

BIOLOGY CONCEPTS PERCEIVED AS DIFFICULT BY TURKISH HIGH SCHOOL STUDENTS

LİSE ÖĞRENCİLERİNİN ZOR OLARAK ALGILADIKLARI BİYOLOJİ KAVRAMLARI

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ABSTRACT: This study was performed to determine what content in biology was perceived as difficult for Turkish students to learn and whether gender differences affect students' perceptions. A total of 368 high school students, 184 were boys and 184 were girls, participated in the study. Descriptive statistics was used to determine frequencies of difficult, moderate and easy biology concepts as perceived by students. Hormones, genes and chromosomes, mitosis and meiosis, nervous system, and Mendelian genetics were found to be difficult concepts for students to learn. On the other hand, the students identified cells and organelles, and ecology as easy topics. The results of independent-t test indicated significant difference in perception by gender ($t=3.09$, $p=0.002$). To determine possible reasons behind students' learning difficulties, 14 high school biology teachers were interviewed.

KEY WORDS: Öğrenme zorlukları, biyolojik kavramları, cinsiyet farkı

ÖZET: Bu çalışmada, lise öğrencilerinin öğrenmede zorlandıkları biyoloji konuları ve cinsiyet farkının konuların zor ya da kolay algılanmasına olan etkisi araştırılmıştır. Çalışmaya erkek ve kız sayısı eşit olmak üzere toplam 368 öğrenci katılmıştır. Öğrencilerin anlaşılmasını zor, orta ve kolay bulduğu biyoloji kavramlarının sıklığını bulmak için betimsel istatistik kullanılmıştır. Hormonlar, genler ve kromozomlar, mitoz ve mayoz, sinir sistemi ve Mendel genetiği öğrencilerin öğrenmede zorlandıkları konular olarak belirlenmiştir. Diğer taraftan, öğrenciler hücre ve organeller ve ekoloji konularını öğrenilmesi kolay konular olarak değerlendirmiştir. Bağımsız t-test sonuçları cinsiyet farkının öğrencilerin biyoloji konularını zor ya da kolay olarak algılamasında etkili olduğunu göstermiştir ($t=3.09$, $p=0.002$). Öğrencilerin biyoloji konularındaki olası zorlanma nedenleri 14 lise biyoloji öğretmeni ile görüşme yapılarak belirlenmiştir.

ANAHTAR SÖZCÜKLER: Learning difficulties, biology concepts, gender differences

1. INTRODUCTION

Students' difficulties in learning biology concepts has been investigated by many researchers. Johnstone and Mahmoud (1980), reported that water transport in plants and genetics were among the most difficult biology topics to be learnt by secondary school and university students. Two years later, Finley, Stewart and Yaroch (1982), showed that cellular respiration, protein synthesis, photosynthesis, Mendelian genetics, mitosis and meiosis, were difficult and important topics for students to learn. Respiration and photosynthesis (Anderson, Sheldon & Dubay, 1990), gaseous exchange (Seymour & Longdon, 1991), and concept of energy (Jennison & Reiss, 1991), were other topics which students find difficult to learn. Lazarowitz and Penso (1992), identified the Israeli high school students' learning difficulties in biology concepts such as cells, organelles, organs, and physiological processes, hormonal regulation, oxygen transport, controlled experiments and the principle of structure and function. Bahar, Johnstone and Hansell (1999), found that monohybrid and dihybrid crosses and linkages, genetic engineering, meiosis, central nervous system, gametes, alleles and genes were perceived by Scottish first year university students as the topics of highest difficulty.

To date no study has been conducted to determine Turkish high school students' difficulties in learning biology concepts.

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Therefore, this study was designed to answer the following research questions:

1. What topics in biology were difficult for Turkish students to learn?
2. What makes these topics so difficult?
3. What is the effect of gender differences on their perceptions with respect to learning difficulties in biology concepts?

2. METHOD

2.1. Subjects

This study consisted of 368 students from different high schools. The sample consisted of an equal number of boys ($n=184$) and girls ($n=184$). Fourteen high school biology teachers were interviewed to obtain information about students' learning difficulties concerning biology concepts.

2.2. Instrument

To determine students' learning difficulties, high school biology syllabus was examined and 30 concepts were identified. In the first part of the instrument developed, there were 30 items corresponding to these concepts and students were asked to indicate their view of difficulty. Difficulty categories were rated on a 1-3 scale with 3 being difficult. In the second part, students were asked to explain reasons behind their difficulties.

2.3. Data analysis:

Statistical analysis included generation of frequency distribution and t-statistics. Descriptive statistics was used to determine frequencies of difficult, moderate and easy biology concepts as perceived by high school students. Students' difficulties in learning biology were determined by calculation of total scores for each concept rated from difficult to easy. Independent t-test was conducted to find out the effect of gender differences on students' perceptions with respect to learning difficulties of biology concepts.

2.4. Interviews with biology teachers

In order to determine content areas perceived as difficult by students and possible reasons

behind these difficulties, interviews were conducted with 14 biology teachers. Selected examples of excerpts are given below:

"Most of the students had difficulty in learning mitosis and meiosis concepts. These difficulties can be attributed mainly to terminology and abstract level of concepts. Terminology is very complicated and includes many terms foreign in origin such as chromosome, gene, allele, chromatid, and DNA. Students always mixed these terms to each other, especially gene and allele. They generally memorized these concepts and forgot them after some time."

"Respiration and photosynthesis are perceived by students as difficult to learn. Reason lies, I think, in the interdisciplinary nature of the concepts. Students should have mastered the concepts like chemical reactions, organic and inorganic molecules in their chemistry courses in order to understand the chemical nature of respiration and photosynthesis. However, it is not the case."

"Some students had difficulty in learning excretory system, especially filtration through kidneys. The understanding of this concept depends on prerequisite knowledge about osmosis and diffusion. Students could have learned these concepts in the previous years. Nervous system, especially functions of it, is another topic that students had difficulty in learning. Regarding circulatory system, they had difficulty in learning some concepts like blood pressure, velocity of blood which were interdisciplinary in their nature. Also, they could not appreciate the role of diffusion as a main mechanism of material exchange through capillaries"

"Some students had difficulty in learning Mendelian genetics. But some others enjoyed it, since this topic is based on problems and is not abstract in nature."

"Students generally learn ecology easily. Because they transfer concepts of ecology to many contexts of everyday life. Cell and organelles are the other topics which are easily learnt by students"

3. RESULTS

3.1. Addressing learning difficulties

The analyses of results reveal that students have difficulties in learning mainly five content

areas (Table 1). Three of them are directly related to genetics and two of them are related to body systems.

Table 1. Percentage indicating the level of difficulty perceived by students

Concept	Gender (%)		Mean (%)
	Boys	Girls	
Hormones	37.0	38.0	37.5
Genes and chromosomes	43.5	28.3	35.9
Mitosis and Meiosis	37.5	31.5	34.5
Nervous System	33.7	33.7	33.7
Mendelian Genetics	36.5	27.7	32.1
Protein Synthesis	33.2	20.7	26.9
Respiration	21.7	24.5	23.1
Animal Tissues	23.4	22.3	22.8
Excretory System	22.3	22.8	22.6
Population Genetics	20.7	22.8	21.7
DNA Synthesis	24.5	19.0	21.7
Circulatory System	20.1	22.3	21.2
Digestive System	19.0	22.3	20.7
Skeletal and Muscular System	19.6	21.7	20.7
Plant Tissues	21.2	19.6	20.4
Master Molecules	24.5	15.8	20.1
Reproduction	18.5	19.6	19.0
Homeostasis	19.6	16.3	17.9
Evolution	14.7	21.2	17.9
Photosynthesis	17.9	17.9	17.9
Enzymes	17.4	13.6	15.5
Respiratory System	13.0	17.4	15.2
Classification	12.0	16.8	14.4
Transport in plants	14.1	14.7	14.4
Cycles of materials	14.1	14.7	14.4
Transport of Material	10.9	8.2	9.5
Organic Molecules	10.3	8.2	9.2
Sensory Organs	11.4	7.1	9.2
Ecology	6.0	9.2	7.6
Cell and Organelles	6.0	5.4	5.7

Hormones were recognized by 37.5% of the students as one of the most difficult parts of the high school biology curriculum to learn. Students' responses to the second part of the instrument revealed that they fail to realize its relation to other systems, due to the perception of hormones as a separate system. Therefore, students conceived concepts related to hormones as complicated and to be learnt only by memorization. Another content area that is difficult for students to learn is genes and chromosomes. Approximately 36% of the students had difficulty in learning these concepts. They suggested that terms such as gene, allele, chromosome, chromatid, chromatin are abstract concepts and always confusing. Mitosis and meiosis is one conceptual area in biology which is indicated as difficult by 34.5% of the students. They stated that they had difficulty in differentiating phases of mitosis and meiosis. The nervous system was perceived as difficult to learn by 33.7% of the students. They judged that nervous system is a very complicated subject and includes many foreign terms. In addition, they complained inadequacy of time periods given to the subject. Mendelian genetics has been recognized by 32.1% of the students as difficult. They indicated that they had difficulty in performing mathematical operations especially probability. On the other hand, this concept has been perceived as easy and enjoyable by students who are interested in mathematics.

On the other hand, students rated the concept of ecology, and cells and organelles as easy topics. They indicated that they were introduced with these topics at all levels of schooling, starting from elementary school. In addition, they said that these topics were taught by using different teaching strategies, such as analogy and demonstration. Although both students and teachers do not perceive ecology to be a difficult topic in this study, there are much of the literature indicate the opposite (Johnson & Mahmoud, 1980; Adeniyi, 1985; Webb & Blott, 1990). It is also true for the concept of

homeostasis (Sungur, Tekkaya & Geban, 2001).

Teachers' and students' opinions concerning learning difficulties were closely matching each other. This means that, teachers are aware of their students' difficulties. Interestingly, approximately all biology teachers interviewed have rated photosynthesis as one of the most difficult topic for students. In contrast to teachers' perceptions, only 18% of the students indicated their difficulties in learning that concept. Students most probably memorize the definition and chemical formula of photosynthesis and perceived it as a simple process (Çapa, 2000). However, photosynthesis is a complex process including number of conceptual aspects - ecological, biochemical, anatomical-physiological and energy change - that are interlinked with each other.

Students' responses to open-ended questions and teachers' interviews revealed that terminology, textbooks, teaching methods, curriculum, abstract and interdisciplinary nature of concepts were among the sources of these difficulties. Most of the participants thought that "Biology is a course that presents very many contents, most of which depend on memorization," "Due to time limitation, courses could not be supported by laboratory sessions," "Textbooks are boring and include excessive details," "Textbooks contain too much new and unnecessary information," "Large amount of content tried to be covered, so less time is left for some important topics such as genetics and nervous system," "causal relations are not emphasized in the textbooks. As a result, we fail to realize the links among the topics and conceptualize them."

3.2. Gender Effect

When the students' learning difficulties concerning gender effect was examined, a statistically significant difference ($p < 0.05$) by gender was found. The mean score for boys and girls indicated that boys perceive biology topics easier than girls do (Mean for boys= 88.1, Mean for girls= 94.44). Therefore, it can be concluded that perceptions of students were influenced by

gender. The reason why boys perceive biological concepts as easy than girls, can be attributed to socialization factors and classroom experiences leading to low self-esteem and passive dependent behavior among girls (Çakıroğlu, 1999; Shamaï, 1996).

4. DISCUSSION

Students have difficulty with a wide range of concepts in biology. In contrast to the physical sciences where problems of understanding often originate in the counterintuitive nature of the ideas, many of the conceptual hurdles in biology results from the necessity to integrate knowledge from several sources. Genetics has been considered by many students as the most difficult concept to be learnt. Many researchers discussed the causes behind these difficulties. Tolman (1982), for instance, suggested that the difficulty in relating the concepts of meiosis and genetics came from the sequence in which these topics were presented in biology textbooks. Stewart (1983), and Cho, Kahle and Nordland (1985) stressed the importance of relationships among the concept of meiosis and genetics and the ambiguous and incorrect use of genetics concepts in textbooks. These factors presumably create difficulties not only in learning genetics but also other concepts in biology, such as respiration and photosynthesis (Aşcı, özkan & Tekkaya, 2001; Çapa, 2000). Also the importance of figures in the biology textbooks have been investigated by many researchers (see Kearsy & Turner, 1999). They suggested that the figures presented in a textbook have important roles in the explanation, contextualization and illustration of the text. These studies also showed that learning from the text in biology is enhanced by the presence of figures. Therefore, improvements to the figures in the textbooks are necessary to reduce students' difficulties.

There seems to be a problem with the biology curriculum in Turkish high schools in terms of quantity of subject matter to be covered. As a result, enough time was not given to each topic

to study deeply. At the same time, students are continuously being introduced new terminology and concepts. Therefore, they tend to memorize concepts rather than learn them meaningfully and fail to realize biology as a science which involves formulating hypotheses, making observations, conducting experiments, drawings conclusions, and evaluating results.

Certain prerequisite concepts are necessary for a learner to develop understanding of a certain concept. If these do not exist, it would be difficult for the learner to understand the new concept. Teachers generally assume that the students have already mastered the prerequisite ideas. On the contrary, they may not have assimilated the prerequisite ideas into their cognitive structure, which are necessary for a meaningful understanding of the new topic.

Other source of learning difficulties of Turkish students may be related to the presence of large numbers of foreign terms in textbooks. Ayas, Çeşni and Akdeniz (1993), stressed the richness of vocabulary in English language in comparison with the Turkish. They stated that "It was not possible to find the exact word that gave the original meaning. In some cases, new words were invented to correspond to the English ones but these were not known by the students. In other cases, words coming from English origin and known by students from the earlier education had been replaced with newly invented words. Thus, the students' understanding was different from that intended in terms of concept building and understanding the basic principles and laws of science" (Ayas et al., 1993, p. 437). However, as Penick (1995) suggested, students need to learn the concepts of biology, not the words .

5. CONCLUSION

Possible sources of students' difficulties in learning can be attributed mainly to the high school biology curriculum, teaching-learning strategies, textbooks, and insufficient laboratory conditions and equipment. In addition, students'

motivation and interest must be also taken into consideration. Students had difficulties in learning some subjects and had no interest in the lesson because high school biology curriculum did not include subject matter relevant to daily life. Moreover, it is not interesting to the students, and it is hard to learn without a good sequence of the subjects to be learnt in the curriculum. There is a necessity for making the subject matter of high school biology curriculum more contemporary, meaningful and interesting for the students, reflecting the recent developments in the field to the curriculum and relating lessons with daily life issues. Moreover, biology courses must be supported by qualified textbooks, instructional materials, laboratory sessions and observation and experiments that actively engage students in learning processes. Therefore, biology needs to be taught dynamically, not as a static subject in textbooks, emphasizing inquiry instruction allowing students to pursue areas of personal interest.

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