TEXTBOOK: A SOURCE OF STUDENTS' MISCONCEPTIONS AT THE SECONDARY SCHOOL LEVEL

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This paper discusses the results of a survey conducted in relation to students' ideas about various life processes such as respiration, photosynthesis and transport of material. The paper further discusses the causes that may have led to the misconceptions. In the process of identifying the causes for the students' misconceptions, the authors analyzed NCERT and SCERT Science textbooks of secondary level and identified that the textbook is one of the sources of students' misconceptions. School textbook is a major resource in school for both teachers as well as students. The accurate information, illustrations and clarity of contents included in the textbooks play an important role in the learning process. Therefore, textbook should be carefully chosen in order to facilitate students' learning and to prevent the misconceptions being reinforced and/or induced.

Keywords: Misconceptions, Life processes, Textbook analysis, Instructional material

INTRODUCTION

Various researches on science education, over the past three decades, have confirmed that, school students come to the classroom with numerous misconceptions, that is, interpretation of various phenomenon, that differ, often radically from those accepted by the scientific community. Misconceptions make it difficult for students to learn accepted views or textbook theory and are often left unchanged by classroom instruction. According to Perkins and Simmons (1988), to replace students' misconceptions with the textbook contents amounts to affecting a conceptual change because the perspective offered by naive ideas is generally so different from the precise concepts that the information presented in class cannot be assimilated without major restructuring.

One of the major concerns in the field of education all over the world and much research in science education are focused on students' misconceptions. Several studies related to students' misconceptions in physics, chemistry and mathematics have been conducted in India, but not many have been conducted in biology (Deshmukh & Deshmukh, 2007). Hence, this study on students' misconceptions in biology (life processes) at secondary school level has great significance in India and elsewhere.

SOURCES OF MISCONCEPTIONS

A search of related literature reveals that textbooks, reference books, teachers, language, cultural beliefs and practices are some of the principal sources of high school students' misconceptions of many science concepts including those in biology.

Textbook as a source of misconception

Textbook is a tool used in the teaching-learning process and is the guide for teachers and students. It is the tool to show the scope and limitations of the curriculum and a major resource in school sciences. The textbook is usually regarded by educators throughout the world as a good source of information for teaching. Abimbola and Baba (1996) stated that American biology teachers rely solely on textbooks for use in their instruction. According to them, "Nearly 90% of teachers use a textbook 90% of the time". In India too, science teachers, rely solely on textbooks for the appropriate content materials that satisfy the requirements of the science syllabi and the national curricula in the different science subjects. Textbooks are perhaps the only learning materials available and used in most Indian schools.

The textbook as a tool of instruction has great significance in learning because it presents a treasure of knowledge to students and also creates real interest for subjects. If the instructional material contains any defective knowledge or information, the consequences will be serious for students and hence for the whole country. In India most textbooks are prepared by the government bodies such as, the National Council of Educational Research and Training (NCERT) (2006), Delhi and are used all over the country for central schools, or by the State Bureaus of Textbook Production and Curriculum Research, for use in state

schools. In Maharashtra, the Maharashtra State Bureau of Textbook Production and Curriculum Research, Pune prepares textbooks for use in the state schools of Maharashtra (2006).

Aim of the Study

This study aims to investigate the prevalence and persistence of misconceptions among students, related to life processes and to determine whether textbooks play a role in inducing or reinforcing students' misconceptions.

Research Methodology

The present study is a descriptive survey research studying the misconceptions in Biology of Secondary school students.

Designing a tool for data collection

A written test was constructed consisting of the following four open ended questions based on life processes, such as photosynthesis, respiration and transport of material.

1. Why heart is known as an important organ?
2. What is the exact meaning of respiration?
3. Are breathing and respiration the same?
4. Do the processes of photosynthesis take place during the day and respiration at night?

Sample selection

The content involved in this study is the part of the State Board syllabus (SBS) of class IX and Central Board syllabus (CBS) of class X. The sample was selected from these two clusters involving a total of six schools; 2 urban English medium schools and 3 rural vernacular schools of State board and 1 school of Central board. The final sample consisted of 378 students of class IX from State board and 62 students of class X from Central board. The number of girls was 197 and boys 243 in the total sample of 440.

Procedure of data collection

The written test was administered to these 440 students and their responses were sought. The researchers also conducted interviews of few students who followed SBS. The aim of these interviews was to find out the sources of students' misconceptions.

Data Analyses and Discussion

Responses to these questions were analyzed separately. The text books were also analyzed in relation to the responses received from students. The salient findings of the analyses are presented below:-

Responses to Q. 1 revealed that many students did not have lucid notion about function of heart. It was found that 314 (71%) students (278 SBS and 36 CBS) mentioned that, heart converts impure blood into pure blood. They also mentioned that heart pumps pure blood to different parts of the body. Surprisingly, 72 SBS and 26 CBS students mentioned that our emotions are stored in the heart. According to 37 students (28 SBS and 9 CBS), heart is an actively responsible organ for blood formation. This group also mentioned that heart pumps pure blood to different parts of the body. Only 112 students explained proper function of the heart.

Interviews: According to Student-1 *'heart is very vital organ, because our feelings, emotions and life are stored in it'*. When asked 'how do you know this?' He replied that his parents had told him. Language textbooks and movies also exhibit romantic ideas about this organ. Student-2 said that, *'heart converts impure blood into pure blood by filtration'*. According to Student-3, *'heart is helping in inhalation and exhalation of air that is why we can see the movement in chest*'.

Observations: It was found that many students did not have scientifically correct notions of structure and function of the heart. The words used in Marathi for pure blood and impure blood (oxygenated and deoxygenated respectively) have added to the confusion. Since the heart is a symbol of love and an origin of feelings in literature the students got confused.

SBS Textbook- Information about the structure of the heart is provided under the title *'Transport of Materials and Excretion'*, (p. 132). The information of various parts of the heart is given without giving the function of each part. In the diagram of the heart; many arrows show the direction of blood flow (for e.g. the right atrium receives deoxygenated blood and left atrium receives oxygenated blood), generating confusion among students.

CBS Textbook- In this book, chapter five entitled '*Life Processes'* a coloured picture of the heart is given (p. 106). The right side of the heart is shown in blue and the left part is in red (figure 6.10 & 6.11). Information about various parts of the heart is also given without giving the function of all the parts. The right atrium is shown receiving carbon dioxide rich blood and the left atrium is shown receiving oxygen rich blood. The blue colour of the right side of the heart creates misconceptions among students that the blood in the right part of the heart is blue in colour.

Discussion: Student's misconceptions about human physiology have been associated also with the way teachers and textbooks present the information and with incorrect use of language in class (Barrass, 1984). Even teachers considered purification as the main function of the heart (Deshmukh, 2009). Since, scientifically heart is just a pumping organ and is not concerned at all with blood purification, filtration, and formation, such terms 'purification', 'pure blood', 'impure blood' 'oxygen rich', 'carbon dioxide rich', and 'emotions' should not be used by teachers and textbook authors. The pictures and figures should be correct. Buckley (2000) found that when children explain blood circulation, they often have misconceptions similar to those portrayed in textbook illustrations.

Research suggest that students are unable to apply models to physiological situations or are missing critical facts such as the right and left ventricle contracting at the same time. Misunderstanding about blood circulatory system can escalate when elementary or secondary school teachers hold their own misconceptions. Yip (1998) evaluated science teachers' knowledge of the circulatory system. In the study, teachers were asked to underline incorrect statements about blood circulation and provide justification for their choices. Most teachers were unable to relate blood flow, blood pressure and blood vessel diameter (Dikmenli & Cardak, 2004). Although teacher education programs focus on teaching principles, methodology, and practice, few provide deep understanding of science content.

Responses to Q. 2 and Q. 3 showed that 319 (73%) students (272 SBS and 47 CBS) did not see any difference between breathing and respiration. They mentioned that respiration means breathing. Many students did not see much difference between respiration and breathing processes. Also 217 students (182 SBS and 35 CBS) mentioned that, respiration is a process of taking oxygen in and giving carbon dioxide off. Few students (56) also mentioned that, respiration takes place only in animals and humans. A considerable number of students have difficulty in distinguishing between respiration and breathing.

Interviews: Student-1, said respiration means we take in oxygen through nose and give out carbon dioxide and it is necessary for life. Student-2 believed that plants only release oxygen gas because this is mentioned in our science textbook. According to Student-3, we take oxygen in and release impure air and this process is observed only in animals and humans. Some animals do respiration through tracheae, others through lungs and still others through gills and skin.

Observations: Most of the students have a common misconception that respiration and breathing are the same. Understanding of the conceptual difference in the two terms, that respiration refers to cellular metabolism and breathing refers to the inhalation and exhalation of air is absent. The word 'respiration' is used commonly at the school level. Students have been taught that our lungs are a part of respiratory system, which may add confusion. No doubt, the notion of cellular respiration is difficult to understand at the school level.

SBS Textbook- Respiration is one of the most important life processes of all living organisms. The term 'respiration' is used in a broader sense for the gaseous exchange of taking in oxygen and releasing carbon dioxide. However, this applies to the organisms having respiratory organs, especially animals. Plants do not have special respiratory organ (p. 117). Under the modes of respiration, cutaneous respiration, branchial respiration, tracheal respiration and pulmonary respiration is mentioned (p. 120). The information about oxidation of organic food is given in mitochondrial respiration in animals but no such mention is seen in case of plants.

CBS Textbook- It explains the cellular respiration processes directly- The food material taken in during the process of nutrition is used in cells to provide energy for various life processes. Diverse organisms do this in different ways - some use oxygen to break-down glucose completely into carbon dioxide and water; some use other pathways that do not involve oxygen (Fig. 6.8). In all cases, the first step is the break-down of glucose, a six-carbon molecule, into a three-carbon molecule called pyruvate. The content is very difficult to understand and activities suggested are also unclear.

Discussion: Terms like 'respiratory system', 'respiratory organ' and 'respiratory centre', in which 'respiratory' actually means 'breathing' are commonly used in text-books and by teachers. This is the main source of confusion for students. As Soyibo (1983) has demonstrated, all these terms are misleading, ambiguous, confusing and capable of breeding students' misconceptions as they indeed did in this study. The process of respiration occurs in the mitochondria of all living cells. The term, 'gas exchange or breathing organs' not respiratory organs should be used. Again, rather than say "external respiration", gas exchange or breathing is the correct term. According to Driver (1989) the use of this term in everyday language is a reason of student's misconceptions. Sanders (1993) noted that, this is a typical misconception held by many students worldwide. Not only students' but also teachers' misconception on various physiological processes are due partly to the tendency of some authors to define such terms almost exclusively in relation to animals particularly humans (Songer & Mintzes, 1994).

Responses to Q. 4 brought out the misconception about photosynthesis and respiration strongly. It was observed that 297 (63%) students (263 SBS + 34 CBS) mentioned that photosynthesis takes place during the day, whereas respiration takes place only at night. The textbooks are not very clear about the two processes. More emphasis is given to the process of photosynthesis while plants respiration is just mentioned. Few students responded that plant release only oxygen & use carbon dioxide.

Interviews: Student-1 opined that plants do not respire. They just release oxygen. According to Student-2, respiration takes place all the time in animals. But plants respire only at night, since they perform photosynthesis during day. We carry out plantation for getting more and more oxygen during day time. Student-3 stated that plants used water and carbon dioxide as raw material during photosynthesis and released oxygen. So there is no respiration during day time. They release carbon dioxide in the night. Therefore at night we should not sleep under the tree.

Observations: For many of the students who hold these misconceptions, photosynthesis is merely a process of exchange of gases. According to them, the plants photosynthesize during the day and conduct cellular respiration only at night. This information is mentioned in the

textbook. However, cellular respiration is a continuous process. They seem to be unaware of the existence of a complex biochemical process by which light energy is utilized to produce complex organic molecules from simple inorganic molecules.

SBS Textbook- It gives details about what is photosynthesis, site of photosynthesis, mechanism of photosynthesis and essential factors of photosynthesis (p. 111-113). In the entire text when photosynthesis takes place and when respiration occurs in plants is not mentioned.

CBS Textbook- Similar to SBS textbook, information is given about site of photosynthesis, mechanism of photosynthesis with equation, structures of stomata and many activities are described (p. 95-97). In the whole text the fact that the processes of photosynthesis take place during the day whereas respiration takes place all the time in the plants is not mentioned.

Discussion: A common students' misconception is that plants photosynthesize during the day and conduct cellular respiration only at night. The emphasis on the process of photosynthesis must have resulted in the misconception that cellular respiration occurs only at night in plants. The concept of photosynthesis, which is usually taught at upper and secondary school levels, is considered important yet quite difficult to teach and to learn. Research in Israel (Amir & Tamir, 1990) revealed a number of prevalent misconceptions about photosynthesis, such as: (a) plants get organic materials ("food") from the soi1 (b) water and minerals taken in from the soil are sources of the plant's "food" (c) photosynthesis is the respiration of plants (d) photosynthesis takes place during the day whereas respiration takes place only at night. Wandersee, Mintzes and Novak (1994) also found identical misconceptions among college students.

Findings and Suggestions

The responses and the interaction helped the researchers to identify the following reasons for student confusion and misconceptions:

— It is a well known fact that students are not 'blank slates', they come with their ideas and experiences. So there is often unexplored conflict between students' everyday experiences and the classroom or textbook presentation.

— The language used by teachers and textbooks creates confusion in some students.

— Everyday use of certain terms, such as respiration, weak heart, impure blood and pure blood, impure air, etc. often used in non-scientific contexts, contributes to students' confusion. Some words have many different connotations in the English language and the "scientific word" can easily be confused with a commonly used term.

— At school level many concepts, such as photosynthesis, circulation, respiration, excretion, are just too abstract for many students who are still at a concrete learning stage. It is difficult for many students to understand these concepts if they are not concretized.

— In teacher education programme there is a need to prepare teachers to look critically at school textbooks so that the advantages and limitation of the textbook are identified and ways of overcoming limitations are designed.

— Science teachers, particularly upper primary school teachers, should be aware of numerous science misconceptions in the teaching literature.

Conclusions and Implications

Findings indicated that many students and textbook writers have misconceptions about various biological concepts. These misconceptions were found to be generally based on social practices and school experiences but also may have come from the textbooks.

1. The illustrations given in the textbook play a significant role in the learning process as they can facilitate the understanding of the scientific content. Therefore, they should be carefully chosen in order to facilitate students' learning and to prevent their alternative conceptions from being reinforced and/or induced by them. Leite and Afonso (2000) emphasized that; teachers should be made aware of the role of illustrations as well as about their powers and limitations not only in order to select the most appropriate textbooks but also in order to help students to cope with illustrations that have severe problems.
2. Many science textbook authors, teachers and students, are unaware of many of the misconceptions in science textbooks and the dangers such misconceptions pose to a thorough understanding of biology concepts. They must be made aware of common misconceptions to tackle the problem (Storey, 1992).
3. Authors of science textbooks should expunge or reduce the misconceptions in their books which students and teachers conventionally regard as infallible documents.
4. Textbooks are human enterprises and should not be expected to be perfect materials. However, more care should be taken by the textbook writers as many a times it is the only source of authentic content for many a teachers and students.

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