evidence and knowledge. The degree to which a new concept fits this mental environment determines its fit. Whether it is accepted, modified, or rejected. Even young students have well developed ideas of how they think the world works, and childrens preconceptions can hinder learning in science. Ausubel (1968) pointed out that these preconceptions are amazingly tenacious and resilient to extinction. Research since that time has shown that student preconceptions are so strong that, in some cases, they are preserved in the face of obvious and contradictory evidence (Osborne & Freybay, 1985). Some students accept the teacher’s science for the duration of the topic being studied and revert to their intuitive views following instruction. In other instances, students contrast separate schema to accommodate the lesson content without altering their preconceived views.

Both preconceptions and learned misconceptions resist conceptual change (Nussbaum & Novicle, 1982). Some teachers find this worrying but the strength of all types of student conceptions means that acceptable conceptions, once learned, are robust and long lasting. Using analogies to learn science can be describe as conceptual growth (the expansion of acceptable student conceptions) or conceptual change (revision of existing unscientific conceptions) or both.

Most of the studies into conceptual change and learning with analogies were based, at least in part, on Piagetian theories. Since the 1980’s researchers have interpreted learning with analogies using Piaget’s equilibrium concepts, Vygotsky’s zone if proximal development, Ausubel’s meaningful learning and social constructivist viewpoints. While most studies of analogy claim to be constructivist few explicitly tie their theory and methods to theorists like Piaget and Vygotsky.
Piaget’s stage development ideas suggest that younger children will benefit most from concrete analogies, analogs they can see and feel. It is reasonable to expect that the abstract thinking that emerges in Grades 8-10 will enhance the effectiveness of verbal and abstract analogies with older students who have begun to master mental models. Teachers should be cautious when using abstract analogies, as even some older students may not possess the necessary visualization skills. This is why teachers must ensure that their students understand the everyday object or experience that is the basis for the analogy. Vygotsky theory recommends locating the analog in the students zone of proximal development. Knowledgeable peers (other students) and adults (teachers) provide the ‘need to know’ information that helps the student to correctly map the similarities and differences between the everyday analog experience and the target concept. Peers and teachers provide the knowledge that can be processed by the learner but is not yet known by the learner. As constructivists point out, it is the student who ultimately has to see and understand the shared analogue-target attributes that lead to conceptual growth. Learning is the personal construction of new knowledge or the restructuring of old knowledge. Analogies help students learn and remember scientific ideas. Analogies also are powerful inquiry tools because they suggest new questions, relationships and investigations.

Teachers who are aware of important and common alternative conceptions often resort to analogies because they realize that it is much easier for students to accept a scientific idea if it against with something they already understand and accept.

**The participative approach.**

Participative theories of learning (eg: Vygotsky, social constructivism) that view learning as a process that involves a community of learners in an ongoing discourse, seem to be more suitable for grasping “process”. The participatory approach focuses on the dialogical interaction between “the outer”
(the social context) and “the inner” (the individual learner) interacting to construct meaning (Marton & Booth, 1997). The established partnership among the members of the community is geared towards constructing common meaning. The situatedness in the social - cultural specific context is leading to the emergence of meaning-knowledge that is appropriate to “here and now”. The nature of the discourse that is the major tool in the process cannot be predetermined (Gedamar, 1990). Rather, it emerges in the process of conversing and unfolds the reciprocal interactions among the involved persons. The group members open themselves to other and at the same time open the possibility of affecting their understanding of the world. This idea of the group discourse leads to collective new understandings has been described as structural coupling or “co-emergence” Sumara (1997). Knowledge, within this approach is understood in terms of what emerges from the continuous discourse and reciprocally fuels that process of learning to go on.

**Anchoring conceptions.**

Student’s preconceptions often pose strong barriers to understanding physics. However, although many preconceptions are detrimental to learning, there may be other preconceptions that are largely in agreement with accepted physical theory. These concepts referred as anchoring conceptions or more briefly as anchors.

We assume that it is desirable to be able to ground new material in that portion of the student’s intuition that is in agreement with accepted theory. It should help students to understand and believe physical principles at a make sense level instead of only at a more formal level. For example, many students refuse to believe that static objects can exert force. They refuses to believe the physicist assertion that a table exerts an upward force on a coffee cup on the table. However almost all students believes that a spring will exert a constant force on ones hand as one holds it compressed. In teaching that inanimate objects can exert forces, this intuition about springs can be built on as anchor. By
working with students to help them see that even rigid objects are springy too some extent, one can anchor the idea of static force in the student’s intuitive conception of springiness.

In theoretical terms we define an anchoring conceptions an intuitive knowledge structure that is in rough agreement with accepted physical theory. By intuitive, it is mean that it is concrete rather than abstract, and in particular that is self evaluated; the strength of the belief is determined by the subjects themselves rather than by appeal to authority.

Individual anchors: a problem was considered to be an anchoring example for an individual student if he or she gave the correct answer and indicated a confidence interval greater than or equal to on the confidence scale. Perhaps such an example should actually be called a potential anchor, not all anchoring examples defined in this way can be used effectively in instruction via transfer. Thus in some context it may be useful to split the concept of anchoring example as follows: potential anchors are anchoring examples that can be extended in instruction so that a useful anchoring conception is transferred to other more difficult target situations.

Group anchors: a particular example is an anchoring example for a group as well as for a particular student.

This teaching strategy starts from student’s correct ideas. Many ideas in physics are counterintuitive therefore students don’t accept them easily. This strategy builds on students existing ideas by forming analogy relations between a misunderstood target case and an “anchoring example” which draws up on intuitive knowledge held by students (Clement, Brown& Zeitsman, 1989). Anchoring conceptions are student ideas that are roughly from physics point of view, and can serve as analogies with counterintuitive target conceptions. They represent a good unproblematic starting point for thinking about a certain phenomenon.
If the analogy between the anchoring conceptions and target conceptions does not work immediately, additional bridging analogies are introduced, that lead the student to target conception.

**Concept mapping.**

Concept mapping is a graphic technique for representing ideas, helping to think, solving a problem, planning a strategy or developing a process. Concept mapping means connecting different concept of the subject and constructing relations by compiling the map.

The concept mapping method is based on the theory of meaningful learning (Ausubel 1963) and on the assumption that knowledge saved in the human brain propositionally and the generated concept maps just represent this propositional knowledge saved in the brain Atkinson, shiffrin, Norman, Rumelhart (1978).

The method was introduced in didactics by the American scientist (Novak 1990). Later on analogous methods have been developed by several research groups. Much success has been achieved by the application of concept mapping in the technique process to integrate new concepts into the existing system of knowledge (Novak 1990).

Concept mapping is a process of meaning making it implies taking a list of concepts- a concept being a perceived regularity in events or objects, or records of events or objects, designated by a label – and organizing it in a graphical representation where pairs of concepts and linking phrases from proportions. Hence, key to the construction of a concept map is the set of concepts on which it is based.

Borreguero, et. al (2013) studied effectiveness of concept mapping on remediation of misconcepts and found that concept maps are learning tools
which foster conceptual change and allow misconceptions to be eradicated via meaningful learning maintained over time.

**Computer simulations.**

Computer based labs and especially simulations because of their time efficiency, allow students to ask “what-if questions” (Carlsen & Andre, 1992; Coleman, 1997). When students have the freedom to ask such questions and receive near immediate (real time) feedback they are accessing a powerful tool for conceptual change (Hennesy et. al, 1995). Computers take the drudgery out of science activities and thus encourage students to take part in science fairs and similar learning experiences (Hasson & Bug, 1995; Kelly & Crawford 1996). The immediate feedback possible with microcomputer based labs allows learners to focus on conceptual goals (Mestre & Touger, 1989; Stein, 1987). Dykstra, Boyle and Monarch (1992) also support microcomputer based labs as a tool for teaching conceptual change. Well designed instructional provisions such as structured handouts are used to guide discovery and to keep students on task thereby ensuring the success of such activities (Stein, 1987).

Computer simulations run within a constructivist classroom will bring the students to question their own conceptions (Dykstra, Boyle and Monarch, 1992). These simulations provide the learner with a range of learning experiences (Tao & Gunstone, 1999). Commercially available computer simulations help students avoid forming misconceptions (Coleman, 1997) and can be used to challenge student conceptions through the presentation of discrepant events (Tao & Gunstone, 1999). Computer-based labs have also demonstrated the ability to promote proper conceptual development through activity-based learning (Dykstra, Boyle & Monarch, 1992). Simulations can help students learn about the natural world by having them see and interact with underlying scientific models that are not readily inferred from first hand observations. (Krajcik & Lunetta, 1987; Dykstra, Boyle & Monarch, 1992). Martinez-Jimenez et. al
(1997) claimed that the students who used interactive physics simulations received better marks in freshman physics courses. This follows constructivist model closely as students are building their understanding through their interaction with these learning activities. When the learner poses a conjecture to the computer the simulation system provides a response from which the student can draw a conclusion. Over time, this leads to concept development. Stein (1987) made several observations of students developing acceptable conclusions using microcomputer-based labs. Sornkhatha, P & Srisawasdi, N. (2012) done a study using computer simulation on Newton’s law of motion and found effective as a conceptual change strategy.

Studies on Misconcepts in Physics

Studies reviewed has highlighted several content areas in Physics where identifiable misconceptions exist and which make obstacles in the way of physics learning and teaching field; the studies reviewed are presented under respective areas.

Studies on Identification of Areas where Misconceptions Occur

The studies below are divided into specific content areas and overlapping subcategories according to their main emphasis.

Matter.

In science the word material is used to designate any kind of matter or stuff that can be observed or detected in the world around us, children may initially use the world to mean those things that are required to make objects- for example, fabric for clothing or bricks for buildings. Bouma et. al (1990) studied the meanings pupils gave to the world matter, they show that at age 13 only 20 percent of pupils explained it as something that could be handled and takes up space. The reminder either gave the word a non tangible meaning, no explanation
or confused one. These researchers also found that pupils’ first meaning of the word material was a fabric for making cloths. Other meanings offered included drawing materials and building materials.

Several studies of pupil’s initial conception of an atom show that they perceive it either as a small piece of material or as the ultimate bit of material obtained when a portion of material is progressively subdivided (Ben-zvi, Elyon, & Silberstein, 1986; Holding, 1987; Pfundit, 1981) such bits are thought to vary in size and shape, to have no space between them, and to possess properties similar to the parent material. Thus for instance, children frequently consider atoms of a solid to have all or most of the macro properties that they associate with the solid. Consequently, children often attribute to atoms properties such as hardness, hotness, color and physical state. Their views contrast with a school science one of atoms as the performed building blocks of material science.

Several researchers (Brook, Driver, R, 1989; Sere, 1985, 1986; Mas, 1986; Piaget, 1973; Stavy, 1988) have studied pupils conceptions of gas and found that they do not appear initially to be aware that air and other gases possesses material character. Although young children may have said that air and smoke exist, they do they regard gases as materials as having transient character similar to that of thoughts. In many children thinking, air and gas appear to have contrasting affective connotations: air is good and it is used for breathing and for life; gas is bad because it may be poisonous, dangerous or inflammable. Later pupils develop an awareness of the material character of gases. They come to regard gases as materials which spread and they recognize that some gases can be even though most are colorless, odorless and transparent. However, pupils may not regard gas as having weight or mass, Leboutet and Barrell (1976) suggests that this is because children’s most common related experience is that gases tend to rise or float. This view is supported by studies which show that children aged 9-13 tend to predict that gases have the property of negative
weight and hence that the more gas that is added to a container, the lighter the container becomes (Brook, Driver, R, 1989; Stavy, 1988). Until they construct the idea that gases have mass, pupils are likely to conserve mass when describing chemical changes that involve gases as either reactants or products (Mas, 1986).

Several researchers’ studies of particle ideas concerning the gaseous state, held by students and teachers, have been reported (Dow, auld & Wilson, 1978; Novick, & Nussbaum, 1978; Driver, 1983; Gabel, & Samuel, 1987) Novick and Nausbaum studied conception of gaseous state held by 13 to 14 year olds who had already been instructed in the particulate theory of matter. About 60 percent of the sample population indicated that gas is composed of particles; and 50 percent said that intrinsic motion accounts for the distribution of particles in space. These researchers report a similar study of older students and they propose the use of a conceptual conflict based teaching strategy for particulate theory (Nussbaum & Novick; 1885)

**Air pressure.**

Working with 12- 14- 16 year olds, Engel clough and driver found high percentages (67 %, 80%, and 87% respectively) thinking that increases with depth. However, pupils were less inclined to think in terms of pressure acting equally in all directions, they were inclined to think of a greater pressure downwards students understanding of atmospheric pressure were reported by (Brook and Driver 1989; Engel Clough & Driver, 1985) the former study reports that questions involving atmospheric pressure explanations appeared difficult for pupils to answer, most students referred only two events inside the containers, in terms either of a vacuum sucking or of pressure inside pulling. A difference was noted, however between phenomena where atmospheric pressure was greater than the pressure inside the container and phenomena where pressure inside the container was greater.
Horizontal motions.

Students’ understanding of motion (including horizontal motion) has been the subject of considerable research in many countries through the world. This area of science has been of particular interest because of the difficulties which learners of all ages seem to have in grasping the physicist’s Newtonian view of motion.

Commonly occurring prior ideas about motion include the notions that if an object is pushed. With a constant force this produces constant motion; and that if the pushing force ceases there is a force in the moving about which keeps it going but which gradually gets used up and then the objects stops.

The extent to which student’s ideas about motion are coherent and theory like is a matter of dispute. Some researchers comment on the adhoc and context dependent nature of students reasoning (McClelland (1984), Yates (1988) Di sessa (1982). Others argue that there are underlying consistent forms of reasoning about motion which can be identified. (Ogborn (1982), McCloskey (1983), Clement (1983)).

It is clear that understanding motion in Newtonian terms (in which motion at a constant velocity needs no causal explanation, and in which acceleration is the result of net force) is a major task for pupils. Students of all ages, including physics undergraduates fail to grasp the Newtonian conception of motion (Jung 1981), they modify rather than abandon their gut and lay dynamics and merely attach new labels to their own theories, (Jira (1980). In particular, it appears from the work of many researchers that learners do not easily share the physicist’s commitment to consistency of explanation in the form of a coherent framework they may hold independent and even conflicting ideas about related phenomena.

Children’s ideas and descriptions of motion tend to be less differentiated than physicists. They tend to see objects as either at rest or moving. The period of change, when for example on object speeds up from rest to a steady speed or
slows down and stops, is less frequently focused on by children. The term acceleration is not commonly used by school-age pupils prior to its introduction in science lessons. Everyday terms such as going faster are used in ambiguous ways, sometimes referring to the magnitude of the speed of an object and at other times referring to the speed increasing with time. There are many studies which report such problems.

Jung (1981) reports pupils leaving time out of their thinking such that they were imagining an object getting to certain or being set into notion rather than accelerating over a period of time. Among some 300 university students only 40 percent successfully compared the acceleration of objects Trowbridge, (1981) and only 68 percent of sample of fifty-two 17 year olds studying physics recognized that an overtaking object is going faster all the time.

It is common for pupils to think that, if speed is increasing, then acceleration is also increasing. This was the case for 60 per cent of the fifty-two sixth formers taking physics, and it was the case for 88 per cent of a group of 113 pupils aged 12-14. Who were studied by Jones (1983).

Mechanics.

The dominant topic over the past two decades, within the field of misconceptions in physics has been mechanics i.e. motion, force, vectors etc. The largest numbers of studies completed on misconceptions in physics have focused on students’ comprehension of forces and Kinematics (Wandersee & Novak, 1994). This is not surprising given the amount of time spent on mechanics in introductory physics curricula in high school and first year university programmes. What may be surprising is despite the amount of time spent on mechanics how tightly high school students cling to Aristotelian and impetus based theories of motion (Mintis & Novak, 1994). Many of these incorrect conceptions about basic ideas of force and motion come from the students intuitive interaction with their environment but often are not ‘un-learned” in the physics classroom.
Forces.

The development of ideas about forces, often take place in the context of learning about horizontal motion or about gravity and falling. Consequently a lot of the research into pupils thinking about forces relates to these domains. Some studies, including a developmental study by Piaget have explored pupil’s ideas about forces themselves and how they act.

Underlying pupils ideas about practical experiences of forces are their understandings about the way forces are transmitted through solids, liquids and gases – understandings which also underpin their ideas about pressure. Students do not appear to have focused upon ideas about the transmission of forces but there has been some work focusing on pupils ideas about pressure.

Pupils’ ideas about the nature of forces have been identified from the very substantial body of research into understanding about motion. Younger pupils, between 7 and 9 years, were found to think of force in terms of anger or feeling Osborn (1985). Yet, at the same time, some 7 and 8 year old held the physicists view of force as something cutting to cause a change in motion, although they tended to talk to force getting things going rather than making things stop.

Pupils naturally bring to their learning lay meanings of the word force and many studies have reported the word being associated with living things. Gunstone (1985) found that pupils associating forces with physical activity and muscular strength. When pupils do think of inanimate objects as having or exerting forces, they appear to focus on those objects which can cause things to move and so can be regarded as agents not unlike living things Watts (1983). Pupils sometimes suggest, when describing the action of forces that objects are trying to bring about a particular motion.

Many researchers have found that pupils associate forces only with movement, not recognizing the passive forces involved in equilibrium situations. Driver (1984) reports that pupils are reluctant to accept the presence of force
where there is no motion and a study of 1000 Norwegian upper secondary students supported this finding Sjoberg (1981). About fifty percent of the sample not recognizing such passive forces.

Research shows a widely held view that there is something often called ‘force’ within a moving objects (Vienmot, Clement, (1982), Mcdoskey 1983). This force is thought of as keeping the object moving and it appears to have something in common with physicists’ momentum. Moving objects are thought to stop when the force of motion in than runs out something like fuel getting used up.

Studies of pupil’s ideas about the relationship between force and motion have identified the following main ideas:

- If there is motion, there is force acting.
- If there is no motion, then there is no force acting
- There cannot be a force without motion
- When an object is moving, there is a force in the direction of its motion.
- A moving object stops when its force is used up.
- A moving object has a force within it which keeps it going.
- Motion is proportional to the force acting.
- A constant speed results from a constant force.

Learners generally to think of forces as a property of a single object rather than as a feature of interactions between two objects and this is reflected in Brown and Uanents (1987) studies as well as in those of Maloney (1985), Minstrell and Stimpson (1986) found that pupils think of weight, motion, activity and strength as being important in determining an object’s force. Pupils inclination to think in terms of force as a property of an objects leads several researchers to propose introducing the word ‘momentum’ for this, recognizing that in the early secondary years this would mean only a quantitative, intuitive understanding of the term. It is argued that this is readily accepted by younger
pupils and it allows them to think about the meaning of force without wanting to attribute it as a property of a single object.

Several researchers stress the importance of paying more attention to Newton’s third law, in order to help pupils appreciate that a force is not a property of an object but forces are characteristics of action between objects. Given pupils difficulties in recognizing a force of reaction, Minstrell (1986) proposes offering ‘bridges’ between prior ideas and science ideas. For example, pupils who did not recognize a reaction between a table and a book resting upon it were led through thinking about a book resting on an outstretched hand, a book resting on a spring and a book on a springy plank, back to a consideration of the book on a table. Such bridging strategies have been found effective in a number of different contexts.

The references below are divided into overlapping subcategories according to their main emphasis (2) Kinematics (3) Dynamics and (4) relativity and frames of references.

**Kinematics.**

In the following papers, the authors identify and analyse specific difficulties that students have with the kinematical concepts and their graphical representations, and with the relationship of concepts and graphs to real world.

“Investigation of student understanding of the concept of velocity in one dimension” Trowbridge and Mcdermott (1980).

“Investigation to student understanding of the concept of Acceleration is one dimension” Trowbridge and Mcdermott (1981).

The two papers above report on an investigation of student understanding of the concepts of position, velocity and acceleration. Individual demonstration, interviews conducted with 200 university students, indicated that even after instruction many students confused position with velocity and velocity with acceleration.
“Even honours students have conceptual difficulties with physics”, Peters (1981) found a variety of conceptual difficulties among students in an introductory honours physics course. Although mostly about kinematics, the discussion include dynamics, electricity and magnets.

Aguirre (1988) in his paper, student preconceptions about vector kinematics “discussed student difficulties with vector kinematics”.

Mcdermott and Vanzee (1987) had done a study “student’s difficulties in connecting graphs and physics: Examples from Kinematics”. A long-term study involving several hundred students helped identify student’s difficulties in relating kinematical concepts, their graphical representations, and the motion of real objects.

Goldberg and Anderson (1989) has done a study by the help of interviews and written tests at four universities probed student understanding of negative velocity and found many difficulties with graphical representation of negative values of velocity.

**Dynamics.**

The references below focus on the identification of student difficulties with dynamics including Newton’s laws, Circular Motion and the concept of energy and momentum.

Viennot (1979) done an instigation conducted among European students drawn from the last years of secondary school through the third year of university. The students demonstrated a strong tendency to assume a direct linear relationship between force and velocity.

Champagne and Anderson (1980) conducted a test on more than 100 students in an introductory university course on force and motion prior to instruction. Many non-Newtonian ideas were observed, including a constant
force produces constant velocity and in the absence of force, objects are either at rest or slowing down.

Mecloskey and Green (1980) conducted a study on university students. The students were asked to predict the motions of objects moving in constrained curved path. Many believed that an object would “remember” the curve after it left the constraint.

Caramazza and Green (1981) conducted a study on 50 students about misconception in trajectories of objects. Here students were asked to trace the path of a pendulum bob if the string were cut at different positions along its path, only about one-fourth responded correctly.

Gunstone and White (1981) done a study on understanding of gravity by simple lecture demonstration shown to several hundred first year university students in Australia. The students exhibited a strong tendency to observe their prediction regardless of what actually happened.

Clement (1982) done a study on students preconceptions in introductory mechanics. The result of the study indicates that many students believe that motion implies a force, both before and after the study of introductory mechanics.

Maloney (1984) conducted a study on Newtons third law with more than 100 university students with different backgrounds in physics. They were asked to compare the forces that two interacting objects exerted on each other. About two-thirds thought that they would be of different magnitude in some circumstances.

Lanwson and McDermott (1987) conducted a study after instruction on the work, energy and impulse – momentum theorems. Most students were unable to relate the algebraic formalism to motions that they observed.

Boyle and Maloney (1991) had done a study on effect of written text on usage of Newtons third law. They examined the beliefs about Newtons third law
of 100 university students before instruction. Half of the students were given a handout describing force with explicit statements of the third law no student without the handout applied the third law correctly and of those with the handout, fewer than half applied it correctly.

**Mass.**

Researchers have found that, from an early age, children notice how objects differ in the way they appear to press down on the hands shoulder or head they learn to feel the weight of objects. Children compare objects by their felt weight over time, generate an idea that felt weight is a characteristic property of an object (holding; 1987; Mullet & Gervais, 1990). Holding (1987) investigated the development of an idea of an object being pulled down by a force (rather than actually pressing downwards), and also the development of the concept of mass. Both conceptual changes appeared to be developing slowly. Mass often becomes associated with size or volume. In that event pupils often estimated the mass of material from it bulk appearance.

**Relativity and frames of references.**

Saltiel and Malgrange (1980) conducted a study on 700 university students about spontaneous ways of reasoning in elementary kinematics and identified student difficulties with relative motion and reference frames.

Panse and Kumar (1994), Ramadas and Kumar (1996), Ramadas and Kumar (1998). The three papers above describe a series of studies in which undergraduate students in India were asked questions about transformations between different frames both kinematical and dynamical issues were considered and student responses classified.

**Electricity.**

Most pupils’ introduction to learning about electricity the world over involves using a battery, wire and a 1.25v bulb to make the bulb light. Pupils
generally tackle this with enthusiasm and also with certain established ideas about both batteries and bulb work, several researchers Shipstone, (1984), Tiberghien (1983), Ogborne (1981) have investigated pupils’ earliest ideas about electricity and they report that these ideas generally indicate a source – consumer model in which the battery gives something to the bulb.

**Pupils ideas about a simple circuit.**

Solomn *et. al* (1985) and Licht (1985) have pointed to the importance of pupils’ background awareness of, and interest in electricity. Licht found among 207 pupils studied, that danger/safety and video apparatus and electronics were the contexts in which pupils were most interested this of course leaves the teacher with the difficult task of maintaining pupils’ interest in the modest DC circuits which will help them to begin to understand the phenomena. The models which are used by children to explain the phenomenon of a simple circuit have been studied in several countries: New Zealand, Australia, the USA, Sweden, Greece, France and Germany as well as the UK. Osborne and Freyberg’s (1985) work in New Zealand identified four explanatory models which have since been found by other researchers world-wide some of these alternative models are very firmly held, not only by young pupils but by physics and engineering students who are regularly involved in practical work and calculations relating to circuits.

In the first of these models, here pupils regard only one wire as active and, whilst most come to recognize the practical requirement for a complete circuit, they nevertheless think that the second wire doesn’t play an active part. It is sometimes regarded as a safety wire.

In the second model pupils think of current flow from both terminals of the battery to the bulb. They sometimes explain the light in terms of the clash of the two currents.

In the third model current is seen as ‘used up’ by the bulb and so there is less in the wire ‘going back’ to the battery. Some pupils expect a second bulb to
be less bright than the first when two bulbs are in the circuit: Others imagine components’ sharing the current is used up by the bulbs.

The fourth model shows the magnitude or value of the current unchanged in the return wire.

It is notable that all the prevalent alternative models are sequential models in which something from the battery travels around the circuit, meeting wires and components in sequence. This deep seated notion, with its roots in the cause and effect everyday experience of other phenomena, underlies many of the problems which pupils have in understanding the behavior of electrical circuits. It is the notion which might be considered as the underlying mental model having various expressions.

In their earliest experience of batteries pupils often think of battery as a unipolar giver of electricity. It seems that pupils generally think of the battery as storage of electricity or energy. They see it as delivering a constant current in a closed circuit, rather than maintaining a constant voltage or potential difference. Indeed, pupils have very little notion of voltage or potential difference and the battery was seen as storing a certain amount of electricity by 85 percent of a group of 400 German secondary students (Maichle, 1981).

Current is usually introduced to pupils as the primary concept and they tend to think of voltage as a property of the current rather than as a precondition for a current flow (Von Rhoneck, 1984). It follows that pupils expect voltage to increase as current increases. They are very reluctant to believe that if no current flowing, there can still be a voltage between two points plenty of experience is advised, with both ammeters and voltmeters in simple circuits, in order to erode the voltage equals current idea. Pupils tend to start with one concept for electricity in a direct current circuit, a concept labeled current or energy or electricity all inter changeable and having the properties of movement, storability and consumption (Shipstone, 1984; Psillos; Koumaras; & Tiberghien 1988).
Understanding an electrical circuit involves first differentiating the concepts of current, voltage and energy before relating them as a system, which the energy transfer depends up on current, time and the potential difference of the battery. The notion of current flowing in the circuit is one which pupils often meet in their introduction to a circuit and because this relates well with their intuitive notions, this concept then becomes the primary concept (Cohen; Eylon & Ganiel; 1983). The result of this tends to be that when voltage is introduced it is seen as a property of current. Psillos et. al point to the need for particular effort to introduce voltage initially as a property of the battery, a precondition for current to flow and present even when no current is flowing. In this it could more easily be differentiated from current.

Von Rhoneck (1981) found in a group of thirteen pupils that eight of them thought of voltage as a force and that all thirteen of them thought of current as energy. Clearly pupil’s notions of the relationship between force and energy can have bearing on their views of electrical energy. The earliest idea of resistance is of a hindrance- a barrier to the flow of charge. Shipstone explains how pupils think of resistance affecting only parts of the circuit downstream coupling their idea of hindrance with the notion of the sequential circuit in which the current is influenced by each circuit element in turn.

**Electricity and magnetism.**

Students misunderstanding of concepts in electricity and magnetism has not been investigated in as great detail as in mechanics. Public articles on student difficulties have dealt primarily with two topics: DC circuits and electric fields.

Fredette and Clement (1981) conducted a study on simple electric circuits and also Fredette and Lachhed (1980) done same sort of study and these two discusses the responses of college students to the task “combine a battery bulb and one wire to make the bulb light”.
Cohen and Ganid (1983) conducted a study on potential difference and current in simple circuits and analysed responses from multiple-choice test given to 145 high school students and 21 in-service physics teachers in Israel although the teachers did better than the students many had similar conceptual difficulties.

Dupin and Joshua (1987) had done a study in France about conceptions of French pupils concerning electric circuit which is held by students ranging in age from 12 to 22 years. It was found that some simple misconceptions disappear with instruction, but teaching seems to have little effect on others.

Shipstone and Rhoneck (1988) conducted a study on students understanding of electricity in five European countries and revealed substantially the same difficulties everywhere.

Heller and Finely (1992) conducted a study on variable uses of alternative conceptions. Fourteen in-service elementary and middle school teachers were found to have a coherent but incorrect, model of current.

McDermottee and Shaffer (1993) conducted a study on introductory electricity. This paper identifies specific difficulties that may undergraduate students have with DC circuits.

**Electric and magnetic field.**

Since many of the basic concepts in electricity and magnetism are not familiar from direct experience and are quite abstract, students can be expected to have conceptual difficulties. The few published studies are quite provocative, but far from complete.

Ferguson and Jokes (1981) conducted a study on the quality of knowledge in the field of electricity and magnetism. The authors investigated how first-year university students organized their knowledge of electromagnetism. Successful problem solvers had a more coherent knowledge structure.
Mcmillian and Swadener (1991) conducted a study on novice use of qualitative versus quantitative problem solving in electrostatics. Six students in a calculus based physics class were observed as they solved electrostatics problems. The successful students differed from the others only in mathematical facility, not in qualitative understanding. Both groups had difficulty with qualitative questions and had similar misconceptions.

Viennot and Rainson (1992) conducted a study of the difficulties of French and Algerian university students with Gauss’s law and with electric field in an insulator.

Tornkvist and Transtormer (1993) conducted a study about comprehension of the electric field concept. Analysis of more than 500 written responses and nearly 100 interviews revealed difficulties with the concept of electric field lines among second-year students at the Royal Institute of Technology in Stockholm.

Galil (1995) conducted a study on mechanics background influence on students conceptions in electromagnetism. Difficulties with electromagnetism were identified in a study that included 10th graders and pre-service technology teachers in Israel.

**Electrostatics and magnetostatics.**

In contrast to other topics of physics, students’ misconceptions and conceptual difficulties related to static electricity has not been researched deeply yet (Guruswamy *et. al.*, 1997). Maloney *et. al.* (1985) noted that developing instruments to assess student ideas in electricity and magnetism is a very different task than other areas of physics. Since electricity is very common in everyday situations, it is natural that students (and also adults) have many misconceptions about electricity (Caillot & Xuan, 1993). Although almost all books start to discuss electricity with the concept of electric charge, students do not have a clear understanding of charge concept (Eylon & Ganiel, 1990; Galili
Students’ typical concept is that ‘a neutral object has no charge’ (Calilot & Xuan, 1993; Thacker et. al., 1999). Another common misconception about the concept of electric charge is that ‘a charged body contains only either electrons or protons’ (Siegel & Lee, 2001). Students have many difficulties about the concept of static electricity. Many students and also adults think that ‘friction is the cause of static electricity’ (Calilot & Xuan, 1993; Siegel Lee, 2001). Researches on students’ misconceptions in electrostatics are mainly focused on electric fields and forces exerted by electric fields on charges (Eylon & Ganiel, 1990; McMillan & Swadener, 1991; Galili, 1993; Törnkovist et. al., 1993; Rainsen et. al., 1994; Furio & Guisasla, 1998; Savelsberg et. al., 2002). The findings of these researches showed that most of the students do not have clear understanding of the concept of electric field and hence held different misconceptions. For example, students have difficulties about representation of electric field lines. Galili (1993) found that according to students, electric field lines are real. Besides, Törnkovist (1993) found that students think that electric field lines can both cross each other or make sharp boundaries and force exerted on a charge on the field line is along the field line. Some other misconceptions are ‘field lines can begin/ and end anywhere’ and ‘there are a finite number of field lines’ (Rainsen et. al., 1994; Maloney et. al., 2001). Guruswamy et. al. (1997) showed that students have many difficulties concerning charge transfer. Examples can be given as ‘there is no transfer of charge between two metal objects with charges of the same sign’, ‘transfer between oppositely charged metal objects occurs until one of the objects is neutral’, ‘there is no transfer between a charged metal object and a neutral metal object’, and ‘the charges on the two metal objects remain the same after touching regardless of the signs of the initial charges’. Calilot and Xuan (1993) discussed that similar misconceptions are held by adults. Students also have many conceptual misunderstandings about concepts of potential, potential difference and capacitance (Thacker et. al., 1999). For example, ‘charges jump from one plate of the capacitor to the other’, ‘parallel plate
capacitors store a net charge’, students do not know what is meant by net charge, ‘parallel plate capacitors store voltage’, and students do not know what a capacitor is (Beaty, 1996).

Simanek (2002) observed that sometimes textbooks may lead to misconceptions with inappropriate definitions (Sanger & Greenbowe, 1999). When investigated, there are phrases like ‘capacitor is a device for storing charge’ in some textbooks (Jones & Childers, 1992; Ohanian, 1989). This may cause students to think that ‘there is a net charge on a parallel plate capacitor when it is charged’. Capacitance is the ability of a component to store charge. But this can be misleading unless it is explained clearly. The total charge at all times on a parallel plate capacitor is zero; when it is charged, it holds equal amounts of positive and negative charges (Ellse & Honeywill, 2001).

Misconceptions are very stable and traditional instruction does not encourage meaningful learning hence it is not easy to replace them with scientific conceptions (Hestenes, 1987; Clement, 1993; Novak, 2002). Changing misconceptions is not simply adding new information to an individual’s mind, but care should be taken to account for the interaction of new knowledge with existing provided that the new may be replaced with the existing (Hewson & Hewson, 1983). Replacing the existing faulty knowledge with the scientific one is one of the aims of conceptual change strategies (Posner et. al., 1982; Hewson & Hewson, 1983; Novak, 2002). Many researches about students’ misconceptions in science stated that traditional instruction (transfer of knowledge) is ineffective on correcting misconceptions and does not usually result in meaningful learning (e.g. Hestenes, 1987; Mestre, 1991; Dykstra et. al., 1992; McDermot & Shaffer, 1992; White, 1992). Furthermore, all state that most of students’ misconceptions exist after instruction. It is not easy to change students’ beliefs. After the instruction students might use scientific knowledge in school, and give correct answers to standard questions, but in unfamiliar situations or outside the school will use their own alternative beliefs (White, 1992).
Maloney (1985) conducted a study on charged poles in an algebra-based physics class and strongly suggest that even after instruction many students are confused about interactions between electric charges and magnetic poles.

Guruswami and Hussy (1997) conducted a study on students' understandings of the transfer of charge between conductors. Individual demonstration interviews were used to investigate students' understanding of charge and behaviour of charged conductors. After instruction few students were able to identify the forces of a charge on a conductor or to describe how charges were shared between touching conductors.

**Magnetism and gravity.**

Relatively little research has been published in relation to children’s ideas about magnetism, although some studies of ideas about gravity have touched upon it. Researchers studying ideas about gravity have found that pupils are inclined to link magnetism with gravity. They sometimes account for gravity in terms of a magnetic force drawing objects towards the earth Bar (1987). Conversely; pupils have been found to account for the way magnets act by calling magnetism a type of gravity Barrow (1987).

Given that pupils tend to link magnetism with gravity and given that pupils also tend to link gravity with the effects of air, Bar and Zinn (1989) looked for pupils’ ideas suggesting a link between magnetism and air among the 9 – 14 age group. These researchers found 40 per cent of their sample of ninety-eight pupils considering that a conducting medium (air) is necessary for a magnet to have an effect. A connection between magnetism and gravity has made by 20 per cent of the sample.

Barrow (1984) investigated awareness of magnets and magnetism among seventy-eight pupils across all age ranges. All were well aware of magnets in their everyday experience, in picking up nails or ping or in sticking notices to refrigerators. Before teaching, most pupils offered no explanation of magnetism.
A few referred to chemicals making them stick. After teaching, references were made to a type of gravity, to energies and to electrons and protons. Less than 10 per cent of the sample appeared to have the idea of poles, although approximately 25 per cent responded accurately when tested on attraction and repulsion of poles. However, pupils tended to think of poles only at the ends of magnets and Barrow suggests that pupils might be encouraged to focus on the magnetic force and find the part of the magnet where attraction and repulsion are strongest. There was generally a lack of experience of repulsion as distinct from attraction. Barrow (1987) stresses the importance of work with two magnets (in the context of distinguishing between a magnet and magnetic material which is not magnet used Gagliari (1981) stresses the importance of repulsion as the only test for a magnet to distinguish it from magnetic material).

Barrow’s study found that pupils’ awareness of the uses of magnets had not been extended by teaching. Barrow raises the possibility that teaching about magnets might dissociate pupils from their everyday awareness of magnetism. With this in mind, approaches which draw in everyday experience and focus upon the use of magnets would be advisable.

A study of pupils between the ages of 3 and 9 by Selman et. al (1982) found two levels of conception of magnetism the first level appeared to be only linking events. At a more sophisticated level the notion of an unseen force began to emerge and pupils talked of a magnet working by pulling on things.

Finley (1986) studied the effect of a television programme about magnets on the ideas of twenty-four pupils. Pupils, prior to the programme, referred to magnets sticking to objects and they recognized specific examples of things affected, such as pins or paper clips. They also thought of big magnets as stronger than small ones. After the programme; magnets were thought of in terms of picking up rather than sticking, and there was awareness of action at a distance. Pupils identified a generic group of materials affected by magnets,
although they took this to be all metals rather than certain metals. The effect of the program’s presenting a small strong magnet has simply to reverse pupils’ prior ideas such that they thus thought of all small magnets being stronger than all big ones. In general pupils appeared to have embraced some of the ideas of magnetism without adopting the language and the use of words attract, repel or magnetize.

**Electromagnetism.**

Pupils in barrows study did not generally recognize the magnetic effect of an electric current; only 10 per cent did so. Selmen *et al.* found some pupils in the 3-9 age groups focusing on the wire as the active agent whilst others referred to electricity as the explanation of electromagnetism. In a sample on ninety four 13 year olds, Anderson found sixty four who thought that a coil of wire had to be uninsulated in order to create an electromagnet.

**Light and optics.**

*The nature and representation of light.*

Ideas about the nature of light are often taken for granted in school science and the only definition given is usually that it is a form of energy. Watts (1984) suggested that young people are therefore in the position of having to construct their own understanding of what light is whilst exploring its properties.

Guesne (1985) concludes that most 10 and 11 year old children conceive of light as a source (such as an electric bulb), an effect (such as a patch of light) or a state (such as brightness). She found that children of this age did not recognize light as physical entity existing in space between the source and the effect that it produced. She also found that at the ages of 13 and 14 many studies recognized light as an entity, the majority using this notion to explain shadows but only where the light was intense enough to produce perceptible effects at some point in its path.
Ramadas and Driver (1989) report on the findings of a study involving 456 15-year-olds in which various ideas about light were considered. When questioned about light rays many children thought of them as long; thin, flashing, unlike ordinary light. Pupils sometimes associated them with science fiction contexts. The fact that the path light takes is not itself directly visible presented special difficulties for children, especially in representing the presence of light in various situations. Darkness appeared to be as important a part of students’ conceptions as light and in their diagrams. It was not uncommon, in certain contexts, for students to shade in the darkness on white paper instead of shading in the light.

Investigating children understanding of source of light Osborne et. al (1990) found that children between the ages of 7 and 11 showed knowledge of a wide range of source but that they talked about primary sources nearly four times as often as they mentioned secondary sources of light. These researches found no evidence to suggest that the children’s ideas about sources developed with age. This study also considered the representations used by children to show light and it found that nearly all children’s drawings showed the light around sources represented by short lines. The use of extensive numbers of lines linking source and object was very limited. The representations used by older children become more varied and context dependent. Very few children offered no representation of light, although for many lower juniors it was limited to simple lines surrounding the source.

Andersson and Karrqvist (1981) made observations on colloquial speech and they suggest that the everyday concept of light is psychological rather than physical in nature, citing phrases such as ‘the light is bad’ or it is light. The other meaning of light which they noted in the English language has a source of light such as an electric bulb.

Watts and Gilbert (1985) suggest seven frameworks which encompass the bulk of youngster’s responses about light
- Ambient light where a distinction is drawn between direct light and normal daylight (on a scale which runs from very bright to dark, daylight would be somewhere near the midpoint and shadows are thought to occur only in bright light).

- Composite light in which responses describe the composition of light (although some children treat light as a single entity, many discuss its parts or bits)

- De-coupled light in which the responses describe light as being completely separate from seeing (situations are thought to require light in order that things are lit up but there is no suggestions that light is then reflected to the eyes: rather, eyes simply observe a well-lit scene).

- Illuminative light in which responses describe light as intentionally designed to allow us to see and which emphasis the general human purpose of light.

- Modal light in which many different kinds of light, derived from different circumstances and giving different effects are identified.

- Obvious light in which light is thought to be property only of large conspicuous luminous bodies.

- Projected light in which responses treat light as a substance that is projected, in some instances transporting colours (light might be described as a directed beam which can be stopped or slowed down by obstacles)

The science view of light does not appear to be common among pupils. In a multiple-choice question about how a lamp brightens a room Anderson and Smith (1983) found that more than 75 percent of the sample of 27 did not choose the scientifically correct answer but preferred a response that specified no mechanism at all by which a lamp brightened a room

When children have notion of light as an entity they do not necessarily think of light travelling – a point made by Guesen (1985), La Rosa et. al suggest
that students who talked of light going from point A to point B might have thought of it as like a wire or a rod going from A to B.

Watts (1984) describes a boy who talked about rays of light as strands of a rope making up a beam of light and also about light in different modes such as natural or electric.

Stead and Osborne (1980) used different contexts (such as candle, a lamp, a TV and a mirror) to test for the idea of light existing in space. They found that most students did not think of light traveling out very far from the source, particularly in day time. Pupils thought of light as travelling further at night. Fetherstonhaugh and Treagust (1990) found that around 40 per cent of the forty seven 13 to 15 year olds in their study thought that light travels different distance depending up on whether it is night or day. About 20 per cent believed that light does not travel at all during the day. A smaller proportion thought that light did not travel at night.

Feher and Rice (1985), from their work on children’s ideas about shadows, conclude that many younger children think of a shadow as the presence of something that light allows us to see, rather than as the absence of light. The shadow was thought of as existing on its own hiding in the object, until the light pushes the shadow away from the object on the wall or ground. These researchers suggest that children tend to expect the shadow of an object to be the same shape as the object. Pupil’s explanations of their prediction often reoffered to the shadow as a reflection or as a dark reflection on the screen.

Gusen (1985) found that 10 and 11 year old children perceived the light source as being responsible for shadows but noticed only the reproduction of the object form. The majority of 13 and 14 year olds interpreted shadows in terms of an obstacle blocking the passage of light and they used the notion of light entity in space. Tiberghien et. al (1980) report that ninety percent of their sample of ninety four 10 and 11 year olds correctly located where their own shadow would
fall when the sun was in front or behind them. The same group of children found more difficulty in anticipating where the shadow of a tree would fall, with 60 percent offering the correct idea of the relative positions of the source, the object and the objects shadow. Pupils did not offer an explanation in terms of straight path of light.

When children were asked why red light is seen to come from a red projector slide, Zyberstajn and Watts (1982) found that only 2 per cent of the sample of 150 13 year olds gave an answer in terms of transmission of some frequency of light, despite having recently been taught about color. About half thought that the white light from the projector had been changed in some way, with a third of this group suggesting a dyeing mechanism. Another 13 per cent of the total offered models in which the white light projected the color of the filter forward in a kind of knock on effect.

Anderson and smith found that 72 percent of their sample did not think that white light was a mixture of colors of light. Of those who did not hold the idea, only 20 percent also know all the colors involved in the mixture. Sixty one per cent of the children thought that color was an innate ability of an object and that light helped our eyes to see the object. They thought that our eyes see the color of the object rather than the color of the reflected light.

Watts (1985) conducted a study on student conceptions of light. A detailed description is given of the views of a high school student on the nature of light. Saxena (1991) conducted a study on understanding of the properties of light by students in India. This article reports the results from a multiple-choice test that was administered to both secondary school and undergraduate students in India.

Goldberg and McDermott (1981) conducted a study on difficulties in understanding image formation by a plan mirror. During interviews university students were shown an object in front of a mirror and asked what an observer at
various locations would see. Many students could not make correct predictions either before or after instruction.

Goldberg and *et. al* (1981) conducted an investigation of student understanding of the real image formed by a converging lense or concave mirror. Even after instruction, many students could not apply the formalism of geometrical optics to predict or account for the image formed by a converging lense or concave mirror.

Ambrose and Shaffer (1999) conducted an investigation of student understanding of single-slit diffraction and double slit interferences. This article identifies specific difficulties that many students have in selecting and applying an appropriate model to account for the pattern produced on a screen when light is incident on one or two narrow slits. It is also found that students at introductory and more advanced levels have seriously mistaken beliefs about photons and the wave model of matter.

**Sound.**

Many children’s explanations of how sounds are produced are in terms of the physical properties of the material producing the sound. Children suggest that the sound is produced because the object is made of plastic or of rubber, or because it is thick, thin, taut or hard. This idea is noted both by Watt and Russell (1990) and by Asoko *et. al* (1991). The latter note that younger children very often link the production of sounds with their own actions, or consider the sound to be part of the instrument, ‘released by human actions’.

Watt and Russell found that pupils often commented upon the action used to generate the sound and attempted to suggest a mechanism for sound production. The proportion (of a groups of fifty-seven) suggesting a mechanism for sound production from a drum increased with age, from 13 per cent of infants to 95 per cent of upper juniors. The suggested location of sound generation also changed with age: younger children suggested that sound is generated inside the
drum and older children that it is generated on the surface; although some explanations involved both. Mechanisms of sound production offered by the children were context-specific, those proposed for a rubber band being very different from those proposed for the drum. However, there have three main groups of explanations.

- Those which involved the physical attributes of the object (for example, the tautness of a drum)
- Those referring to the force needed to produce the sound (for example, the human action of beating the drum)
- Those which involved vibrations

Asoko et al. Working with 260 pupils between the ages of 4 and 16, explored ideas about sound production in four contexts: a guitar string being plucked; a tag hooter horn being sounded by squeezing the bulb; stones being clashed together; and a cymbal being struck. Although they found that reference to movement or vibration of the sound source became more common with increasing age, this was context specific to objects which could very obviously be seen to vibrate, such as the guitar string and the cymbal. No pupils used ideas about vibrations consistently, in all contexts.

With reference to the guitar, there was an increase throughout the infant and junior years of responses which referred to the vibration of the source. At the same time there was a decrease in other ideas, particularly those relating only personal action and properties of the source, such as tautness. Approximately 80 per cent of the responses of secondary children referred to vibration of the guitar string. However over the whole age range very few children described the transfer of the vibrations of the string to the surrounding air.

In thinking about the cymbal, almost 40 per cent of reception class children associated the sound with vibration, and the proportion was greater among older children as personal action references decreased. Again there was
very little mention, by children of any age, of the vibration being transferred to the air.

In the context of the hooter horn, references to vibrations were far fewer. The younger children explained the hooter horn in terms of personal action but this notion fell away sharply with age as more references were made to the involvement of air to movement. The number of replies focusing on the involvement of air remained high, with approximately 40 percent of the secondary aged sample referring to it. There were very few references to the vibration of the source and even fewer to the vibration being passed to the air.

When the students considered how the stones produced sound, the vast majority of answers at all ages referred to personal action and these responses were often complimented by references to the properties of the stones. There were virtually no explanations based on the involvement of air or vibrations.

Asoko et. al suggest that, because children do not have a generalized theory of sound production transferable across contexts.

Teachers should plan to give children experience of sound production in less obvious contexts as well as in contexts where the vibrations are clearer. It may be useful to allow the children to experiment with applying vibration ideas developed in obvious contexts to less obvious contexts with a view to developing a generalized theory.

They also propose that, because the role of the ear does not appear to be problematic for most children, this may be useful contexts for developing ideas about vibrations in air. When explaining how covering a sound affects its volume many children used ideas about gaps or stopping the sound and these ideas may lead to the scientific view of sounds as vibrations travelling through air and other materials.
**Sound transmission.**

Watt and Russell (1990) found that the idea of sound traveling was not one which children readily expressed. When they did so, they tended to think that the sound needs an unobstructed pathway in order to travel. This idea seems to draw upon everyday experience of moving among furniture, of umbrellas stopping the rain or of building a dam across a stream, where movement would be impeded by anything in the path. Watt and Russell suggest that children may envisage sound as an invisible object with dimensions, which would need room in order to move. The idea that air is needed as a medium for sound transmission was rarely mentioned, but when it was Watt and Russell (1990) concluded that children’s notion of air had a bearing on their understanding of sound travel for example, those children who envisaged air as empty space would be thinking of sound transmission in air as sound traveling through an empty space. Likewise Asoko _et. al_ found that pupils rarely suggested a mechanism for sound travel at any age. Moreover, it was difficult to interpret children’s explanations when certain expressions, such as sound ‘goes’ could have had various meanings. When they were asked how the ticking of a clock is heard, children up to the age of 14 focused their answers either on the mechanism of the clock or on the personal action of the child listening. The role of air was mentioned only a small number of children. Only among 16 year-olds has the notion of sound travel in air common: it was referred to by 70 per cent of this group.

Difficulties in thinking about sound traveling are not restricted to younger children. In a study of tertiary students, who were shortly to go on to teach secondary school physics, Linder and Erickson (1989) observed four conceptualizations of sound.

- As an entity that was carried by individual molecule to another through a medium.
- As an entity that was transferred from one molecule to another through the medium.
As a substance which traveled, usually in the form of flowing air
As a substance in the form of some traveling pattern

Linder and Erickson describe the first two perspectives as ‘microscopic’ given that the students explained sound in terms of molecules and tended to portray sound as a thing’ they describe the other two perspectives as macroscopic; since students explained sound in terms of the bulk properties of the medium.

**Heat and temperature.**

Children’s ideas about heat have been the subject of a lot of research and studies have taken place in many countries, certain patterns emerge and it is clear that children have difficulty in understanding this area of science. Harris (1981) as reported by Hewson and Hamlyn (1984) suggests that the source of this confusion centers on the use of words like ‘heat’, ‘heat flow’ and ‘heat capacity’. Harris (1981) referring to students tendency to think of heat as a ‘substance’ which flows from place to place, claims that ‘many’ ‘students’ conceptions of heat today are, on the whole, not very different from those of Lavoisier (1789), that is, they think ‘calorically’. Indeed, many researchers have found that children think of heat as a substance, and Hewson and Hamlyn (1984) have drawn attention to language and cultural influences.

Erickson reported that children think of heat as a type of subtle substance, like air, that is capable of flowing into and out of objects. Other studies have observed a similar notion and that the substance is often thought to flow or have fluid characteristics. Erickson noted that both cold and heat are often associated with air.

Engel Clough and Driver (1985) report that pupils up to the age of 16 think of cold as an entity which like heat, has the properties of a material substance. It appears that children do not necessarily think of hot and cold as part of the same continuum. Rather they perceive them as two different phenomena, with cold often being thought of as the opposite of heat.
Watts and Gilbert (1985) found seven alternative frameworks for thinking about heat which have commonly used by a group of 14 to 17 years olds.

- Conspicuous heat, in which heat is only associated with very hot bodies and large amounts of heat;
- Dynamic heat in which heat is associated with movement;
- Motile heat, in which heat is seen as something which spreads out from one place to another and as more insidious and fluid-like than direct (conspicuous) heat;
- Normal heat, which is taken as body temperature and humans are seen as the standard for measuring heat
- Product heat, which is taken to be manufactured, deliberately contrived heat as distinct from natural heat;
- Standard heat, in which any temperature above ‘freezing’ represents heat and in which cold is the opposite of heat and applies to any temperature below freezing.
- Regional heat, which assumes a static model of heat occupying a particular area, and cooling, is seen as a reduction of heat intensity.

Erickson reports that distinguishing between the concepts of heat and temperature was one of the most difficult tasks for children. They tend to view temperature as the mixture of heat and cold inside an object, or simply as a measure of the amount of heat possessed by that object, with no distinction between the intensity of heat and the amount of heat possessed. Many children think that the temperature of a body is related to its size, volume or the amount of stuff present. Children also think of temperature as a property of the material, their everyday experience of teaching objects supporting a notion that some substances are naturally warmer or colder than others. When considering pupils ideas of the differences between heat and temperature, Tiberghien (1983) reports three categories of response.
The idea that heat is hot, but temperature can be cold or hot: temperature you can have something freezing, whereas heat – you tend to think of something being hot. Heat…. It’s the warm end of the scale (this view was more common among 10 to 12 year olds).

The idea that there is no difference between heat and temperature: temperature is heat (this type of thinking was found in pupils from age 10-16.

The idea that temperature is a means of measuring heat: Temperature – you can measure heat with, but heat is not – you can feel heat.

Tiberghien notes that children do not recognize temperature as a physical parameter that can describe the condition of a material for them other criteria are more pertinent for describing materials.

There have been several studies of children’s ideas about the resultant temperature when volumes of water at different temperatures are mixed. When a quantity of cold water is mixed with an equal quantity of hot water children often say that the mixture will be ‘warm’. However, if the initial temperatures of the water are given there are fewer correct answers.

Driver and Russell (1982) studying 324 Malaysian and English pupils found that over 50 per cent of 8 to 9 year olds and 80 per cent of 13 to 14 year olds gave correct qualitative judgments, but less than 25 per cent of 13 to 14 year olds predicted an average temperature when numerical values were introduced. They tended to add or substrate the two initial temperatures to find the final one. This pattern was also found by Stavy and Barkovitz in their study of seventy seven Israeli, 9 to 10 year olds.

Strauss and Stavy (1982) report that, when considering the final temperature of a mixture of two beakers of Cold water. Children aged 4 to 6 often judged the temperature to be the same. However, older children, and 5 to 8, often said that the water would be twice as cold because, there was twice as
much water. Older children aged, up to 12 again judged the water to have the same temperature as the separate beakers. To explain this, Strauss and Stavy suggest that the youngest children do not consider the amount of water when making their judgment, whereas older children do attend to the amount and judge the temperature as if it were an extensive physical quantity. The oldest children are able to differentiate between intensive and extensive quantities and make judgments accordingly, underestimating that the temperature remains unchanged despite changes in the amount of water. Strauss and Stavy also found that children tended to make more correct predictions of temperature when equal amounts of hot and cold water mixed than when two equal amounts of cold water were mixed.

**Properties of matter, fluid mechanics and thermal physics.**

Misconceptions frequently occur in these areas are a) Heat, Temperature and Thermodynamics, b) Pressure, density and Structure of matter

**Heat, temperature and thermodynamics.**

Warren (1972) conducted a study on teaching of the concept of heat. This paper discusses the inability of first year university students to separate the concepts of heat, internal energy and temperature.

Johnston and Webb (1977) conducted a study on misconception in school thermodynamics. A thermodynamic approach test was administered to 98 middle and high school students in Scotland. Eight prevalent “misconceptions” were identified. Several of these pertain to chemical reactions.

Erickson (1979) conducted a study on children’s conceptions of heat and temperature. It was observed in the study that many students aged 11-16 believe that heat and cold are substances and that temperature is a measure of their amount; few students were able to distinguish between heat and temperature. Alwan, A.A. (2010). Conducted a study students of different category and the
findings revealed that most of the students held alternative conceptions of heat and temperature.

*Pressure, density and structure of matter*

**Pressure.**

Research into ideas about pressure has focused up on fluid pressures and particularly air pressure. Sere (1982) working with eleven French 11 to 13 years old, pupils found pupils thinking that only wind, and not still air has pressure. Working with eighty four 12-14 and 16 year old, Engel Clough and Driver (1985) found high proportion thinking that pressure increases with depth. However pupils were less inclined to think in terms of pressure acting in all directions in air or water, they were inclined to think of a greater pressure downwards. This study found frequently references to air or a vacuum sucking in pupil’s explanations changes experienced with straws and syringes. Atmospheric pressure pushing was mentioned but few pupils explained in terms of balancing pressure.

Studying French 11 to 13 year olds and their ideas about air pressure differences and consequently movement of air, Sere found 85 per cent accurately describing the extent to which air is squashed in a ball before and after blowing it up. However only 63 percent of the pupils accurately compared air pressure inside the ball with the air outside. Generally pupils did not readily make pressure comparisons. An important finding from Seres (1982) study is that pupils tend to associate pressure in gases with moving air assuming pressure acting in the direction of motion. There were fewer tendencies to associate pressure with static gases.

Mackinnon and Geol (1971) conducted a study on Earth Science, density. He describes how student difficulties with ratio reasoning can lead to difficulties with the concept of density, even among university students.
De Berg (1995) conducted a study on student understanding of the volume, mass and pressure of air within a sealed syringe in different states of compression. He studied the responses of high school students in England. Only about one-third of students demonstrated a qualitative understanding of these concepts.

Anderson (1989) conducted a study on pupils conceptions of matter and its transformation. This paper reviews some of the research literature on the ideas of high school students about matter, including chemical reactions, phase transitions, conservations of matter, and the nature of atoms and molecules.

**Energy.**

Across the field of research studies on pupil’s ideas about energy, several recurring conceptualizations of energy have emerged. Energy is seen as:

- Associated only with animate objects
- A causal agent stored in certain objects
- Linked with force and movement
- Fuel
- A fluid, an ingredient or a product

*Energy and living things.*

The idea that energy is associated with living things and particularly with human beings is reported from several studies. Watts and Gibert (1985) describe several frameworks observed among children one of these involves ‘human centered energy’ in which energy is associated mainly with human beings or with objects which were treated as if they had human characteristics. Such anthropomorphic views were found to be held by pupils of all ages including ‘A’ level students.

Solomon (1983) examined children’s thinking about energy by asking them to write three or four sentences showing how they would use the world
‘energy’. Human activities, health, food and fuels all figured prominently in pupil’s responses, which showed a movement with age away from the idea of energy associated only with living activities and also a significantly greater interest in living associations on the part of girls than among boys.

Solomon outlined four themes into which responses fell. Two of those were:

- Vitalism, in which energy is thought to be needed for life (as in when we run out of energy we need medicines and vitamins and exercise is good for you, it builds up your energy)
- Activity, in which we are thought to need energy to more (as in ‘when we run out of energy we need food and rest’ and exercises use up energy, than you become tired)

**Energy, movement and force.**

Many children appear to link energy with movement and force. Stead (1980) found that those children who associated energy with inanimate objects often suggested movement or the lack of it, as determining whether energy was present or not. Absence of activity was reported by Bliss and Ogborn (1985) as an explanation given for energy not being attributed to a situation. Watts and Gilbert (1985) found an obvious activity framework among their subjects, in which energy was associated with over displays of movement. Often the outward display itself was thought of as the energy: energy was thought of as doing.

Duit (1981) notes a close association between energy and force in children’s response. Watt and Gilbert (1983) also found some students using the ward ‘force’ and ‘energy’ Synonymously and some treating the two concepts as distinct but interconnected.

Ault *et. al* (1988) found an undifferentiated view of energy, work, force and power amongst their students, and Barbeta *et. al* (1984) suggest that
confusion in the use of the words ‘force’, ‘energy and ‘work’ is not only terminological but conceptual the latter group found that two-thirds of the pupils who had not been exposed to the concept of energy in class thought that it was something necessary for movement and/ or that it was a type of force. The remaining pupils offered no ideas. The majority of pupils who had been introduced to the concept of energy answered by giving text book definitions or by question forms of energy.

Brook and Driver (1984) also found that pupil’s notions of energy movement and force were strongly associated. Almost one in five of their pupils focused on the amount of force which a ball-bearing had at different points on a track and some used the words force in a way similar to that in which a scientist would use ‘kinetic energy’. About one in ten children Thought that a truck would have energy only when moving, or would have most energy when moving. These researchers suggest that students tend to focus on directly observable features of phenomena rather than on abstract ideas (such as energy) which are often used by scientists.

Confusion between energy, force friction, work and gravity was identified by Stead (1980) who also noted that potential energy was confused with the potential to have energy.

Several researchers have found pupils holding ideas of energy as a fuel, with global perspectives and ideas about limited resources. One of the themes which Solomon (1983) identified in children’s responses relates to shortage of energy in the future and the need for new sources of energy to meet the worlds needs. Duit (1981) found that German students closely linked energy with fuels and electricity, although this was not the case for students from the Philippines.

Stead found that for pupils ‘energy’ was synonymous with fuel and that phrases like energy crisis and conserve energy meant fuel crisis and conserve fuel. Children had the notion that fuel is energy rather than that fuel ‘contains’ or is a source of energy.
Watts and Gilbert describe the fundamental model of energy in which energy is a very general kind of fuel. Energy is associated mainly with technical applications. It is not seen as essential to all processes but just those which make life comfortable. A similar notion of energy as a fuel was also noted by Ault et. al.

Gravity.

Several studies investigating children’s ideas about the earth gravity. Selman et. al (1982) has classified pupils thinking about unseen forces in general, identifying broad phases in which they perceive unilateral, then multiple and balanced forces. Others have studied developing ideas about gravity in particular. A detailed study, by stead and Osborne (1980) of New Zealand pupils aged 11 to 17 revealed ideas of gravity pushing, pulling or ‘holding’ appeared to be the most common perception of gravity and this was bound up with ideas of gravity being connected with air pressing down and with an atmospheric shield which prevents things floating away. The notion that there must be air for gravity to act appears to be widespread. It has also found among. Italian middle school pupils by Ruggvero et. al (1985). The idea that gravity is in some way related to air has implications, of course, for the way pupils think about gravity acting in space, on the planets and on the moon. Relating gravity to air appears to offer an explanation of gravity which less outside objects rather than in terms of a property of all objects. Stead and osborne found only one pupil in a sample of 42 who had the idea that all objects exert a gravitational force.

A considerable amount of work has been directed towards pupil’s ideas about the way gravity changes with height above the earth’s surface. Significant numbers appear to hold the physicists view that the force of gravity decreases with height above earth surface. Stead and osborne (1980) found one – third of a sample of 257- 14 year old thinking this way and Ruggiero et. al (1985) also found this idea among 12 and 13 year olds. However, it appears that pupils who hold this view tend to expect a far bigger decrease in the force of gravity with increasing height than is actually the case.
Stead and Osborne (1980) also found one-third of their 14 year old sample holding the view that gravity increase with height above the earth. This idea was also present among pupils studied by Ruggiero et al. (1985). Pupils holding this the ‘higher the stronger’ gravity view assume this applies until things get outside the earth’s atmosphere. Watts (1982) found that pupils with 12 – 17 age range thought that gravity depends upon height, but they appeared to confuse gravity with potential energy in assuming a higher force of gravity at greater height.

**Lunar phenomena.**

Childrens (Barnett & Morran, 2002; Dove, 2002; Sharp 1998; Taylor & Jones, 2003; Trumper, 2001) Science and non-science university students (Zeilik and et. al, 1998), preservice teachers (Suzuki, 2003; Trumper, 2003) and in-service Teachers (Parker & Hey Wood, 1998; Summers & Mant, 1995) conceptions of the moon and some lunar phenomena have been a central focus for various studies from different countries. Some of these studies were conducted after the instruction and the results were compared with those gathered before instruction.

Dove (2002) for example, analyzed the response to nine questions about astronomical events provided by 98 girls attending a secondary school in the UK after they were instructed for a certain period. She found that the reason why the moon always presented the same face to the earth was less well understood and estimations of the time in earth days from sunrise to sunrise on the moon varied.

Taylor & et. al., (2003) worked with elementary students in New Zealand and implemented a 16 day period of teaching intervention. They found that while 53% of the students determined the moon as the main cause of tides on earth in the pre test, the rate was increased to 100% after 11 intervention lessons. Moreover, whereas 9% of the student in the pretest accepted the sun’s affect on tides, the number was 63% in post test. They reported that before the intervention almost all student know that the moon could be seen in the day time sky, but none of the students selected scientists responses for the cause of moon phases.
Suzuki (2003) found that pre-service teachers had some knowledge of the moon; however, they assumed that the moon could only be seen at night.

Trumper (2003) conducted a study on Israel student teachers and presented the following result; a considerable number of students misunderstood the role of earth and sun in the cause of moon phases. A great proportion of students reasons for seeing the same side of the moon has that the moon did not rotate on its axis, and some of the students claimed that the moon only revolved around the earth and not around the sun.

A considerable amount of research has been conducted to determine both childrens and adult conceptions of moon phases only (Collison & Wright, 1993; Dai & Capice, 1990; Rider, 2002; Stably & Sphepardson, 1990; Taylor, 1996) “there is evidence that people with vertical levels of schooling and training from elementary school through in-service Teachers do-not understood the cause of moon phases” (Trundle & *et. al*, 2002) and some of them still hold misconceptions even after they were provided a scientifically correct explanation” (Hermann & Lewis, 2003; Callison and Wright, 1993). For example determine pre-service elementary teachers scientifically inaccurate views about moon phases before the instruction and concluded that some of them kept inaccurate views after the instruction. Analysis of the research indicates that the most common misconception of the cause of moon phases hold by students is “Earth shadow falling on the moon”.

Review of the literature shows that, although from different countries, there are commonalities in people understanding of the moon and some lunar phenomena. These commonalities are follows, the moon does not rotate on its axis, the moon is the only cause of tide on earth, the moon is seen only at night, and the moon does not revolve around the sun.

Miller (2010) Quantitative estimated of the nature of the misconception among United State university students by asking them, in an open-ended response
format, to make estimates of the distances from the Earth to the Moon. The data showed that while there is great variation, a general pattern emerged that US undergraduate participants overestimated the distance from the Earth to the Moon, moderately underestimated the distance from the Earth to the Sun, and dramatically underestimated the distances to the nearer star and to the nearest galaxy.

Rosemary A, M. (2014) in a science misconception workshop focused on demonstrating instructional strategies that bring about understandings through successful verbal and written explanation of science concepts the use of academic language and modeling concepts through interactive role-play. The workshop replicated instructional intervention strategies implemented by teachers who participated with their students as a part of the authors’ research studies with middle school students it is revealed that sixty percent of students exhibited misconception in moons phases.

**Effectiveness of Conceptual Change Strategies**

Recent researches have demonstrated how different individual learners can be and how teaching methodology should vary accordingly. (Linder, 1993; Novak, 1998; ScotAsoko & Driver, 1991). The methods and strategies that can be employed to dispel misconceptions include verbalization of misunderstandings (Marioni, 1989; Scot, Asoko & Driver, 1991), metacognitive strategies (Hammer, 1989; Gorden, 1996), concept mapping ((Fraser & Edward, 1987), anchoring conceptions(Clement *et. al, 1987) analogical reasoning (Clement, 1987; Shultz; and Murrey, 1987), computer simulations (Dykstra, Boyle and Monarch, 1992) among others.

One of the most common teaching strategies for conceptual change is verbalization of the students understanding. (Marconi, 1989; Scot, Asoko & Driver, 1991). If student can group their difficulties verbally; they are a step closer to overcoming them.

Metacognitive approach can definitely help students understand where they are having difficulty with their understanding of physics. Methods for
identification of misconceptions have been proposed by Tobias (1987) and others. Most of these techniques require the student to keep journal style record of their learning and problems they have encountered in learning. (Hammer, 1989; Gorden, 1996). However, Some of the approaches are more explicit in their use of metacognition as they require the student to consciously think about how they learn best.

The concept map techniques have been a popular topic in literature for years. Concept maps illustrate the relationships between ideas in a knowledge domain as lines graphically linking key words. Through concept mapping, students learn to visualize a group of concepts and their interrelationships within a domain (Fraser & Edward, 1987).

Many preconceptions are detrimental to learning; there may be other preconceptions that are largely in agreement with accepted physical theory. These are known as anchoring conceptions or more briefly as anchors (Clement et. al, 1987). Studies have shown that significant gains can result from bridging from an anchor without the benefit of empirical demonstration (Brown, 1987). A teacher can help a student more conceptually from anchor to target by using a bridging analogy (Clement, 1987; Schulz & Murray, 1987).

Analogical reasoning as a tool for helping students overcome misconceptions is described by different researcher as bridging analogies or chains of analogies (Clement, 1987; Shultz; and Murrey, 1987). Computer based tutors have been programmed to use bridging analogies or conceptual chain to tutor students in such topic as forces in static (Schutz, Clement & Brown, 1987). The software chooses how to present information to the user dependent on their responses.

Various technologies have been shown useful in confronting and remediating misconceptions. Computer simulations run within a constructivist classroom will bring the students to question their own conceptions (Dykstra, Boyle and Monarch, 1992). Commercially available computer simulations help students avoid forming misconceptions (Coleman, 1997) and can be used to
challenge students conceptions through the presentation of discrepant events (Tao & Gunstone 1999).

There is no common instructional strategy for all misconcepts. It will vary according to the nature of concept. Eventhough many studies are done abroad about the identification and remediation of misconcepts, it is necessary to do a study here by locally because misconceptions can arise by locally prevailing beliefs, metaphors, instructional environment etc (Ivovi & Oludotum, 1987).

So the proposed study is an attempt to identify the misconcepts in physics among VIII standard students in Kerala and to test the effectiveness of an instructional programme developed out of an eclectic array of strategies tried and found effective else where by some isolated successful teachers and researchers. This will help the normal physics teacher by prescribing him a set of proven strategies appropriate for remediation of the most prevalent misconceptions in Kerala context.

**Conclusion**

From the literature research, it appears that misconceptions are much more complex and prevalent than simple misunderstandings or receiving incomplete information. There are multiple methods for arriving at misconceptions. They can occur as result of misunderstood vocabulary or they can occur because of combining several ideas into one. Some are caused by deeply held beliefs, while others are caused because the recipient was overwhelmed with information causing a shutdown of all processing. Misconceptions can also occur from not knowing where or how to look to find the correct answer. The next thing that calls for investigation is how teachers can help students to confront and overcome their misconceptions.

Majority of the studies done on the area of misconception were on above high school level. All of them were done abroad. There is lack of sufficient studies regarding the misconception among high school students especially in Kerala. Majority of the studies confined to a few areas and rest to be revealed and conquered by further studies.