Hacettepe Üniversitesi Eğitim Fakültesi Dergisi 23 : 259-266 [2002]

MISCONCEPTIONS AS BARRIER TO UNDERSTANDING BIOLOGY

BİYOLOJİ KAVRAMLARININ ANLAŞILMASINDA KAVRAM YANILGISI ETMENİ

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ABSTRACT: During past two decades, a significant body of research has focused on students' understandings of scientific phenomena. Among them, investigations into students' understanding of biological concepts indicate that students of varying ages possess misconceptions about biology concepts. Educators agree that prevalence of misconceptions among students not only presents a serious obstacle to learning in biology but also interfere with further learning. To promote effective and meaningful learning, there is a need to identify the causes of such misconceptions and find ways to rectify them or prevent them from occuring. Therefore, this review beriefly summarizes the findings of misconception research studies to refocus our efforts on ways of effective lasting conceptual change in biology.

Keywords: misconceptions, conceptual change, biology education, meaningful learning

ÖZET: Son yirmi yıldır yapılan çalışmalar öğrencilerin bilimsel olayları nasıl anladıklarının araştırılması yönünde odaklanmıştır. Öğrencilerin biyoloji kavramlarını nasıl anladıklarını araştıran çalışmalar, farklı yaş grubundaki öğrencilerin biyoloji konularında kavram yanılgıları olduğunu göstermiştir. Kavram yanılgılarının konuların anlamlı bir şekilde öğrenilmesinde önemli bir etmen olduğu görüşünden yola çıkılarak hazırlanan bu derlemede, öğrenciler arasında yaygın olan bazı kavram yanılgıları sıralanmış saptanması ve giderilmesi için yollar önerilerek biyoloji konularında uzun süreli bir kavramsal değişim yaratmak hedeflenmişir.

Anahtar Sözcükler: kavram yanılgıları, kavramsal değişim, biyoloji eğitimi, anlamlı öğrenme

1. INTRODUCTION

Students come to school with varying experience with ideas about and explanation of the natural world. The scope of these ideas are as diverse as the students' backgrounds and they are often different from those of scientists. These differing frameworks have been described as misconception (Fisher, 1985), alternative conceptions (Arnaudin, & Mintzes, 1985), preconceptions (Gallegos, Jerezano, & Flores, 1994), alternative frameworks (Driver, 1981), erroneous ideas (Sanders, 1993), and children science (Gilbert, Osborne & Fenshman, 1982). For the sake of simplicity of description, this review will use the term 'misconception' to denote any ideas held by students that are inconsistent or in conflict with those generally accepted by scientists. The characteristics of misconceptions are summarized by Adeniyi (1985) and Fisher (1985). They tend to be pervasive (shared by many different individuals), stable, well embedded in individual's cognitive ecology, often resistant to be changed at least by traditional teaching methods and remain intact throughout the university years and into adult life. To date, several studies have investigated students' understanding of biological concepts in different countries: Cell (Dreyfus, & Jungwirth, 1988) photosynthesis (Bell, 1985; Haslam, & Treagust, 1987; Waheed, & Lucas, 1992), genetic (Lewis, Leach, & Wood-Robinson 2000, 2000; Pashley, 1994), ecology (Griffiths & Grant, 1985; Munson, 1994), respiration (Sanders, 1993), classification (Trowbridge & Mintzes, 1988), the circulatory system (Yip 1998), vertabrate and invertabrate (Braund, 1998) and energy (Boyes & Stanisstreet, 1991). These studies revealed that the majority of

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students leave secondary school with a distorted view of biological objects and events. Many of these topics about which students hold misconceptions are basic to biology knowledge and interrelated.

In Turkey, in recent years there also has been an interest in determining students' misconceptions concerning various biological concepts (Çapa, 2000; Özkan, 2001; Sungur, Tekkaya & Geban, 2001; Tekkaya, Şen & Özden, 1999; Tekkaya, Çapa & Yılmaz, 2000; Tekkaya, Özkan & Aşcı, 2001). These studies revealed that regardless of the age and the level of schooling misconceptions are also prevalent among Turkish high school and university students. Therefore, to provide effective, complete and accurate understanding of biological concepts, the aims of this review, are to compile lists of common misconceptions detected in students in order to alert teachers to the prevalence of misconceptions on basic biological concepts and to suggest ways to remadiate them.

2. SOURCES OF MISCONCEPTIONS

Misconception researches indicate that students have considerable degree of misconceptions related to biological concepts. At this point, there is a need to identify the sources of these misconceptions. Misconceptions may originate from certain experiences that are commonly shared by many students. Some of them rooted in everyday experiences. The concepts like source of plant food, respiration in plants, and classification are belong to this category. For instance, in our society there is a common belief that there should not be flowers in the bedrooms. Furthermore, in daily life, we add word 'fish' behind dolphin and seal which imply that they are fish rather than mammals. Bell (1985), in one of his studies, suggests that words 'energy' and 'food' are often used in everyday sense of being 'energetic' and needing 'to stay alive' and 'be healthy'.

Many world in biology are used in an alternative way in daily life, for this reason, some misconceptions may arise from the use of words that mean one thing in everyday life and another in a scientific context such as food, respiration, and population. Gilbert et al., (1982), says "the word –particle- is scientifically used to mean atom, molecule or ion. However, in daily life it refers to small but visible piece of solid substance. Consequently this situation result in misapplication of that while explaining the air made up of small particles".

Misconceptions also arise when students combined a newly learned concepts (plants make their own food) with his previously held, more primitive concept (plants get their food from soil). Such situation creates conceptual conflict in the students' mind.

It has been also shown that teachers could have played a role in the formation of misconceptions held by their students (Sanders, 1993; Yip, 1998). These studies indicated that misconceptions passed from teachers through wrong or inaccurate teaching. Furthermore, Sanders (1993) suggested that, assesment strategies used by biology teachers could be a factor influencing the development of misconceptions in their students. She says "teachers should not only assess to get mark for the pupils. They need to listen to what their pupil tell them, as it can provide information about pupils' understanding or lack thereof. Pupils require constant feedback about their correct and incorrect ideas". Recently, Mintzes et al., (2001) suggested several new assessment strategies that encourage meaningful learning and conceptual understanding in the biological science. Among there are concept maps, V diagrams, clinical interviews, portfolios and conceptual diagnostic tests.

Another factor that contributes occurrence of misconceptions by students is textbooks, which include many errors and incorrect information (Storey, 1991, 1992). Many concepts in biology are interrelated and they are keys to understanding other concepts. Therefore, not

only lack of integration among topics but also inappropriate presensation of topics in textbooks influence students' further understanding. For example, without understanding of photosynthesis, the concepts of food chain and food web are meaningless to students. However, before photosynthesis, students must understand the distinction between producers and consumers, as well as organic and inorganic molecules.

It is known that most of the concepts in biology are closely related to concepts presents both in chemistry and in physics. Berthelsen, claimed that many biological concepts such as genetics, evolution, metobolic processes, ecosystems, might have their foundation in physical science and students' understanding of biological processes breaks down because of physical science misconceptions. She says "students understand that living things are made up of cells, but do not extend their understanding to include the concept that those cells are made up of atoms and molecules". Similarly, the concept of conservation of energy is essential to understanding of many feeding relationships in a food web, photosynthesis, and respiration. However, students thought that energy was created and destroyed by living things rather than transferred in the various life processes. Therefore, it is reasonable to think that the lack of prior knowledge in chemistry and physics contributes to misconceptions in biology. At this point, curriculum developers and textbook authors can make a concentrated effort to catch potential problems early, for example by including examples that explain multiple meanings.

As a summary, it can be said that children hold misconceptions that are developed before and during their school years, and these misconceptions may be compounded by daily life experience, use of everday language in a scientific context, compartmentalization of concepts, teaching strategies, and textbooks. All these factors seem to be not only results in rote learning and the compartmentalization of ideas, but also defeat the aim of the biology syllabus to promote meaningful learning.

By reviewing the possible source of misconceptions, it is suggested that conceptual development can be promoted by classroom instruction that avoids excessive factual details, establishes meaningful connection between new and existing concepts, and takes into account students' prior knowledge.

4. COMMON MISCONCEPTIONS IN BIOLOGY

Table 1 represents a summary of students' common misconceptions concerning respiration, photosynthesis ecology, genetics, classification, and the human circulatory system.

Table 1. Common Misconceptions in Biology

Respiration
The purpose of respiration is to provide oxygen and to remove carbon dioxide
Respiration is a gaseous exchange process during which oxygen is taken in and
carbon dioxide is given off.
Respiration is synonymous with breathing
Respiration takes place in lungs
Respiration in plants occurs only at night
Some animals, particularly invertebrates, do not respire
Animals respire aerobically, plants anaerobically
Plants do not respire; they photosynthesize instead

Photosynthesis
Photosynthesis is the respiration of plants in light
Photosynthesis is the process by which the plant breathes
Photosynthesis is a gas exchange process
Carbon dioxide, water, fertilizer and minerals are food
Only green plants can carry out photosynthesis
Photosynthesis is an energy providing mechanism
Plants get their food from the soil
Plants take in CO_2 and change it to O_2
Ecology
Living things do not interact with the nonliving things, they stay apart
Population is an area where living things occur
Population is the number of people/organisms (e.g. population of Turkey)
Community is the same as population
There are more herbivores than carnivores because they have more offspring
Stronger organisms have more energy
Bacteria are the source of energy in a food chain
Energy
Digestion is the energy releasing process
Plants get their energy from soil, air, sun, wind, water and other animals
Animals get their energy from sleeping, keeping warm, and the air they breathe
Genetics
Genes contain alleles
Alleles contain genes
Genes and alleles are the same
DNA replication occurs in prophase
Sexual reproduction occurs in animals but not in plants
Chromosomes and DNA present seperately in nucleus
Classification
Penguins, lizards, crocodiles and turtles are all amphibian
Whales, dolphins, seals, jellyfish, starfish are all fish
Bats are birds
Behavior and habitat are criteria for classification
Paramecium belongs to animal kingdom
Human beings are not animals
The Circulatory System
Serum is the storage form of plasma
The thick and elastic wall of arteries helps prevent heat loss
Low blood velocity in capillaries is due to their small diameter
Heart is responsible for storing, cleaning, filtering or manufacturing blood

As it is seen clearly from the Table 1 that students held several misconceptions related to various biology topics each of which form prominent aspect of most biology syllabuses.

5. IDENTIFICATION OF MISCONCEPTIONS

Before misconceptions can be corrected, they need to be identified. Since identification of misconceptions is needed to develop strategies to provide students with the accurate conceptual knowledge. As mentioned earlier, misconceptions also developed by the students during the lesson. If they are not detected and corrected immediately, they will adversly affect the students' subsequent learning. This is a major source of learning problems in schools. In many countries, including Turkey, assessment can be done at the end of a semester. However, this kind of assessment is not appropriate as a feedback on teaching. The teacher has no idea of how well or how poorly his students have learnt until at a very late stage. In order to identify and analyze misconceptions at an early stage, various forms of assessment should be used throughout a course. For example, quiz and discussion can take place any time during the lesson which provide opportunities for students to express their own ideas clearly. A short test given at the end of a topic also helps to motivate the students to review their work. A concept map, constructed by each students, is an excellent way of not only the reviewing a given topic but also detecting students' specific misconceptions. Interview is a widespread techique used to identify students' misconceptions on a particular topic (Fisher, 1985; Özkan, 2001; Sungur et al. 2001). The purpose of interview is to tease out the students' meaningful understanding of a particular concept. Multiple choice items can be marked objectively and efficiently, but may not able to probe into the learners' reasoning processes and causes of conceptual problems. For these reasons some researchers suggest the use of two-tier diagnostic test to identify students' misconceptions (Haslam & Treagust, 1987; Odom &Barrow, 1995; Özkan, 2001). The focus of the test is to detect common misconceptions as well as to help students' reason. This type of assessment sends students the message that reasoning and/or thinking are important. On the other hand, a typical multiple-choice item usually requires students to recall specific content. This type of assessment sends the message to the students that memorization of content is important. Reasoning is not required. Mann and Treagust (1998) suggest another diagnostic instrument including true/false type questions instead of multiple choice items. Besides, Concept Evaluation Statement (Simpson & Marek, 1988; Westbrook & Marek, 1991), Proposition Generating Task (Amir & Tamir, 1994) and Writing Assays (Sanders, 1993) also used to assess students' understanding of a particular topic. In addition, combinations of these methods have been utilized by many researchers (Friedler et al., 1987; Özkan, 2001; Sungur et al., 2001) to identify misconceptions.

6. REMEDIATION OF MISCONCEPTIONS

To promote meaningful learning, ways must be found to eliminate or prevent misconceptions. Various instructional methods can be used for this purpose. One such method involves the use of a conceptual change approach. A conceptual change approach proposes that if students are to change their ideas they must become dissatisfied with their existing conditions (dissatisfaction), new concepts must intelligible, plausible, and fruitful (Posner et al., 1982). Several research studies suggested that instructional strategies leading to conceptual change such as analogies, concept maps, conceptual change texts and refutational texts could be employed to eliminate students' misconceptions. This review briefly discusses concept maps and conceptual change texts.

6.1. Concept Maps: Comparmentalization of concepts is a common problem in biology

learning, which occurs when concepts are studied with little integration. Students may be able to state correctly the individual events but often do not understand the relationship between them. An effective way to tackle this problem is to use a concept map. They are diagrammatic representations, which show meaningful relationships between concepts in the form of proposition. Propositions are two or more concept labels linked by words, which provide information on relationships or describing connections between concepts. Concept maps serve to clarify links between new and old knowledge and force learner to externalize those links. From these aspects, concept mapping has become increasingly useful as an instructional strategy for the diagnosis of students' misconceptions by facilitating meaningful learning (Guastello, 2000; Kinchin, 2000; Novak, 1990; Okebukola, 1990; Sungur et al., 2001; Yılmaz, 1998).

6.2. Conceptual Change Text: Conceptual change text is an instructional technique that creates conceptual change on students' minds while promoting meaning learning. Conceptual change texts are designed to make students aware of both their misconceptions and scientifically accepted concepts. Misconceptions are directly stated within the texts and helped students to understand and apply the target scientific knowledge through the use of more plausible and intelligible explanations (Erdmann, 2001; Özkan, 2001; Sungur et al., 2001; Yılmaz, 1998). Thus, conceptual change instructional techniques have to use to change students' misconceptions with the scientific view of world and taught the concepts in a meaningful manner to students. Recall that misconceptions also arise when the learning fails to induce the conceptual change in students' minds.

These strategies not only help teachers analyze the ideas of their students but also help students get a better understanding of biological concept.

7. DISCUSSION

Misconception research contains findings indicating that students show wide range of difficulties in undestanding in biology. The most important reason for these difficulties is close relationship of units with each other. Since each new lesson contributes in recognizable ways to the students' understanding of some major ideas or concepts of biology. Therefore, in teaching and learning of biology, concepts do not exist in isolation. Each concept is closely related to others (Novak, 1970) and certain prerequisite concepts are necessary for a learner to develop understanding on a certain concept. If these do not exit, it would be difficult for the learner to understand the new concept. Unfortunately this is often the case for a large class with students of varied abilities, as in the case of Turkey. Since class sizes are large, science teaching is dominated by an expository style based on standart textbooks, which emphasize factual datails to meet the demand of examination. A teacher normally plans his/her teaching according to the structure of the course, assuming that, students have already mastered the prerequisite ideas. On the contrary, they may not have accomodated the prerequsite ideas into their cognitive structure which are necessary for a meaningful understanding of the new topic. When failing to grasp the basic concept, they tend to employ a rote learning strategy in studying biology in order to pass examination in biology.

Waheed and Lucas (1992) suggest that photosynthesis is an ideal topic to study this problem. They imply that it is a complex biological topic and has a number of conceptual aspect namely ecological, biochemical, anatomical-physiological and energy change. Thus, the interrelationship of the various aspects makes photosynthesis an integrated concept. They also indicated that understanding of photosynthesis, as a complex topic is important in understanding how the world functions as an ecosystem, and how photosynthesis acts as a bridge between the non-living and living world.

Hence, to promote meaningful learning, it is necessary to overcome these difficulties with the help of different instructional methods rather than traditional instructional methods. Recent studies done in Turkey have been revealed that conceptual change approach was effective in achieving meaningful learning in the cell division (Yılmaz, 1998), the human circulatory system (Sungur et al., 2001) and ecology (Özkan, 2001) concepts.

8. CONCLUSION

Most students who hold misconception are not aware that their ideas are incorrect. When they are simply told they are wrong, they often have a hard time giving up their misconceptions, especially if they have had a misconception for a long time. They often do not see the reason to change their beliefs because they provide good explanations of their everyday experiences, function adequately in the everyday world, and are tied to years of confirmation. In order to persuade students to invest the substantial effort required to become science literate and to re-examine their initial explanations of scientific phenomena, we need to provide them with an environment that will motivate such changes and relate them to the social and cultural environment outside the narrow context of the school.

In this brief review, I focused on literature in biology education concerned with students' understanding of biological concepts. Characteristics and possible sources of misconceptions were discussed and examples of some common misconceptions were provided. The issue of how teachers best address students' misconceptions was discussed in conjuction with suggestions for remediation. Further research will be concentrated on methods, which encourage meaningful learning and conceptual understanding in biology.

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