REVIEW OF SELECTED LITERATURE ON STUDY OF MISCONCEPTION IN SCIENCE AMONG TEACHER EDUCATORS IN PUNJAB

Ms. Harmeet Kaur

Research Scholar

Desh Bhagat School of Education

Desh Bhagat University, Mandi Gobindgarh

Abstract

The modern world is a world of science. From rudimentary human needs of food, shelter and clothing to health, industry, agriculture, defence and environment, science has a prodigious effect on every nook and crevice of human existence. Teaching-learning process is a fundamental mechanism of exploration and manifestation of latent capabilities, proficiencies and abilities of an individual. It assists in conservation, communication and development of human beliefs and is an entrance way to novel boulevards of brilliance. Learning is the process of modifying our intellectual prototypes to provide accommodations to new experiences. It is an act of refurbishment and reorganization of different skills. The students who arrive in the classroom with inappropriate pre-existing notions about the world, which are not in harmony to scientific explanations, are said to have misconceptions. Misconceptions are also called as pre-conceptions, naïve conceptions, naïve theories, alternative conceptions and alternative frameworks (Blosser, 1987). The review of studies in present chapter is intended to put together the experiential confirmation regarding the misconception in science among teacher educators in Punjab. The errors and misconceptions among individuals at different stages and in different subjects have been studied so that the learning gaps in education have been explored and have to accomplish the level of mastery learning in teaching learning process.

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

Introduction

Effective science teaching requires creativity, imagination, and innovation. In light of concerns about American science literacy, scientists and educators have struggled to teach this discipline more effectively. Science Teaching Reconsidered provides undergraduate science educators with a path to understanding students, accommodating their individual differences, and helping them grasp the methods--and the wonder--of science.*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.

Studies Related To Diagnosis of Errors and Misconceptions in Science

Halloun and Hestenes (1985) analysed the post graduate students of Physics for the comprehension of the concept of motion. They reported that almost every student used amalgamation of concepts and appeared to be inconsistent in application of the same concept in different situations concerning linear and projectile motion.

Ameh and Gunstone (1988) scrutinized Nigerian school teachers' understanding of science conceptions and the results elucidated that teachers had same range of misconceptions as students and these misconceptions passed through teaching in students.

Abraham et al. (1990) employed five chemistry concepts to assess the students' understanding of chemistry concepts and to detect specific misconceptions. A general failure of textbooks to teach a rational understanding of chemistry concepts was specified.

Westbrook and Marek (1990) scrutinized 7^{th}-grade life science students, 10^{th}-grade biology students, and college zoology students for understanding of the concept of diffusion. It was highlighted that many of the misconceptions could be sketched to misapplication of scientific terminology.

Bodner (1991) acknowledged the misconceptions of graduate students related to the concept of rusting of iron. He asked the students to predict the change if any in weight of the iron after rusting. The results indicated that 10% of the students in his sample predicted that the weight of an iron bar would be less after rusting and another 6% predicted that the weight would remain the same.

Hapkiewicz (1992) identified misconceptions on the concepts of light and sound with the facilitation of a questionnaire. The conclusions showed that the common misconceptions were: loudness and the pitch of the sound is the same thing; sound cannot travel through solids and liquids; colors appearing on the soap films and oil slicks are reflections of the rainbows and the size of the image depends on the size of the lens used to form the image

Driver (1993) piloted a study to find out the misconceptions of students about the conservation of matter under physical and chemical transformations. The conclusions showed that many students could not apply the law of conservation of mass to chemical and physical changes. The outcomes also indicated that nearly half of the students surveyed advocated that the weight of steel wool would decrease after burning and that the mass would change when dissolving sugar in water.

Nakhleh and Krajcik (1994) investigated various misconceptions of secondary students understanding of acid, base and pH concepts. The results shown that the students had various misconceptions viz. pH is invariably related to harm and bases are not harmful; bubbling is a sign of chemical reaction; pH is a compound called phenolphthalein, a chemical reaction and a number related to intensity; acids are strong and bases are not strong.

Grayson et al. (1995) conducted study on a physical class comprising fifth grade (11 year old) boys in Australia in order to track pupils' development of the concepts of heat and temperature. The students were provided with course material called "Physics by inquiry: heat and temperature" and then changes in their understanding were examined. Various misunderstandings were identified viz. objects could have some quantity of heat in them; objects could get hotter than their surroundings; the temperature of water could exceed the boiling point.

Huddle and Pillay (1996) conducted an investigation into the misconceptions held by students at South African University. The students were required to balance an equation and determine the mole amount of each product. Only 38% of the students were able to successfully complete the question though 91% were able to balance the equation.

Graham and Peek (1997) pointed out understanding of some aspects of rigid body motion and it was found that developing an understanding of rigid body motion was not easy, and misconceptions that sample had with particle mechanics could be carried forward to cause further problems with rigid body motion.

Graham and Berry (1997) delineate a transparent link between the developments of students' understanding of force within the direction of motion's misconception/preconception. A model was given to the participants that showed that as students touched from a read dominated by this idea or preconception to a Newtonian read, they undergone variety of intermediate stages. They additionally showed that a lot of students had not reached the upper levels of understanding before they went on to contemplate application of Newton's law of motion.

Hardt and Paula (1997) examined student's understanding of electrical circuits. The results showed that each high school and university students had misconceptions regarding electricity resistive electrical circuits. Students attended confuse term particularly current and appointed the properties of current to voltage and/or for resistance.

Rowland et al. (1998) created associate degree investigation of students' understanding of moments of forces to supply some indication on the character of intuitive concepts during this space. The results showed three obstacles within the abstract understanding of moments of forces. The primary obstacle looked as if it would contain issues wherever the forces applied were still acting vertically, however the points of application of the forces weren't at a similar horizontal level. The second obstacle looked as if it would either contain issues wherever the forces applied were vertical however there was no obvious sense of symmetry, or issues that painted an abstract link between moments and rotation. The third obstacle contained queries whereby the coed had to acknowledge the road of action of to the suitable force and observe of the purpose of application of the force.

Houssart and Weller (1999) hold a study on identifying and dealing with misconceptions and errors in primary mathematics with the aid of an assignment, based on students keeping a diary of misconceptions which arose while they were working in school and to ask the students to write an essay based on the dairy. It was finished that in some students' diary and related assignment increased their awareness of common misconceptions in mathematics while some students found it hard to participate with the issue of the difference between a misconception and an error and thus found it difficult to reduce or avoid misconceptions in mathematics.

Orhun (2001) investigated the levels of learning in the subject of Mathematical Physics on the topic trigonometry and mistakes and misconceptions in trigonometry. It was found that students' mistakes were very systematic which were mainly due to faulty teaching method.

Pine et al. (2001) investigated the process of conceptual change and described experiential studies into children's naive theories of physics concepts by surveying 122 teachers of primary science in England. It was stated that children held many incorrect ideas about the science topics that could not be sidelined by the teachers to effectively bring about conceptual change in the students.

Kusnick (2002) examined narrative essays-stories of rock formation- written by pre-service elementary school teachers who had completed a college-level course in earth science. It was described that misconceptions arose from deeply held but largely unexamined beliefs called as conceptual prisms.

Chen and Lin (2003) constructed a two- tier multiple choice test- diagnostic tool for identifying students' understanding and learning problems in geometric optics held by junior and senior high school students. The results depicted that the students' misconceptions about the image formation still persisted through their schooling years despite the related scientific concepts had been met numerous times.

Sencar and Eryilmaz (2004) identified and analyzed plausible features that intervene the effect of gender on ninth grade Turkish students' misconceptions in relation to electric circuits. It was specified that overall performance of the students was comparatively low and witnessed gender difference was mediated on the total scores on the practical terms.

Kutluay (2005) conducted a study on finding of eleventh grade students' misconceptions about geometric optics with the assistance of a three-tier test. He informed that all errors were not misconceptions. Some errors might arise from lack of knowledge and henceforth added third tier to the multiple and reasoning parts of the items i.e. first and second tiers of a diagnostic test respectively.

Chen (2006) developed and validated a two-tier diagnostic assessment test for atmosphere and to explore the types and classification of atmospheric misconceptions of the 9^{th} and 10^{th} grades after they had received instruction in atmospheric classrooms. It was indicated that teachers themselves and students' intuition developed misconceptions in the students.

Kucukozer and Kocakulah (2007) discovered secondary school students' misconceptions about electric circuits in Turkish schools and it was conveyed that everyday language was one of the causes of the misconceptions.

Hancer and Durkan (2008) examined the misconceptions about the subject of force and movement in seventh and eighth class elementary science curriculum. Results specified that students of both the classes had many misconceptions about the concept of force and movement. It was also observed that although 8^{th} class students studied force and movement in previous year, they had the same misconceptions and same ratio as the 7^{th} class students.

Sharma (2008) conducted a study to identify the misconceptions of the students relating to mechanics. The sample consisted of students of Senior Secondary stage, I^{st}, II^{nd}, III^{rd} and IV^{th} year of B.Sc. B.Ed. course, one/two year of B.Ed. course and Post-graduate teachers of Physics. The tool comprised Mechanics Baseline Test (MBT) established by Hestenes and Wells (1992) and experimental activities. It was specified that pre-conceptions was accredited to the ineffective transactional strategies, incompetence to apply the knowledge, lack of interest in the content and lack of internalization of the concepts.

Gafoor and Shyni (2009) analysed misconceptions in Physics and Biology among 625 student teachers in Teacher Training Institutions in Malappuram District of Kerala. Tests of achievement and concept attainments used as research tools discovered that there were more misconceptions in Physics than in Biology and the prevalence of misconceptions was across all levels of overall achievement.

Sharma (2009) focused on students' misconceptions related to ozone depletion and global warming. Six open-ended diagnostic questions were administered to 103 randomly selected lower secondary school science students in Trinidad and Tobago. The findings discovered that students had a number of misconceptions about ozone depletion and global warming.

Risch (2010) examined arithmetic and physics ideas of 941 engineering students. Results indicated that the most reason behind idea was shifting imagination from troublesome exponential thinking to simple linear thinking.

Kambouri, M. (2011) examined teachers' response to early year's children's misconceptions in Cyprus. The results indicated that often teachers do not acknowledge the existence of these misconceptions and this is likely to be an obstacle for children's learning.

Miller et al. (2011) deliberated the methodology used to identify important and difficult thermal and transport science concepts included in the TTCI instrument. The sample consisted of 1,200 students of more than 20 engineering schools. It was shown that the schema training approach did not help students in the experimental group repair misconceptions about the emergent nature of heat conduction.

Gardner, R.M. and Brown, D.L. (2013) constructed and evaluated a contemporary misconception test based on popular myths in psychology. Misconceptions in psychology are commonplace, strongly held, and can be problematic for teaching accurate information. This study examined several predictors of misconceptions in eleven psychological topic areas. Participants were 137 undergraduate students from two higher education institutions. On average, participants believed misconceptions to be partly true and partly false. There were significant differences in misconception levels between the 11 topic areas. Reported reading of news magazines predicted lower misconception scores. It has been concluded that students continue to believe many popular misconceptions and that identification and refutation of those misconceptions is necessary as part of the instructional process.

Taylor, A. K., and Kowalski, P. (2014) highlighted that teachers are well aware that education is at least partly a matter of informing students that some of what they think they know just isn't so. From the belief that Columbus fought against those who claimed the earth was flat to students' certainty that increasing self-esteem causes better school performance, inaccurate prior knowledge exists in every domain. Not only are these beliefs pervasive, they can be particularly (and frustratingly) resistant to instruction. In physics (Hake, 1998; Kim and Pak, 2002), biochemistry (Morton, Doran & MacLaren, 2008), history (Leinhardt and Ravi, 2008), and psychology (Kowalski and Taylor, 2009) researchers and even the best instructors (e.g., McKeachie, 1960) find students enter class with misconceptions and leave with them intact. In addition, even when research shows short-term gains in correct knowledge, these gains often disappear over time (Liddy and Hughes, 2012). It has been concluded that inaccurate prior knowledge as the broadest term referring to students' initial knowledge, when it is inaccurate has been elaborated. Although one rarely knows the exact underlying nature of a student's inaccurate knowledge, "alternative conceptions" or broad frameworks of mistaken knowledge from misconceptions, more specific inaccurate beliefs has been differentiated.

Kaulu, G. (2015) extracted one of the research questions from a PhD study on conceptions and performance of student teachers of physics in basic electronics. The study sought to investigate the misconceptions student teachers of physics hold about basic electronics in the Zambian context. A mixed-methods approach was employed to investigate the issues involved. The study revealed several misconceptions held by student teachers of physics in basic electronics, the common ones being that: Cathode rays are waves which travel at the speed of light (32%), Half wave rectification produces an output, part of which is direct current and the other part an alternating current (38%), and that a capacitor discharges when it is not part of a circuit (33%). In view of these findings, the study recommended that: Lecturers at the University of Zambia (UNZA) who handle physics student teachers in introductory electronics should address this issue, for a possible solution.

Chattopadhyay, D. (2016) described situations where textbooks actually promote misconceptions in physics students. The particular case of weighing a filled balloon was taken up. An experimental approach to exploring this topic has described, bringing home the fact that because of Archimedes' principle, one cannot weigh air in a container surrounded by air at the same pressure. This example was used to make some general points about addressing misconceptions.

Kuczmann, I. (2017) reported that misconceptions are beliefs that contradict accepted scientific knowledge but they are seemingly supported by commonsense arguments. Misconceptions in physics attest the lack of recognition of existing physical correlations but improper ideas can often be found in their place. From testing of misconceptions, it was deduced, that they are also related to the structure of knowledge. Some basic rules (the rule of completeness of information, the knowledge of closely related ideas, the existence of entire trains of thought, and the thorough knowledge of basic principles) were identified as a tool for the elimination of the students' misconceptions, a distinct guidance to the prevention or elimination of misconceptions is proposed based on this.

Halim, A.S. et al. (2018) pointed that student misconceptions are an obstacle in science, technology, engineering, and mathematics courses and unless remediated may continue causing difficulties in learning as students advance in their studies. Writing-to-learn assignments (WTL) are characterized by their ability to promote in-depth conceptual learning by allowing students to explore their understanding of a topic. This study sought to determine whether and what types of misconceptions are elicited by WTL assignments and how the process of peer review and revision leads to remediation or propagation of misconceptions. The authors examined four WTL assignments in an introductory biology course in which students first wrote about content by applying it to a realistic scenario, then participated in a peer-review process before revising their work. Misconceptions were identified in all four assignments, with the greatest number pertaining to protein structure and function. Additionally, in certain contexts, students used scientific terminology incorrectly. Analysis of the drafts and peer-review comments generated six profiles by which misconceptions were addressed through the peer-review process. The prevalent mode of remediation arose through directed peer-review comments followed by correction during revision. It was also observed that additional misconceptions were elicited as students revised their writing in response to general peer-review suggestions.

Bozzi, M. et al. (2019) pointed out that many higher education students have a fairly large number of mistaken ideas on some Physics topics. Consisting of three main stages closely connected with each other, the research aimed at identifying, comparing and overcoming the most significant and widespread misconceptions shown by first-year university students enrolled for engineering, in relation to their basic knowledge of Physics, with specific reference to Mechanics, Thermodynamics and Electromagnetism. It is being developed by Politecnico di Milano [ITA] along with Doshisha University [JAP] and Bauman Moscow State Technical University [RUS], which offer Physics and Engineering courses, as well as with Università degli Studi di Trento [ITA], which provides pedagogic support. First of all, data about the above mentioned misconceptions were gathered by each technical institution through the use of an ad hoc test, which consisted of 12 multiple choice quizzes administered to about 750 students attending the 7 courses globally involved in the research. Hence, misconceptions related to the main macro-areas were further classified according to specific headings, i.e. kinematics, heat engine, electric field, among others. Secondly, the misconceptions expressed by the students attending the different universities involved in the research were compared. They appear to be broadly widespread among the freshmen, with Electromagnetism being the macro-area where the students' results are the worst. Throughout the third and final stage of our study, a trial video has been produced to enable students to overcome some significant misconceptions.

Soeharto, S. et al. (2019) provided information about an overview of the common topics that students usually get misconception in science, and diagnostic assessment used to identify students' misconception in science. This review also provided a comparison of every instrument with the weaknesses and the strengths reviewed from a total 111 articles that had published from the year 2015 to 2019 in the leading journal having the topic of students' misconceptions in science. This study revealed that 33 physics, 12 chemistry, and 15 biology concepts in science that mainly caused misconceptions to students. Furthermore, it found that interview (10.74%), simple multiple-choice tests (32.23%) and multiple tier tests (33.06%), and open-ended tests (23.97%) are commonly used as diagnostic tests. However, every kind of tests has benefits and drawbacks over the other when it is used in assessing student conception. An expert user like teachers and researchers must be aware when using diagnostic assessment in the learning process, exceptionally to construct student conception.

Overview

From the above cited studies undertaken, the following conclusions can be deducted viz.

1. Many researches have been done in numerous subjects to identify the naïve ideas of the individuals that can create learning difficulties (Arnaudin and Mintzes, 1985; Phillips, 1991; Boyes and Stainstreet, 1991; Driver, 1993; Lee et al., 1993; Marques and Thompson, 1997; Palmer, 1998).
2. Researches have also been conducted to ascertain misconceptions of different concepts of Physics (Fredette and Clement, 1981; Cohen, Eylon and Ganiel, 1983; Ameh and Gunstone, 1988; Piburn et al., 1988; Hapkiewicz, 1992; Haki, 2005; Kucukozer and Kocakulah, 2007; Hancer and Durkan, 2008, Gafoor and Shyni 2009, Gardner and Brown 2013; Kaulu, 2015 Chattopadhay 2016, Kuczmann 2017, Bozzi 2019).
3. Researches have been done to diagnose misconceptions of varied concepts of Chemistry (Treagust, 1988; Rose, 1989; Abraham et al., 1990; Schmidt, 1996; Sindhu and Sharma, 2004; Cetin, 2007).
4. Researches have been undertaken to detect misconceptions of different conceptions of Biology (Barrass, 1984; Fisher, 1985; Eisen and Stavy, 1988; Westbrook and Marek, 1990; Odom and Barow, 1993; Khalid, 1999; Cakir and Crawford, 2001; Hershey, 2004).
5. Researches have been done to recognize misconceptions of many concepts of Mathematics (Orton, 1983; Houssart and Weller, 1999; Orhun, 2001; Steinle, 2004; Miller,2011).
6. Errors made by the learners were identified by some researchers (Raman, 1989; Shook, Linda Jean, 2003; Bhise, Desetty and Patnam, 2004; Soeharto 2019).
7. Many researchers have established different causes of misconceptions. Some researchers discovered that misconceptions were related to the nature of concepts/lack of knowledge of the

concepts (Graham and Berry, 1997; Eryilmaz and Surmeli, 2002; Hershey, 2004; Sindhu and Sharma, 2004, Risch,2010).

8. Certain studies established that misunderstandings/ misconceptions were disseminated by teachers (Barrass, 1984; Kinderfield, 1991; Debra, 2000; Sanders, 2006; Taylor and Kowalski 2014).
9. Textbooks were found to be the source of misconceptions and complications by some researchers (Barrass, 1984).
10. Certain studies determined that children made a great deal of concepts on the basis of their observation of day to day happenings resulting in the establishment of misconceptions (Mohapatra, 1988; Galleogos et al., 1993; Halim et al. 2018).
11. An array of studies reported that children inclined to puzzle the terms (Chandrasegaran, Treagust and Mocerino, 2008).
12. Some studies determined that overgeneralization was the reason of misconceptions (Hershey, 2004).
13. Misclassification and misidentification were found to be the sources of misconceptions (Fisher, 1985; Chen and Lin, 2003 ; Kambouri,2011).
14. Certain studies reported language inaccuracy to be the foundation of misconceptions (Mestre, 1989; Comins, 1993, Sharma,2009).

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