PERCEPTIONS OF THE UPPER PRIMARY STUDENTS ON RESPIRATION AND RESPIRATORY SYSTEM

Animesh Kumar Mohapatra* and Saptabarna Mukharjee

Department of Life Science Education, Regional Institute of Education, Bhubaneswar
***Email:** akmncert@gmail.com

The research studies from a developmental or psychological perspective indicate that many children reside in an ideal world devoid of appropriate scientific understanding. They are thought to accumulate a huge variety of naive concepts, which are a product of their ideas supplemented with the surrounding social milieu. The mismatch in the opinions portrayed in the scientific world versus their ideas gradually compels the students to develop alternative conceptions, leading to their entrapment into a highly interwoven web of misconceptions. The living world and various physiological systems housed within a living body are areas of great familiarity for the students. However, it cannot be negated that in reality the upper primary students are only exposed to the superficial images of the organ systems and are totally in the dark about the mechanisms of processes occurring within a living body. This gradually leads to imbibing certain alternative conceptions and misconceptions in them. This study is focused on investigating the variety of probable misconceptions of several concepts under the topic of respiration and highlighting the relevant genesis. Proper administration of the tests comprising of open-ended questions to a lot of 34 students of Class VIII, who are already acquainted with the topic in their previous classes and interviewing a few of them provides detailed qualitative and quantitative data of the misconceptions along with their origins. A search through the literature reveals that the formal, informal and non-formal learning resources contribute to the inhibition of misconceptions, a few of which include textbooks, reference books, teacher's language, cultural beliefs, etc. The questionnaires asked in the interview are an indirect attempt to create a cognitive conflict in the students' minds and challenge their misunderstandings to facilitate the students to overcome them. Hence, it highlights the importance of the skill of questioning in the teaching-learning process as well as its efficiency in serving as a remedy for misconceptions.

Keywords: Enquiry-based Learning, Respiration, Heart, Misconceptions, Formal, Informal and Non-formal Learning

Introduction

The study of nature, commonly tagged as science, is both a process and a product. Regarding science as a process of enquiry-based learning, it emphasises learning mediated through a series of steps, which includes observing and defining a practical problem, framing hypothesis, conducting experiments, collecting and interpretating data, drawing conclusion as well as revising hypothesis in case of lack of relevant results. However, science as a product can be viewed as a combination of facts, concepts, principles and theories. These fragments are integrated through a diverse network of interrelations between the definitions, concepts and definitions and concepts.

Fact is an objective consensus on a fundamental reality that has been agreed upon by a substantial number of people. In other words, it can be an information about a particular subject, especially actual conditions

or circumstances. Although, the stuff to study is a vast compilation of facts. However, education in a real sense is something that surpasses the boundary of mugging up of facts.

Albert Einstein believed that education is not the learning of facts but the training of the mind to think. Here comes the importance of concepts, which are perceived regularities of objects or events in our mind. A simple example is the statement, "mitochondria are the powerhouse of the cell" is a fact, but the reason as to why it is called so is nothing but the concept. This implies that the mere mugging up of facts is not education; rather formulating appropriate generalisations by relating facts to everyday experiences that lead to the construction of meaningful concepts. Based on Ausubelian assimilation theory (Ausubel, Noval and Haunesian, 1978), learning isolated concepts and facts is not likely to lead to a comprehensive knowledge base for any student, since knowledge is the hierarchical framework of concepts, sub-concepts and propositions along with their interrelations.

The students do not come to the school as 'blank slates' (Resnick, 1983). Instead, they are from different backgrounds with different theories in their minds constructed from a great variety of past experiences, ideas and expectations. These actively constructed theories are used to further the development of perceptions about the world. They are, however, incomplete half-truths (Mestre,1987). These are actually misconceptions. However, these are not only confined to kids (Black, 2006). According to Gardner (1991), many highly educated adults rely on the models, beliefs and theories they developed as pre-schoolers.

Many terms are coined to refer to the different misconceptions of the students that actually differ from the appropriate scientific explanations. These include naive concepts, alternative concepts, etc. The misconceptions that arise while forming ideas, notions or beliefs of a concept or process based on their previous experiential background centred on the natural world are referred to as alternative concepts. These ideas may be right or wrong but the pertinence of the latter (misconceptions) should be removed from the cognitive framework. If the learner's previous ideas do not match the scientific explanations and are partially correct, they are called naive concepts (NCERT, 2013). Relating it to Piaget's theory, these misconceptions arise due to inappropriate 'assimilation and accommodation' of the scientifically appropriate concepts into their existing schema, which leads to the persistence of the ambiguous concepts in their cognitive framework. These naive concepts need to be addressed and reconstructed, evading which will cause the persistence of the cognitive conflict produced due to naive concepts. These concepts will progressively deepen into the schema of the children and hamper further knowledge construction.

The majority of the studies carried out in the field of science now focus on students' understanding of science and their misconceptions. Since these thinking patterns are contrary to scientific realities, they pose a significant barrier to science education (Tekkaya, 2003; Wandersee, Mintzes and Novak, 1994). Misconceptions are widespread in formal education and significantly resistant to change (Modell, Michael and Wenderoth, 2005; Bahar, 2003).

If the science teachers and curriculum designers are aware of the students' misconceptions and ideas related to science concepts, it might help in preparing an effective teaching strategy. In this situation, teachers can play an essential role in teaching these concepts (O-Saki and Samiroden, 1990). Furthermore, directly challenging the misconceptions and providing appropriate opportunities for the students to reconstruct their worldview leads to a significant increase in the proportion of students, who can use scientific conceptions to explain phenomena (Fisher, Wandersee and Moody, 2001).

Numerous techniques are standardised and accepted to be effective indicators of the misconceptions and misunderstandings of the students. These include open-ended questions (Ozay and Oztas, 2003), two-stage diagnostic tests (Treagust, 1988), concept maps (Novak and Cañas, 2004; Mason, 1992), word association (Torkar and Bajd, 2006; Assaraf and Orion, 2005; Bahar, Johnstone and Hansell, 1999) and interviews (Abdullah and Scaife, 1997). Drawing methods are also used as a determiner of misconceptions as it provides a window to peep into the minds of the students laden with thoughts, feelings and perception of a particular concept (Thomas and Silk, 1990). The common masses are biased to opine that mastery in the subjects under the branch of physical sciences can be possible only by the imbibition of the concepts, whereas expertise in Bioscience can be attained by mere memorisation. However, the intense advancement in the studies related to the core and the applied areas of biology highlights that detecting and eliminating misconceptions is the need of the hour. Therefore, a study of the students' misconceptions in biology conducted on upper primary and secondary school students has great significance.

Hypothesis

The topic, 'Respiration in humans', included under the umbrella of human physiology, is selected with which the upper primary students are first familiarised in Class VII of all the CBSE schools. After going thoroughly through the pedagogical content of their level, some of the basic concepts are isolated. Among them, a few of the possible misconception areas, extending their extremities to the simple contents at one end and highly complicated content at the other end, are identified. These are enlisted below:

- The distinction between breathing and respiration.
- Track of air inside our respiratory system.
- The reasons behind entry and exit of air.
- The composition of air entering and leaving our body.
- The connection between the respiratory and circulatory systems.
- Utilisation of the inhaled air inside our body.

Method

The study was conducted in two-tier, the first tier with the administration of the written test and the second one being the semi-structured interview. Relevant open-ended questions are generated to provoke the students to think over those probable ambiguous areas, which are enlisted below:

1. Are breathing and respiration the same?
2. Why do our lungs expand?
3. What enters into our windpipes through our nostrils when we breathe in?
4. What leaves our body when we breathe out?
5. Is there any connection between the heart and lungs? If yes, what constitutes the link?
6. Where does the inhaled air go after entering the respiratory system?
7. What does the blood flowing out of the lungs contain?
8. Does our body use oxygen? Discuss the purpose.

Phase 1—A heterogeneous group of 34 students were selected from Class VIII in the Demonstration Multipurpose School, Bhubaneswar. They were provided with the above-cited open-ended questions with appropriate instructions. The time limit was also set up to 1 lesson hour. The questions were designed to probe the conceptual understanding rather than recalling the factual knowledge. The data collected with the individual written responses enabled us to work with a large variety.

Phase 2—After analysing the written responses and collecting all misconceptions, a few students were selected randomly for the interview. The interview consisted of questionnaires focused mainly on extracting the genesis of their deeply buried misconceptions. Few questions for challenging their misconceptions were also asked. An attempt was made to channel them to assimilate and accommodate the scientifically consistent ideas into their cognitive schema.

Analysis of the Written Responses

The advantage of administering the open-ended questions is that it helped us fetch the students' thoughts concerning the topic on pen and paper. In addition, various misconceptions regarding each question were enlisted and interpreted.

Are breathing and respiration the same?

Most students have an incorrect notion about the differences between the two processes. Although, most of them know that the two processes are different, they lack clarity on the differences.

A total of eight different kinds of misconceptions have been isolated. These include:

(a) They are the same but differ in their properties.

(b) Respiration is a part of breathing.

(c) Respiration is a chemical change.

(d) Breathing occurs in the nasal cavity.

(e) Breathing is an external process.

(f) Respiration involves the breakdown of only glucose.

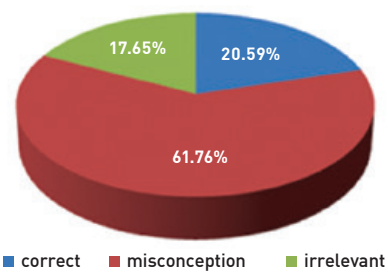

Fig. 1. Responses of students on item 1, (N=34)

The first option shows incompleteness. Options (b), (c) and (f) lack appropriateness, while option (e) shows a lack of clarity. Few unrelatable answers have also been isolated, categorised under the category of 'irrelevant'. Among these 34 answers, a unique and correct answer is also noted, that is, breathing is an extracellular process and respiration is an intracellular process with a single frequency of occurrence.

Why do our lungs expand?

This is one of the most prominent misconceptions that deserves teachers' attention. Most students cannot enlist the processes facilitating the expansion of lungs. Therefore, the correlation between the initial expansion of the lungs, caused by the movement of the associated ribs and diaphragm due to their contraction, and the subsequent increase in the volume of the lungs — thereby lowering the internal pressure than the atmospheric pressure, which allows air to enter — is incorrectly perceived by most of the students.

A list of various misconceptions collected includes the following:

(a) Lungs expand to store air.

(b) Lungs expand due to the entry of air.

(c) Lungs expand due to both entry of air and movement of the diaphragm.

(d) Air entry builds up pressure inside the lungs, making them expand.

(e) Lungs expand due to both the entry of air and the movement of the diaphragm. However, the expansion of the lungs reduces the internal pressure, which makes air enter the lungs.

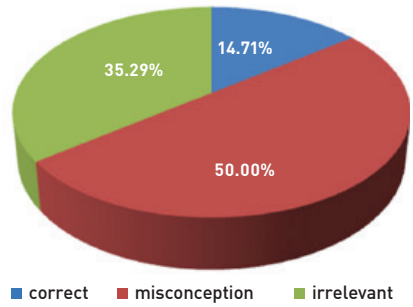

Fig. 2. Responses of students on item 2, (N=34)

Most of them perceived that it was due to the entry of air that makes the lungs expand, as shown in option (a). Some opined that the expansion of lungs was a manifestation of both the processes, that is entry of air and movement of the diaphragm, that is option (c). Very few students answered correctly with appropriate reasons. One of the students answered the correct sequence with valid reasons and extended the correlation up to the difference in pressure. However, the statement of his answer included both the reasons as shown in option (e). A few of the 'irrelevant' answers included—the lungs expand because they are essential organs.

What enters into our windpipes through our nostrils when we breathe in?

Although, the question seems very straightforward with the possible answers capably being categorised as either correct or incorrect. However, the answers showed a wide variety of misconceptions, a list of which is given below:

(a) Oxygen enters our windpipe.

(b) Air enters our windpipe because air contains many types of gases but it contains more amount of oxygen because we need oxygen.

(c) Air consisting of oxygen, carbon dioxide, dust particles and other particles enter our windpipe through our nostrils when we breathe.

(d) The oxygen mixed with dust particles enters our windpipe.

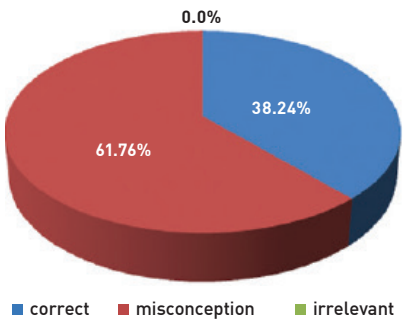

Fig. 3. Responses of students on item 3, (N=34)

Some of the students answered correctly that air enters our windpipe. A few justify the reasons according to their self-perceived incorrect notions, as shown in option (b). Most of them highlighted that only oxygen enters through our nostrils, that is, option (a), which shows that they lack the idea that air is a homogenous mixture of gases that cannot be separated through our nostrils. Options (c) and (d) indicate that some of the students lack the idea of filtering air by the nasal hairs.

One of the students among the sample mentioned the composition of air (21% O_2, 78% N_2 and others) along with the role of hairs in trapping the dust particles and finally stated that the air we inhale is rich in oxygen.

What leaves our body when we breathe out?

Specificity is indeed essential but some of them are indicators of latent misconceptions. The misconceptions regarding this are enlisted below:

(a) The exhaled air contains only carbon dioxide.

(b) The exhaled air contains other gases without oxygen.

(c) Dust and unwanted particles leave our bodies when we breathe out.

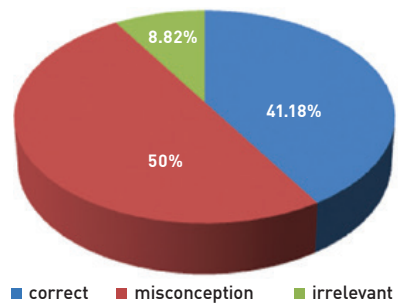

Fig. 4. Responses of students on item 4, (N=34)

The perfect answer that carbon dioxide-rich air leaves our body when we exhale has been obtained from about 14 students. However, most of the students opined that only carbon dioxide is exhaled, that is, option (a); some answered that the entire oxygen in the inhaled air was utilised by our body and not exhaled at all, that is, option (b). This is the consequence of a lack of basic idea of diffusion at such an early stage. Furthermore, the students, who answered the third option (c) were unclear about the function of nasal hairs.

Compared with the previous question, the pupils answering the third answer in this question mostly answered option (c) or (d) in the previous question. This indicates that the misconception about a single aspect can propagate recklessly in all its interrelated areas.

Is there any connection between the heart and lungs? If yes, what constitutes the link?

The respiratory and circulatory systems are intricately connected, which needs to be perceived by the students to be clear about their integrated functionality. The diverse answers regarding this are enlisted below:

(a) The heart transfers oxygen to our lungs to form oxygenated blood.

(b) The heart and lungs are connected by our bones and cartilage.

(c) The left artery and right artery connect the heart and lungs.

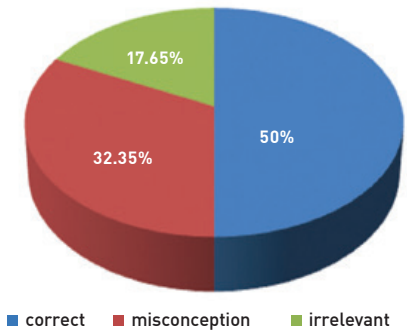

Fig. 5. Responses of students on item 5, (N=34)

Most students answered almost correctly that the blood vessels connect the heart and the lungs. Some wrote blood instead of blood vessels. However, the most appropriate answer referring to the connection to be of pulmonary blood vessels is given by very few students.

The first misconception, as mentioned in (a), indicates that students are not clear about the functions of the heart and lungs. The result of a lack of understanding of the skeletal system (course of Class VI) and organ system (course of Class VII) can be seen among those, who answered the second option, that is, (b). Finally, the third option, that is, (c), indicates that a few students cannot distinguish between artery and veins.

Where does the inhaled air go after entering the respiratory system?

The question has been framed to isolate the fate of oxygen from the minds of the students. However, indirectly it has also fetched the schema of the respiratory tract route embedded in the students' minds. Different students perceive the question differently. Hence, the collection of answers varies to different degrees. The typical answer collected mainly indicates the cell, where oxygen is carried to conduct biological combustion of assimilated food. However, some students have enlisted the entire route of the air passage. Misconception regarding the tract as written by a student includes:

Inhalation of oxygen → nasal cavity → windpipes → lungs → trachea → enter alveoli connected with trachea → oxygen enter blood vessels → heart gives out carbon dioxide → carbon dioxide transfer from the heart to alveoli → carbon dioxide to trachea → trachea to windpipe → nasal cavity → atmosphere.

This indicates that the mental model of the respiratory system is incorrectly constructed in the students' minds. The name of the heart has been mentioned in the route, which indicates that they are conscious of the integrated function of the respiratory and circulatory systems. However, the inappropriateness indicates a lack of a clear understanding of their interrelatedness.

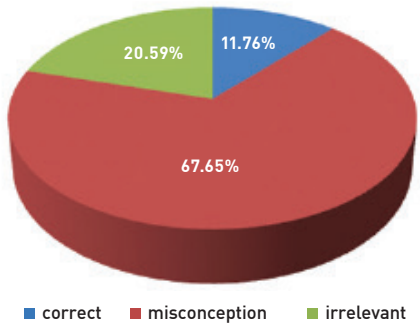

Fig. 6. Responses of students on item 6, (N=34)

What does the blood flowing out of the lungs contain?

Unlike the expected answer, that is, the blood flowing out of the lungs contain a high concentration of oxygen, a wide variety of misconceptions are extracted from the students answers which are enlisted below:

(a) Blood flowing out of the lungs contains carbon dioxide.

(b) Therefore, it contains both oxygen and carbon dioxide.

(c) It contains carbon dioxide-rich air. Therefore, when air is released from our lungs, it contains more amount of carbon dioxide and less amount of oxygen.

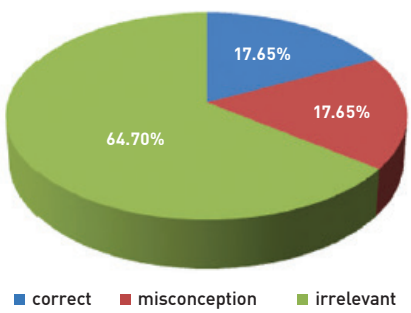

Fig. 7. Responses of students on item 7, (N=34)

The answers in options (a) and (c) are similar. The answers indicate the inability of the students to understand the question correctly. They misinterpreted that they were expected to answer the composition of the exhaled air. Some answers under irrelevant and unspecific categories include RBCs, WBCs and platelets.

Does our body use oxygen? Discuss the purpose.

The misconceptions are enlisted below:

(a) The heart takes out oxygen from the filter present in our heart.

(b) Oxygen is used in the breakdown of food, breathing and respiration.

(c) Our body uses oxygen as they help us in breathing.

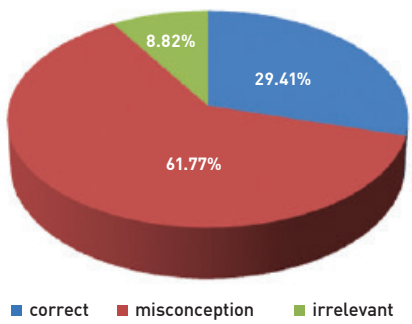

Fig. 8. Responses of students on item 8, (N=34)

The first answer reveals the presence of the students' self-constructed mental model of the heart structure. Half of the second answer, that is, oxygen is used in the breakdown of food, is correct, while the other half, along with the third option, cannot be related. A few irrelevant answers have also been isolated, like oxygen is used by blood in the respiratory system.

Among the students, who answered correctly, the most appropriate one highlighted the relation between oxygen intake and food as the former aids in the combustion of the latter.

Responses to Interview Questions

While interviewing the students to evince a clear picture of the difference and interrelatedness of breathing and respiration prevailing in their minds, they were asked a few basic questions to which they responded as follows:

- When asked about the fuel, which gets broken down in our body during respiration to obtain energy, most replied only glucose. However, one answered that respiration involves the breakdown of glucose and fat in our body. Further, it was added that the fats get converted into glucose and broken down by respiration. This response was purely the product of his mind.
- Responding to the question on the interrelatedness of breathing and respiration, they were confused, if breathing is a part of respiration or vice versa is true. This indicates a lack of clarity in their conception. All the students, who initially had written that respiration is a chemical change, were convinced to refer respiration as a biochemical change.
- When the students were asked to clarify the meaning of oxygen-rich air, some replied that the air we inhale contains more oxygen. On further asking about the percentage composition of air, they implied that nitrogen is the most abundant in air. This indicated their inability to set the reference concerning which inhaled air contains more oxygen. Two students answered that only oxygen enters from our nostrils into our respiratory tract.

Discussion and Suggestions

The resources utilised by the students include textbooks, guides, reference books, teachers and tuition classes. Unfortunately, the language of the books is such that it leaves a grey area in the student's cognitive schema. This compels them to make illogical assumptions beyond the scientific world, which are seldom clarified. A few sentences of the NCERT textbook, which are a bit conceptually inconsistent and might have contributed to framing illogical assumptions are as follows:

- The air we breathe is transported to all body parts and each cell. The statement is likely to create cognitive conflict among the students because they will think about the utility of the fraction of carbon dioxide in the inhaled air in our body because the exhaled air normally removes carbon dioxide. This may lead some to think that all air components enter the blood when a gaseous exchange occurs.
- The food (glucose) in the cells is broken down into carbon dioxide and water. Most students perceive the statement that glucose is the only component of food broken down and utilised by our body to derive energy. Citing glucose as the primary component of food being broken down would have helped the students to infer that apart from

glucose, other components of food are also used for energy depending on the need of the body and that glucose is not the only source of energy.

Though the NCERT textbook is adequately enriched with various real experiences and thought-provoking questions, the suggested examples and models need to be performed by the students with the teacher's facilitation. For example, the model of an artificial bottle representing the thoracic cavity with the balloons fitted inside resembling the lungs in terms of physiological perspective very accurately portrays the mechanism of the influx of air into the lungs. The construction of such a model by groups of students would have ensured the collaborative study among them to discuss with reasoning the mechanisms of air intake.

The basic concept of diffusion, or the movement of substances from a more crowded to a less crowded area, could have been provided to the students to clarify their ideas about the composition of inhaled and exhaled air. In addition, the diffusion of gases between the air track and the alveoli of the lungs during both inhalation and exhalation could have been highlighted in the text.

Conclusion

Although, most of the students can point out the correct answer, they cannot provide sound scientific reason underlying their response. This is primarily due to their self-created hypothetical reasons, which are not consistent scientifically. Hence, the misconceptions need to be uprooted right from the beginning to ensure the construction of appropriate concept maps in their cognitive schema.

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