Review of Literature on Student’s Misconceptions in Science

Author

Dr. Manmeet Oberoi (Baweja)
Professor cum Principal Shah Satnam Ji College of Education, Sirsa
E-mail:- drmanmeetoberoi@yahoo.in

ABSTRACT

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

Key Words: Misconceptions, Conceptual learning, concepts, concept mapping, learning.

INTRODUCTION

Children come to school already holding beliefs about how things happen, and have expectations - based on past experiences- which enable them to predict future events. Science educators who were interested in conceptual development have used a variety of terms to describe the situation in which students’ ideas differ from those of scientists about a concept, like student’s misconceptions, naive theories, alternative conceptions and alternative frameworks (Blosser, 1987). Students do not come to the classroom as “blank slates” (Resnick, 1983). Instead, they come with the theories constructed from their everyday experiences. They have actively constructed these theories and use these to make sense of the world are, however, incomplete half truths (Mestre, 1987). These are misconceptions.

But it is not just kids who have these misconceptions (Black, 2006). Gardner (1991) says many highly educated adults rely on the “models, beliefs, and theories” they developed as preschoolers. It is argued that misconceptions serve the needs of the persons who hold them (Blosser, 1987). These erroneous ideas may come from strong word association, confusion, conflict or lack of knowledge (Fisher, 1985). Misconceptions are a problem for two reasons. First, they interfere with learning when students use them to interpret new experiences. Second, students are emotionally and intellectually attached to their misconceptions, because they have actively constructed them. Hence, students give up their misconceptions, which can have such a harmful effect on learning, only with great reluctant (Mestre, 1999).

A brief account of some related studies is being reviewed to provide acquaintance with causes and identification of misconceptions in science learning.
CAUSES OF ERRORS AND MISCONCEPTIONS IN CONCEPTUAL LEARNING

The sources of errors and misconceptions must be identified for effectual conceptual learning. Many researchers found various causes of misconceptions among students. Some studies revealed that misconceptions were related to the nature of concepts or the lack of knowledge of the concepts, text books, confusion, language and overgeneralization etc. The varied causes of errors and misconceptions identified by researchers are discussed as below:

Longden (1982) identified sources of misconceptions and learning difficulties by interviewing academically sound students who were having difficulty with genetics. The results indicated that misconceptions were related to nature of concepts used in genetics, such as frequent representation of meiosis by fixed inanimate stage diagrams and to instructional strategies.

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

Cho, Hee-Hyung et al. (1985) found high school biology text books as sources of misconceptions and difficulties in genetics to determine possible sources of misconceptions and related learning problems associated with genetics.

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

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

Pearson and Hughes (1988) examined the technical vocabulary of genetics as a source of error and confusion and reported misuse of terms in textbooks.

Mahapatra (1989) observed that children made a great deal of conceptualization on the basis of their observation of the day to day happenings in the environment and home situations. In this process they formulated alternative concepts about things, objects and events.

Kesidou and Duit (1993) conducted clinical interviews with 10th class students. The main misconception was that heat transfer starts and does not stop at once when temperatures have equalized. The main reasons for this kind of thinking was- these ideas were based on everyday experiences and not on a scientific basis as taught in schools.

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

Sanger (1997) identified the student’s misconceptions about electrochemistry and found the text books as the possible sources to misconceptions.

Palmer (1998) used a multiple choice instrument to identify the students who hold alternative conceptions about force and motion. It was concluded that the contextual error was the factor which resulted in inaccurate diagnoses of alternative conceptions in students.

Tyson, Treagust and Bucat (1999) used a two-tier test, coupled with interviews from a case study, to explore student’s understanding of what happens when reaction mixtures at equilibrium are disturbed. According to the findings, language turned out to be a key factor, causing misinterpretations by students.
Ross (2004) studied children’s misconceptions of animals as the concept, by interview of elementary junior high school students to name five animals and animals as a group. It was revealed from the response patterns that for defining the animal as a concept, students consider ambiguous and often conflicting pieces of information when classifying animals.

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

IDENTIFICATION OF ERRORS AND MISCONCEPTIONS IN SCIENCE LEARNING

In this section, we give a brief, critical review of major published studies relating to research on identification of misconceptions in science by various researchers over the past nearly forty years. An array of tools viz. interviews, multiple-choice questions, concept mapping, drawings, two-tier and three-tier diagnostic tests were used to assess the existence of errors and misconceptions in conceptual learning which are discussed briefly as follows:

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

Haslam and Treagust (1987) described a multiple choice instrument that reliably and validly diagnosed secondary school students’ understanding of photosynthesis and respiration in plants. A high percentage of students were found to have misconceptions regarding plant physiology.

Treagust (1988) explained the use of diagnostic instruments for identification of misconceptions and identified misconceptions for covalent bonding and photosynthesis and respiration in plants.

Dreyfus and Jungwirth (1989) diagnosed the concepts of secondary school students about living cell as the basic unit of life. The results indicated the presence of misconceptions among students about cells.

A research was conducted by Amir and Tamir (1990) to define misconceptions about photosynthesis. A specially designed paper and pencil test was administered to students. The results showed that even though these students were familiar with the concept of limiting factors, they had trouble applying it in everyday life.

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

Hill (1997) examined the conceptual change through the use of student generated analogies of photosynthesis and respiration. There were eleven items and a three tier multiple choice instrument was designed to assess the common misconceptions. There was no significant change in performance between the pretest and post test administration. But the confidence in their responses about the two concepts had increased.

Voska and Heikkinen (2000) developed a ten-item pencil and paper, two-tier diagnostic instrument, and used it to identify and quantify chemistry conceptions students’ use when solving chemical-equilibrium problems.
problems. Eleven prevalent misconceptions about chemical equilibrium were identified with the help of the test. Eryilmaz and Surmeli (2002) estimated proportions of misconceptions about heat and temperature in terms of three tier test. The results have shown that the errors were due to mistakes, lack of knowledge and misconceptions. McWilliam (2002) examined misconceptions particularly in the area of force and motion. Structured interview templates, containing concept and parallel questions and predicted responses, were designed covering frequently misunderstood area of force and motion. The results revealed common misconceptions but more importantly indicated critical moments, the points where a student realizes that their apparent understanding is flawed, prior to conceptual change. Tan et al. (2002) developed a two-tier multiple choice diagnostic instrument to access understanding of high school students’ inorganic chemistry. The study showed that the grade ten students had difficulty in understanding the reactions involved in the identification of cations and anions, for example, double decomposition reactions and reactions of complex salts and thermal decomposition. Lin (2004) performed a study which involved the flowering plant growth and development. The instrument development procedure had three general steps: defining the content boundaries of the test, collecting information on students' misconceptions, and instrument development. Misconceptions were identified through analysis of the items. Sençar and Eryılmaz (2004) developed a two-tier test to diagnose the misconceptions concerning electric circuits among students. It was analyzed that most of the students had many misconceptions. In addition, it was found that females had more misconceptions as compared to males. Yen et al. (2004) examined alternative conceptions and the extent to which these conceptions remain intact through the elementary, junior and high school students. A multiple choice and free response instrument was administered to assess various levels of students' understanding of amphibians and reptiles. The results showed that most of the students were able to classify snakes as reptiles but few students classified sea turtles as reptiles, majority of the students classified sea turtles as amphibians. More students were able to correctly classify frogs as amphibians than toads. In most instances, students correctly classified “Prototypical” representatives of two animal classes more readily than less exemplary representatives. In the purpose of assessing misconceptions of ninth grade students about simple electric circuits a three tier test was developed and administered to students by Haki (2005). Students gave a lot of wrong answers because of lack of knowledge but mostly misconceptions. Parallel circuit misconception was the most common misconception. Kutluay (2005) developed a three-tier test for assessing misconceptions among students about geometric optics. The proportion of false positives and false negatives was estimated to be 28.2% and 3.4% respectively. The results showed that the proportions of misconceptions were observed to lessen gradually as the tiers of the tests increased one by one, due to mistakes and lack of knowledge while the proportions of the correct responses were observed to lessen gradually as the tiers of the tests were increased one by one, and were due to false positives and lack of knowledge. Chandrasegaran, Treagust and Mocerino (2008) developed a two-tier multiple choice diagnostic instrument to evaluate the secondary school student’s ability to describe and explain chemical reactions using multiple levels of representations. Despite the emphasis on multiple levels of representation during instruction, fourteen conceptions were identified that indicated confusion between macroscopic and submicroscopic representations, a tendency to extrapolate bulk macroscopic properties of substances to the submicroscopic level and limited understanding of the symbolic representational system.
Klymkowsky and Gravin (2008) developed Biology Concept Inventory. Results indicated a striking lack of understanding on two questions related to randomness, even after three major's courses in molecular, cell and developmental biology at the University of Colorado at Boulder.

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

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

Bayrak (2013) identified primary students’ conceptual understanding and alternative conceptions in acid-base. For this reason, a 15 items two-tier multiple choice test administered to 56 eighth grade students in spring semester 2009-2010. Data for this study were collected using a conceptual understanding scale prepared to include the concepts used in the subject of “Acids and Bases”, which is a part of the unit “Structure and Properties of Matter” taught in the eighth grade Science and Technology course. The conceptual understanding scale was developed by the researchers to identify the alternative conceptions students might have concerning this subject. The scale consists of diagnostic tests (n=15) designed to measure levels of understanding among students concerning the subject of acids and bases, and to identify their ways of thinking and rationales. Data were first analyzed by tabulating students’ answers to the first tier of each question, and the percentages of the reasons they selected for their answers. Analysis of results showed that students find difficulty about conceptual understanding and they have some alternative conceptions related to acid-base.

**IMPLICATIONS**

The misconceptions are barriers in teaching learning process as students are emotionally attached to them and bestow up their misconceptions with great efforts. For the success of teaching learning process it is henceforth imperative to identify, acknowledge and breakdown the misconceptions.

- This paper will help the teachers to identify the misconceptions among their students which will help to enhance the achievement of the students.
- The review of the literature about the identification of misconceptions will provide a lead to future researchers, not only in the area of science, but in other subject areas as well.
- It will provide some suggestions to the educational practitioners to adopt new strategies to avoid misconceptions and increase the probability of high achievement of students.
- New researchers and teachers can use various tools to identify misconceptions.

**REFERENCES**


