

Identification of Misconception Using A Three-Tier Test

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Abstract

This research paper is on the identification of misconceptions among students of standard ten in selected areas of Physics. Today's classroom learning demands active involvement from the part of the students. Misconceptions possessed by students are barriers in learning because learning is not only based on the learning situation provided, instead it depends on the existing knowledge of the learner. If the knowledge possessed by the learner is erroneous, it prevents the correct concept formation. So, knowing what the student knows is an important factor in the teaching-learning process. After identifying the discrepancy that the learner has, the teacher can take necessary steps to bridge the gap so that the students are capable of generating new knowledge. The objective of the study is to identify the misconceptions that exist among students of standard ten in selected content areas of Physics. The misconceptions were identified using content analysis, semi-structured interview guide, conceptual understanding test in Physics and misconception identification test in Physics. The analysis of the data proved that there exists a misconception among the students of standard ten in selected content areas of Physics.

KEYWORDS : misconceptions, identification, like individualization, pattern, hierarchical

INTRODUCTION

The motivating force behind the study of Physics and its application must be the students' desire to be a responsible citizen, to understand the world around and to enrich the life of the people whom he is associated with. An important objective of teaching and learning Physics is to promote the understanding and application of principles and concepts in addition to training of the mind, development of skills and infusion of right attitudes. A student in Physics should be able to observe, think logically, draw conclusions and to make the right decisions. In future they will be faced with new situations, circumstances and problems which require critical analysis and discussion with colleagues before reaching the final right decision. It is to this end that the education and training of a Physics student should be directed.

Physics teachers need to teach the essentials of Physics while encouraging the learners to experience the excitement and fascination of Physics. They should also educate the students through the training of the mind, the development of skills and the infusion of right attitudes and equip them for the variety of roles and activities necessary for active participation and leadership in society.

Need and Significance of the Study

Students come to the classroom with a lot of naïve ideas about science that they have developed over the years. If the knowledge possessed by the student is erroneous, it hinders the process of learning or result in erroneous learning. Thus the

erroneous or incorrect knowledge usually termed as Misconceptions need to be identified and corrected before starting the instruction. The Misconceptions are not normally identified in ordinary classes. As a result, the purpose of the teaching strategy fails to meet the proposed goal.

For the understanding of science, the students need to be realized that their views are inconsistent with the accepted facts. In the development of understanding, maturation and learning play a vital role. The quality of understanding is determined by three essential factors - the ability to see relationships, the ability to comprehend the underlying meanings and the ability to reason. Usually learners' concept formation is characterized by certain factors like individualization, pattern, hierarchical, development from undefined to specific and from specific to general, emotionally weighted, frequently resistant to changes. The conceptual framework thus formed influence the quality of behaviour.

The major hazards in the correct concept formation are developmental lag in understanding, Misconceptions, and barriers in changing Misconceptions. Misconceptions are faulty interpretations of different sensory experiences (Hurlock, 2008). If the students' pre-instructional knowledge is erroneous, illogical or misinformed, it is termed as alternative conceptions or Misconceptions (Lucariello and Naff, 1997). When these experiences are associated with wrong meanings, it may give rise to faulty concepts. Major causes of Misconceptions are incorrect information, limited experience, gullibility, faulty reasoning, vivid imagination, unrealistic thinking, misunderstanding of words and confusion (Hurlock, 2001).

The Misconceptions may be temporary or long lasting. Although the cognitive aspect of a concept can be changed as the child gathers more information, the affective aspect of emotional weighing is likely to persist. Thus the child finds difficulty in changing the Misconceptions and it continues to affect cognitive adjustments unfavourably.

The students come to the class with some pre-instructional knowledge about the topic to be taught in the classroom. Therefore assessing learning before and after teaching is equally important. Prior assessment helps the teacher to check whether the student have essential pre-requisite knowledge needed to learn the new concept and the common Misconceptions that may interfere with the learning process.

Certain ideas developed by students may not match the most current evidence. Additionally, some science concepts may be difficult to grasp. Hence, its understanding may be flawed. In this way, even adults including teachers may sometimes maintain Misconceptions of material (Burgoon, Heddle & Duran, 2010). The presence of any form of Misconception can hamper the learning process. Since, Misconceptions tend to be resistant to instruction; teachers are put in a challenging position to bring about significant, needful conceptual change in the student. Since ordinary forms of instruction have proved to be unsuccessful in overcoming student Misconceptions, the Misconceptions remain as a problem to be resolved. For the formation of correct concepts, misconceptions have to be identified challenged and rectified.

Studies Related to Misconceptions

As the students come to formal learning environment with various Misconceptions (Gilbert & Watts, 1983), many of the research studies during 1970s addressed on (i) what the students learn (ii) the difficulties the students faced in grasping fundamental concepts and (iii) the variation of students concepts from that of the scientists.

The studies reported on the development of various tools for the identification and categorisation of Misconceptions. Some of them were (i) Interview (Fisher, 1985) and (ii) Two tier diagnostic test (Haslam & Treagust, 1987; Odom & Barrow, 1995). Of the various strategies and tools used for revealing Misconceptions, it was reported that diagnostic questions (Kaewkhong, Mazzolini, Emarat, & Arayathanitkul, 2009) are effective in revealing Misconceptions. The use of analogy in teaching (Podolefsky & Finkelstein, 2006; Dilber & Duzgun, 2008) is found to be suitable for teaching for Misconceptions. In the present study, the investigators made an attempt to reveal the misconceptions in Physics among standard ten students in the secondary schools of Kerala state following CBSE curriculum.

Objective of the Study

The study was intended to identify the different Misconceptions of the students of Standard ten regarding the selected areas from 'Refraction of Light' and 'The Human Eye and the Wonderful World'.

Methodology

The topics selected for studying Misconceptions among the students of Standard ten were selected areas from 'Refraction of Light' and 'The Human Eye and the Wonderful World'. Data were collected using Content Analysis, Conducting Semi-structured Interview and Conceptual Understanding Test in Physics for identification of Misconception areas. Then the data were subjected to analysis which served as the basis for the preparation of Misconception Identification Test in Physics (MITP). MITP is used to conduct survey for the identification of misconception among the students of Standard ten. The scores obtained were subjected to analysis.

Sample for the Study

The investigators collected data by (i) Analysing the content of Physics text book of Standard ten of CBSE curriculum to find out the possible Misconceptions that may arise in the concepts in the selected content areas of 'Refraction of Light' and 'The Human Eye and the Wonderful World' of Standard ten Physics. (ii) Conducting the Semi-structured Interview to students of Standard ten using the Semi-structured Interview Guide. The investigators interviewed 12 students comprising of five boys and seven girls of Standard ten from the schools. It served as guideline for the preparation of questions for the Conceptual Understanding Test in Physics. (iii) Administering Conceptual Understanding Test in Physics to randomly selected 100 students of Standard ten in order to identify Misconceptions in its depth and extend. The answers obtained served as the basis for the preparation of questions and responses for the construction of 'Misconception Identification Test in Physics'. The sample selected for surveying the Misconceptions in Physics by administering the Misconception Identification Test in Physics consisted of randomly selected 400 students of Standard ten from the secondary schools in Trivandrum, Alappuzha and Kottayam districts. The test was administered and the results were subjected to analysis.

Tools and techniques used in the Study

The tools and techniques used in the study were:

1. Content Analysis
2. Semi-structured Interview Guide
3. Conceptual Understanding Test in Physics (CUTP) developed by the investigators
4. Misconception Identification Test in Physics developed by the investigators

Content Analysis

The purpose of Content Analysis in the present study is to identify the concepts included in the content area and to spot the concepts which may cause potential Misconceptions. It is achieved by breaking the content into its constituent parts and arranging them in sequence. The investigators analysed content qualitatively in order to identify the terms, facts, concepts and formula included in the selected content of 'Refraction of Light' and 'The Human Eye and the Wonderful World', which may cause potential Misconceptions and to list out the possible Misconceptions. To prepare the coding categories, the investigators classified the entire content as terms, facts, concepts and formula.

Semi-structured Interview Guide

In a Semi-structured Interview, the interviewer and the respondents engage in a formal interview, where the interviewer uses a formal 'Interview Guide' which contains the list of questions or topics in a particular order, that should be covered during Interview. The investigators prepared the interview guide on the basis of Content Analysis, discussion with secondary school Physics teachers and personal experience. It included introduction of the interviewer, preliminary details of the interviewee, and questions to be asked during the Interview.

Conceptual Understanding Test in Physics

Conceptual Understanding Test in Physics contains open-ended questions. These questions address concepts, process and skills that go beyond the specifics of instructions to define a subject area and also require higher mental process from students than simply memorizing facts. In the present study, the investigators used Conceptual Understanding Test in Physics to find out the various Misconceptions in Physics among the students of Standard ten.

The investigators prepared the open-ended questions which the respondent have to answer in his / her own words. The test items were selected and prepared on the basis of (a) Content Analysis (b) student Misconceptions revealed during the Semi-structured Interview (c) related literature (d) question banks and e) online questions. The selected items were divided into two series of test (CUTP-A and CUTP-B) along with space for answering. Each set consists of 10 questions and each student had to answer only one test, for expressing a clear understanding of the concept he/she has.

Construction of the tool 'Misconception Identification Test in Physics'

To find out the Misconceptions that exist among students, different diagnostic tools have been developed, each having its own advantages and disadvantages. In order to overcome the limitations of the interview and multiple choice items, the researchers have developed two tier and three tier tests. The two tier test was first developed by Treagust,(1988). In it, the first tier consists of multiple choice question. Among the set of choices of responses provided, the respondent is expected to choose the correct response for the question. The distracters form the wrong answer or Misconception. The second tier requires the respondent to give reason for his/her selection of response from the choices given in the first tier. Critics of two tier tests observe that it lacks the ability to distinguish between the gap in knowledge and Misconceptions and hence it overestimated the percentage of Misconceptions (Griffad & Wandersee, 2001). In order to overcome this limitation, researchers have developed three tier test to determine Misconceptions. In the three tier test, the first two tiers are same as that of two tier test. In the third tier, the respondent is asked whether he/she is confident or not about his/her response given in the first and second tiers, which

reveal whether the response is due to lack of knowledge or Misconception. Because of the advantage of three tier test over two tier test, the investigators decided to develop a three tier test to identify the Misconceptions in Physics of students of Standard ten on the topics- 'Refraction of Light' and 'The Human Eye and the Wonderful World'.

The Findings of the Study

The identified Misconceptions through Content Analysis, Semi-structured Interview and Conceptual Understanding Test in Physics and MITP revealed the presence of Misconceptions among students of Standard ten regarding the selected areas of 'Refraction of Light' and the 'Human Eye and the Wonderful World'.

The probable Misconceptions identified through Content Analysis

The category wise list of content and anticipated Misconception in Physics obtained through the Content Analysis of the selected areas of 'Refraction of Light' and 'The Human Eye and the Wonderful World' presented in the Physics text book for Standard ten published by NCERT are listed below..

1. Light is brightness.
2. Light expands on entering certain media.
3. Presence of sun is required for reflection.
4. The more the energy associated with light, the greater the distance it travels.
5. The distance travelled by light depends on brightness of light source.
6. Shining depends on reflection. More the reflection, more shiny is the object.
7. Light always travel in a straight line.
8. Light stays on a mirror during reflection.
9. A straight line can represent a light as in the case of lighted bulb shown in pictures
10. Misconception regarding the arrow and pointing direction of arrow.
11. Arrow is not a necessity to represent light ray.
12. Light ray never bends.
13. Light always travels in a straight line with same speed.
14. Bending of light is an optical illusion.
15. Bending can occur anywhere even in the same medium.
16. Optical density is the property of light.
17. Adding more water to a flat vessel need not enable the vision of object at the bottom of the vessel.
18. When an object is viewed through a transparent material, the object is seen exactly where it is.
19. In a prism, refraction takes place inside the prism (as it is usually represented in figure given in the textbook).
20. In a prism, when light enters and leaves, there is only one refraction - at the first face alone.
21. Refraction occurs at the centre of the prism.
22. Light travels in a straight line even if it enters a prism.
23. Light travels in a straight line through a transparent media.
24. In a glass slab, the ray bends towards the glass slab base.
25. Refraction occurs at the centre of the glass slab.
26. Total internal reflection does not depend on optical density of the medium.
27. Reflection depends on the polishes of the surface.
28. Reflection of an object is seen at the surface of the mirror
29. In mirrors, total internal reflection occurs; hence we can see the object completely.
30. Total internal reflection is a property of the light alone as reflection is a property of light.

31. Mirage is an imagination
32. It is the defect of the eye as one is not able to see anything just like after looking at the bright sun.
33. Water is present on the road due to previous day's rain; it reflects light and thus water is seen in tarred road.
34. Optical fiber is made of mirror to reflect light.
35. Lens absorbs light.
36. Light expands on entering into lens.
37. Lens always form image at a single position.
38. The size of the image formed by a lens is determined by the diameter of the lens.
39. Real images can be seen only on a screen.
40. Real images are formed on the same side of the lens.
41. Virtual images are erect.
42. Virtual images are imaginary images, seen in virtual laboratory.
43. Eye receives upright images on the retina.
44. Image formation is the responsibility of lens alone.
45. Brain has no role in vision; it is concerned with mental activities.
46. The image formed by the eye lens is looked upon by the brain which enables us to see the objects.
47. Eye defects in children are due to misuse of our eyes by over watching TV, computer etc.
48. Reading in dim light can result in eye defect.
49. Lens in spectacles form image, eye has no role; hence removal of spectacles obstruct vision.
50. All instruments make use of same type of lens: the instrument determine the function.

Students' Misconceptions revealed through Semi-structured Interview

From the responses given by the students in the Semi-Structured Interview, the investigators identified the following Misconceptions.

1. Light is the same as brightness.
2. Misconceptions about the path of light as it are a straight line.
3. When light travels through prism and glass slab, it expands and reaches everywhere inside and illuminates prism and glass slab.
4. Bending of light (refraction) occurs when light rays hit on obstacle.
5. When light hits on a polished surface, total internal reflection occurs.
6. Mirage is a property of the eye.
7. The higher the energy of the source, the longer the light wave travels as in the case of sun and electric bulb.
8. While moving the lens, the image becomes larger or smaller.
9. Real image is the actual image of an object.
10. Virtual image is seen in a virtual laboratory.
11. In an optically denser medium, the density of light is more.
12. Thickness of a lens determines the power of a lens.
13. Optic centre is the centre of a light ray.

Students' Misconceptions revealed through Conceptual Understanding Test in Physics (CUTP)

The Conceptual Understanding Test in Physics, consisting of 20 statements, 10 in each set, related to various concepts on the selected areas of 'Refraction of Light' and 'The Human Eye and the Wonderful World' was administered to 100 students of Standard ten. After administering the Conceptual Understanding Test in

Physics, each response was analysed and the one which reflects Misconception was assigned a category according to similarities in meaning. Thus meaningfully similar responses to an item fall under a particular category. The table 1 gives the category of misconceptions identified through CUTP.

Table 1 - Summary of Categories of the Conceptual Understanding Test in Physics

Category Number	Category Titles	Frequency
1	Conceptual misconceptions about light and light ray	12
2	Misconceptions about lens	23
3	Misconceptions about relation between magnification and image formation of lenses.	38
4	Conceptual misconception about optical illusion	22
5	Misconceptions about defects of vision	18
6	Conceptual misconception about refraction of light	59
7	Misconception about atmospheric scattering and atmospheric refraction	25
8	Misconceptions about ray and ray diagram	41
9	Conceptual misconceptions about total internal reflection, mirage and optical fiber	37
10	Misconception about focusing in microscope and telescope	8
11	Conceptual misconception about optical density	19

Misconceptions Identified through the Misconception Identification Test in Physics (MITP) among the students of Standard ten

The investigators measured the Misconceptions in Physics among the students of Standard ten by administering the (MITP) to 400 students of Standard ten, selected randomly. The maximum attainable score in the MITP is 20. The investigators scored the response sheet of MITP to get the score of Misconceptions in Physics and used the frequency distribution table and the descriptive statistics Mean, Standard Deviation in order to find out the distribution of Misconceptions in Physics. The frequency distribution and the descriptive statistics of the scores on Misconceptions in Physics of students of Standard ten are given in table 2 and table 3.

Table 2 - Distribution of scores on Misconception in Physics among the students of Standard ten

Class Interval	Frequency	Percentage
0-4	134	33.5
5-9	205	51.25
10-14	58	14.5
15-19	3	0.75
Total	400	100

From the table 2, the investigators observe that among the 400 students only three students have got Misconception score above 15. The percentage of students who have misconception score between 10 and 14 is 14.5. Majority of students (51.25%) have misconception score between 5 and 9. Some students (33.5%) have misconception score less than 4.

Table 3 -Results of the Descriptive Analysis of the scores on Misconceptions in Physics of the Students of Standard ten

Number	M	SD	Skewness	Minimum	Maximum
400	6.63	3.46	1.02	0	18

Note: M- Mean, SD- Standard Deviation

From the table 3, the investigators observe that the Mean and Standard Deviation of the scores on Misconceptions are 6.63 and 3.46 respectively. The Skewness of the distribution is 1.02. From this, the investigators infer that the frequencies are clustered more at the lower part of the distribution and, therefore, most of the students have low Misconception score.

CONCLUSION

The study revealed that the Misconception Identification Test in Physics, meant to identify the Misconceptions in Physics, revealed the Misconceptions of students of Standard ten regarding the selected areas of 'Refraction of Light' and 'The Human Eye and The Wonderful World' and it was proved that there exists misconceptions among the students of Standard ten. The findings of the study help the classroom teachers to identify their students' Misconceptions before starting the teaching and rectify the same during the teaching. Thus a correct concept may be formed in their mind. Such conceptual change is to be happened each classroom which result in correct conception and effective learning.

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