



Conceptual Problems in Biology-Related Topics in Primary Science and Technology Textbooks in Turkey

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Determination of conceptual problems which may cause alternative conceptions in science and technology textbooks is significant to increase in success of pupils and teachers. It is a vital issue to arrange books in a way removing or decreasing these faults in order to improve a better education via textbooks. This study aims to determine conceptual problems which may cause alternative conceptions in biology topics in science and technology textbooks of primary schools. In this study, the units of each textbook were analyzed page by page according to document examination method and conceptual problems were determined. The founded conceptual problems have been classified such as; misidentifications, overgeneralizations, oversimplifications, obsolete concepts and terms, under generalizations. The finding of research results have been shown that various conceptual problems which may cause alternative conceptions in pupils' textbooks about biology topics. The obtained results of research were compared with related literature and in the light of findings some recommendations were developed for future planning and development activities pupils' textbooks.

Key Words: Science and technology textbooks, conceptual problems, alternative conceptions

Introduction

There are plenty of studies held in recent years focused on determination of alternative conceptions in science search and make compensation for their possible origins. It is mostly accepted that one of the main negative factor influencing pupils learning activity is the alternative conceptions. Alternative conceptions or misconceptions imply thinking patterns which do not mostly overlap with scientific realities (Bahar, 2003; Tekkaya, 2002). Since these thinking patterns developed by pupils mostly based on their own interpretations are contrary to scientific realities, they constitute a significant barrier against science education (Driver, 1989). It has been suggested that an alternative conception or misconception usually has three primary features given below. It is a cognitive idea that differs in a significant way from the scientific idea, it is held by a sizable proportion of the population, and it is notably resistant to being taught away; it is often described as a conceptual primitive (Clement, 1982). The studies have been shown that pupils usually develop alternative conceptions as a result of their own inter-

pretations or from some contradictory explanations in school or out of school environments in early periods (Wandersee, Mintzes & Novak, 1994). Expressions of well known subjects by teachers or their expression in textbooks also may lead to alternative conceptions (Barras, 1984; Sewell, 2002). Alternative conceptions are considerably widespread in formal education (Bishop & Anderson, 1990) and significantly resistant against change (Bahar, 2003; Wandersee et al., 1994). If they are not detected and compensated very early, they may continue for long years and may constitute significant barriers in understanding process. Some researches have been detected that pupils have many alternative conceptions in biology in Turkey (Tekkaya, Çapa, & Yılmaz, 2000; Aşçı, Özkan, & Tekkaya, 2001). In order to teach all pupils today's standards, teachers need to understand subject matter deeply and flexibly so they can help students create useful cognitive maps, relate one idea to another, and address alternative conception. Teachers need to see how ideas connect across fields and to everyday life. This kind of understanding may provide a foundation for pedagogical content knowledge that enables teachers to make ideas accessible to others (Shulman, 1986, 1987).

Science textbooks are among commonly used effective teaching materials in science education process that it seems a significant source of conceptual problems have been detected on pupils. So many researchers (Abimbola & Baba, 1996; Barras, 1984; Cho, Kahle & Nordland, 1985; Rees, 2007; Storey, 1989, 1991, 1992) have made a systematic effort to define alternative conceptions or misconceptions in biology textbooks. It is well known that educators have always taken textbooks into consideration as a good source of information. Odom (1993) has been searched how the concepts related with action potentials are presented in high school biology textbooks and alternative conceptions related with this subject. Sewell (2002) identified a major problem with science textbooks that they too often contain many alternative conceptions and false ideas. Dikmenli and Çardak (2004) have been determined 14 alternative conceptions and 10 inadequate knowledge about cell structure and functions in high school 1st class biology textbooks that may lead to alternative conceptions. Hershey (2004, 2005) has been stated that any alternative conception existing in a textbook, article or curriculum program may mislead many teachers or students and classified over 50 alternative conceptions determined in written materials related with plants in 5 categories. These categories were; oversimplifications, overgeneralizations, obsolete concepts and terms, misidentifications and flawed research. Köse, Ayas, Coştu, and Karamustafaoğlu (2004) evaluated how the topic of photosynthesis is presented in a high school biology textbook on the basic views of teachers and specialists. In this study researchers have been concluded that photosynthesis topic is incorrectly included in the textbook and some scientific faults were available. Similarly, Schussler (2008) has been searched how the topic of fertilization in plants is presented and for alternative conception about this topic in 61 science books prepared for children. The researcher evidenced that pollination-fertilization and ovule-egg terms are used in a misleading way in these books. In addition, it was also stated that the term "pollen dust" used in the books is not a botanical term and used incorrectly.

Because, insufficiency of teaching technology and laboratory deficiency and applying traditional teaching strategies in developing countries makes textbooks more dominant teaching material. In this countries science and technology textbooks are the central tool in the instructional process of teaching science. For example, Chiappetta, Ganesh, Lee and Philips (2006) noted that more than 90% of secondary school science teachers rely on textbooks to organize and deliver instruction and assign homework. On the other hand, textbook authors have freedom to develop their own approach to the delivery of national curricula and so textbooks represent a considerable diversity. Concern has been expressed that information in textbooks is not always found to be accurate (Clifford, 2002). It is important for teachers, as facilitators

of learning, to be aware of the conceptual problems of the textbook their students are using. From this point of view, it has been thought that analyzing the conceptual problems which may cause alternative conceptions used in science and technology textbooks in Turkey will be beneficial for students, teachers, textbook authors and programmers.

Methodology

In this study a descriptive research method has been used that this method generally in use for enlightening a given situation, making evaluations according to the standards and to reveal the possible relations between incidents. It has been suggested that the main aim in this kind of works is to define and explain the reviewed situation in a comprehensive manner (Çepni, 2005).

Textbooks

In this study, 15 science and technology textbooks recommended by Ministry of Education in Turkey to be used in primary schools for 5 years have been investigated (See appendix A and B). These textbooks have been prepared in accordance with the national curriculum that they are used in primary school 4th, 5th, 6th, 7th and 8th grades as science and technology textbooks. It was determined that totally there were 15 science and technology textbooks recommended by the Ministry of Education in 2008-2009, given as; “Let’s Solve the Puzzle of Our Body (4th grade, 5th grade)”, “Let’s Get Around and Know the World of Livings (4th grade, 5th grade)”, “Fertilization, growth and development in Livings (6th grade)”, “Systems in Our Body (6th grade, 7th grade)”, “Human and Environment (7th grade)”, “Cell Division and Heredity (8th grade)” and “Living Things and Energy Relations (8th grade)”.

Data Collection and Analysis

For this research document analyzing technique has been used that this technique consists of the analyses of written materials including information about the incidents or incident targeted to be researched (Yıldırım & Şimşek, 2005). Through the aim of the study, each unit taken under examination has been read carefully at least twice by the authors, from the beginning through to the end, in terms of conceptual problems which may cause alternative conceptions with all the details. The texts in each unit were analyzed page by page. All the conceptual problems have been marked on the textbooks and they have been read again and the conceptual problems which may cause alternative conceptions have been determined among them. This method has been used previously by some researchers to ensure reliable information about text concepts (Abimbola & Baba, 1996; Thiele & Treagust, 1994). Determined conceptual problems which may cause alternative conceptions have been classified as it follows: Misidentifications, overgeneralizations, oversimplifications, obsolete concepts and terms, under generalizations (Hershey, 2005). As a result of this analysis, conceptual problems which may cause alternative conceptions were found in 12 of these books (see Appendix A). Views of three lectures in biology education were applied for validity of conceptual problems which might cause alternative conceptions detected and their approvals were received. “Alternative conceptions” were used for expression patterns which do not exactly overlap with scientific realities contrarily contradict with them.

Results and Discussion

The findings of the analysis held in units about biology related topics in primary science and technology textbooks have shown that there were conceptual problems which may cause alternative conceptions were found in 12 of 15 science and technology textbooks (See appendix A). A total of 31 conceptual problems which may cause alternative conceptions have been determined in the textbooks. Each of them has been further examined independently by the researchers and three lectures in biology and education with an original agreement of 27 for the 31 conceptual problems. The remaining 4 problems have been agreed upon following consensus discussions. These conceptual problems include following subjects:

Misidentifications

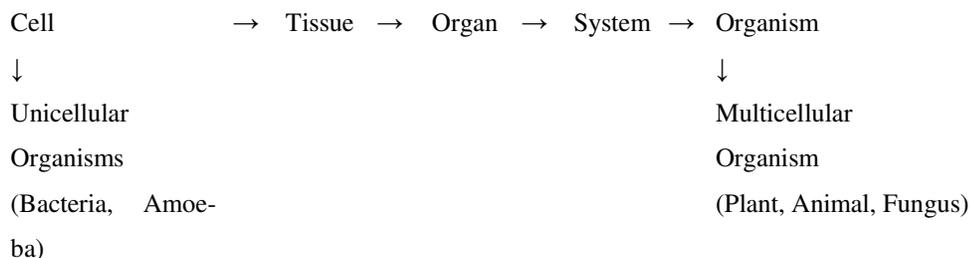
- 1- “Living things have developed organs for respiration” (Book A, p.164). All living things do not have developed respiration organs. For example gas exchange occurs in cell membrane with diffusion in protists, sponges and coelenterates (Campbell & Reece, 2006). In addition, there are also protists making anaerobic respiration, they do not have developed respiration organs.
- 2- “Germination of seeds and forming many plants is an example for fertilization” (Book B, p.157). Germination of seed is a stage in life cycle of a seedy plant. Germination is not a fertilization example or mechanism.
- 3- “Oxygen we intake is used by the organs in our body” (Book C, p.29). Oxygen taken in body is not used organs but used by tissue cells.
- 4- “Respiration is use of oxygen in body” (Book D, p.155). It is seen that anaerobic respiration is disregarded in this sentence defining respiration. Oxygen is used in aerobic respiration but oxygen does not need in anaerobic respiration. Moreover, oxygen is used by tissue cells in body in cellular respiration. Actually, all kinds of processes and transformation related with energy are the events occurred in cell level. Respiration made with organ system is only the event related with inhaling and exhaling. The event constituting the base of energy transformation is cellular respiration (Özay & Hasenekoğlu, 2007).
- 5- “Materials required by our body are called as nutrient” (Book E, p.12). Our body needs oxygen, but oxygen cannot be characterized as nutrient in biology literature.
- 6- “Water, minerals and vitamins are regulator nutrients” (Book E, p.14). Water, minerals and vitamins are not nutrients but nutrient elements.
- 7- “Bat resembles birds with its feather structure, body shape and flying feature” (Book E, p.117). Bat is a mammal not having feather but hair (Kuru, 2006).
- 8- “Egg cells are formed and stored in ovaries of mother” (Book I, p.23). The cells stored in ovaries are not egg cells, but primer oocytes (Sadler, 1995). Egg cells are either fertilized or ejaculated as degenerated once they are formed.
- 9- “Blood platelets are blood cells not observed with microscope” (Book I, p.141). Blood platelets can be observed both in light microscope and electron microscope.
- 10- “Any of the proteins determining blood group does not exist in 0 (zero) group blood” (Book I, p.142). Not only A and B antigens but also Rh antigen is important in determination of blood group. A and B antigens (proteins) do not exist in erythrocytes of zero group blood, but Rh antigen exists in 0 Rh (+) blood (Campbell & Reece, 2006).
- 11- In the Book I (p.141) the light microscopy picture of red blood cells wrongly given such as blood platelets. This may lead to alternative conceptions in pupils.

- 12- “Funguses can live as attached to the soil or environment suitable for them like plants. Their structures like root, stem are similar with plants” (Book E, p.121). Structures of funguses like root, stem are not similar with plants. Moreover, microscopic funguses do not have structures similar to root and stem unlike plants.
- 13- “Ovary and sperm starts to develop by coming together in oviduct of mother” (Book I, p.23). According to this expression, it is conceived that ovary and sperm cells develop separately. However, zygote formed as a result of fertilization starts to develop in oviduct.
- 14- Tadpole is a fish-like living thing having some characteristics enabling life in water before metamorphism. It has a long tail providing it to move in water and fins helping it to intake oxygen in water” (Book I, p.32). It is conceived from this expression that tadpoles use oxygen by means of fins. However, tadpoles supply their oxygen requirements through gills at this phase.
- 15- “Blood conveys oxygen to cells by circulating all our body. Cells obtain the energy required to sustain their vital activities by using this oxygen” (Book I, p.147). A meaning as if cells obtain energy from oxygen is conceived in this expression. But, cells obtain energy from nutrient sources by using oxygen.
- 16- “Red blood cells exist in a less number than white blood cells in blood” (Book K, p.160).
- 17- “Water cycle is the process of continuous transformation of water from liquid state to gaseous state and from gas to liquid between earth ground and air” (Book M, p.195). It is seen that water cycle is presented in a limited way in this expression. Brody (1993) evidenced that students have such alternative conceptions. Water cycle is a term expressing non-increasing or non-decreasing nature of water resources on the earth as in the case of matter conservation law. Water resources on the ground are composed of oceans, seas, lakes, underground waters and glaciers. Water in the world moves, transforms, used by plants and animals, but actually never disappears. Solar energy evaporates water by heating it, this vapor is turned into little water drop in cold stratum and these drops fall on the earth in form of rain, snow and hail by growing in time.
- 18- “DNA provides transition of information in its structure to young cells to be newly formed during the process of cell division” (Book M, p.39).

Overgeneralizations

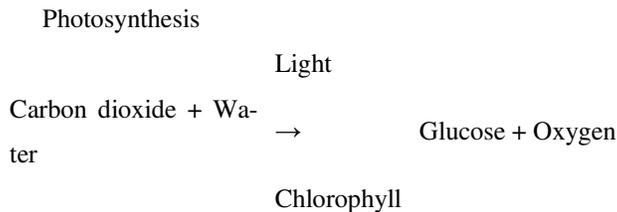
- 19- “All living things need air, water, nutrient and shelter” (Book A, p.174). Living things making anaerobic respiration do not need air, namely oxygen (Campbell & Reece, 2006). Moreover, photosynthetic living things produce their own nutrients by themselves.
- 20- “All plants around us have common features like the existence of leaves, stems in different structures and characteristics, existence of root and attachment to the soil with their root” (Book E, p.107). Root, stem and leaves are not common structures existing in all plants. For example, *Hepaticae* does not have a stem. *Bryophytes* do not have real root, stem and leaves (Campbell & Reece, 2006).
- 21- “Roots, stem and leaves exist in all plants” (Book F, p.126). Roots stem or leaves are not common structures existing in all plants. Real root, stem and leaves start with ferns (Campbell & Reece, 2006).
- 22- “Three main structures are observed in all cells including cytoplasm, nucleus and cell membrane in spite of their shapes and differences” (Book I, p.17). This expression

- may be considered right for eukaryotic cells in spite of the existence of some exceptions. However, prokaryotic cells do not have nucleus (Campbell & Reece, 2006).
- 23- “Some microscopic livings are composed of single cell. Since these livings have no nucleus, their structures carrying genetic features exist in cytoplasm in a dispersed form.” (Book J, p.21). This definition is right for prokaryotic cells but protists like *Amoeba*, *Euglena* etc. have a nucleus encircled with membrane (Campbell & Reece, 2006).
- 24- “Reproduction is the case that a living thing forms a new living thing similar to it. Egg nucleus and sperm nucleus must combine for fulfillment of reproduction. This activity is called as fertilization” (Book J, p.25) this expression is valid for sexual reproduction. However, fertilization does not occur in asexual reproduction. Reproduction is not always fulfilled with fertilization.
- 25- “Optimum temperature, oxygen and water are required for germination of a seed” (Book J, p.47). Some seeds making anaerobic respiration do not need oxygen during germination (Hershey, 2005).
- 26- Organization steps are presented as “cell-tissue-organ-system-organism” in some textbooks (Book I, p.20; Book J, p.23; Book K, p.25; Book L, p.230). However, this presentation is an expression focusing on multicellular organisms and disregarding unicellular organisms. These expressions in textbooks may orient students to the mis-thinking that unicellular organisms like bacteria and amoeba not having tissues and organs are not organism. For this reason, presenting this organization steps in following way in textbooks will be more appropriate.



Oversimplifications

- 27- “There are chloroplasts on cells in green color segments of plants. Simple sugar (glucose) and oxygen is provided by using water in the soil and carbon dioxide in the air in these organelles. This event is called as photosynthesis” (Book M, p.186).



It is seen that photosynthesis activity is presented by oversimplifying with an equation. Hershey (2004) states that such types of simplifications made in texts in textbooks might lead to alternative conceptions in pupils. In the photosynthesis equation given here, simple sugar (glucose) is indicated as the main photosynthetic product. However, glucose is not a main photosynthetic product (Hershey, 2004). There is almost no free glucose generated in photosynthesis (Storey, 1989). The most general product generated in photosynthesis is starch and sucrose. Moreover, single arrow drawing in the photosynthesis equation incorrectly implies that photosynthesis occurs in one single stage. Multiple arrows should be used here (Hershey, 2004).

Obsolete Concepts and Terms

- 28- “Cell membrane is selective in material exchange since it is alive” (Book I, p.18). Cell membrane is not live. This definition does not comply with common features of living things. In addition to this, this expression contradicts with “the most basic and smallest unit of living things is cell” expression.
- 29- *Paramecium* is named as slipper-shaped animal and *Euglena* is named as whipper animal (Book G, p.178). Tekkaya et al. (2000) stated that such types of naming cause alternative conceptions in pupils since they do not overlap with scientific language.

Under Generalizations

- 30- “Do you know that green color chloroplasts are organelles only existing in green plants?” (Book I, p.19). Chloroplasts do not only exist in green plants but also in photosynthetic protists in eukaryotic structure. For example, *Euglena* making photosynthesis has a chloroplast (Campbell & Reece, 2006).
- 31- “Numerical abundance of plant and animal species and types in a region means biodiversity.” (Book L, p.236). This expression restricts biodiversity only with plants and animals. Such excessive restrictions minimize the significance of biodiversity (Hershey, 2004). Significance of biodiversity in *Monera*, *Protista* and *Fungi* is sometimes disregarded.

Totally 31 conceptual problems which might possibly cause alternative conceptions in science and technology textbooks were determined in this study. Similar alternative conceptions determined in pupils by other researchers (Yılmaz, Tekkaya, Geban, & Özden, 1998; Tekkaya et al., 2000) supports the consideration that a great source of these faults is textbooks (Barras, 1984). It has been suggested that conceptual problems which may cause alternative conceptions in textbooks about biological concepts is fundamental to the development of pupils' conceptual understanding (Sewell, 2002).

This study supports the results of former studies held in this field (Abimbola & Baba, 1996; Cho et al., 1985; Dikmenli & Çardak, 2004; Eyidoğan & Güneysu, 2002; Schussler, 2008). Alexander and Kulikowich (1994) states that a significant reason of alternative conceptions students having results from the deficiency of teachers in explaining and planning information included in textbooks. Eyidoğan and Güneysu (2002) evidenced that alternative conceptions related with cell structure and cell divisions exist in science textbooks. Blystone (1987) and Wandersee (1985) state that textbook writers should be careful in the issue that terms not completely accepted by science public opinion yet should not be used in biology texts. Therefore, textbooks as a teaching material should be organized in a systematic order in terms of content.

Textbooks should be written in a fluent language which can be easily understood by students and should ensure systematic improvement in learning via bringing them in knowledge and conceptions (Ajewole, 1991; Shymansky, Yore, & Good, 1991). It has been claimed that textbooks should be adequate in terms of combination and comprehensibility features (Kaptan, 1999). Combination, namely establishing connection, improves the ability of understanding written source in pupils. Comprehensible short sentences, even core sentences can be much more easily comprehended by pupils than complex one. Structures including cause-effect relations should be used after the core part of a sentence.

Hitherto, scientific concepts have a label (name) and a content (meaning) that studying science should involve understanding the concepts. So, it is important for teachers to know how students interpret teaching concepts. Schmidt and Volke (2003) have been suggested that there is a difference between term and meaning of a concept. Some other researchers (Pines & West, 1986) claimed that concepts usually have a different meaning in science and in everyday life that pupils can confuse them. This can also happen with scientific terms that are used in different contexts because they have shifted their meaning in the course of the historical development (Schmidt, 1997).

Conclusion and Recommendations

In this study, conceptual problems which might possibly cause alternative conceptions were determined biology topics of science and technology textbooks and some recommendations were made concerning about way of correcting. It is possible to advise that number of alternative conceptions in science and technology textbooks should be a fundamental criterion in selection of textbooks to be used in teaching. As much as possible science and technology textbooks including smallest number of alternative conceptions should be selected. Also, conceptual problems in all science and technology textbooks studied in primary education should be analyzed as a whole and the number of textbooks should be limited according to analysis results. For this some textbook evaluation information models could be beneficial (Kaptan, 1999; Köseoğlu et al., 2003). Alternative conceptions identified in selected textbooks should be immediately presented to attention of pupils and eliminated. Science and technology teachers also should be aware of alternative conceptions existing in the literature related to biological subjects. Teachers should discuss alternative conceptions with pupils and they should be sufficiently convinced about the issue why alternative conceptions are not scientifically valid and should be refused. Teachers also should assist pupils in the process of eliminating misconceptions, namely turning them into information having scientific validity. During education of teacher candidates' textbook content analysis techniques should be properly given. A science and technology teacher having these techniques will gain the ability of filtering misconceptions existing in textbooks or their students.

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Appendix A: List of Textbooks Used

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Appendix B: List of Textbooks Used

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