Effectiveness of the conceptual change texts accompanied by concept maps about students' understanding of the molecules carrying genetical information

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Contents

Abstract

This study aims to investigate the effects of concept maps, together with conceptual change texts, given to 11th grade students' on the subject of molecules carrying genetical information. The semistructured individual interviews were conducted with 5 upper class students to find misconceptions related to the subject. A success test was developed in the light of information taken from both literature and also interviews. This test was applied to the control group, who was taking traditional educational courses, and to the sample group students who were taking classes using concept maps and conceptual change texts together. The data was collected from 50 students; the groups consisted of 25 in the sample group and 25 in the control group. It was found that the conceptual change texts accompanied by concept mapping instruction produced a positive effect on students' understanding of the concept. The average percent of correct responses of the experimental group was 61.6% and that of the control group was 53.6% after treatment.

Keywords: Concept maps, Conceptual Change Texts, Genetic Subject

Introduction

A great majority of recently published science education studies have shown that intuition is responsible for some of students beliefs and ideas about scientific events. The students learn new information daily and they tend to commit this learned information in the direction of their previously held beliefs and ideas developed through intuition. Thus, students start to restructure scientific events. Since most students' information is restructured based on their own ideas that tend to, contradict scientific realities. This forms an important hindrance in science teaching (Driver, 1989). Students have developed information stated as naive theories, intuitional beliefs, preconceptions, children's science, alternative frameworks, alternative conceptions or misconceptions in consequence of their own comments in the first terms of school years or from some inconsistent explanations made in the environments inside or outside the school (Bahar, 2003; Wandersee, Mintzes & Novak, 1994). In some situations, teachers' beliefs or the statements included in the textbooks have caused misconceptions or have reinforced misconceptions (Abimbola & Baba, 1996; Dikmenli & Cardak, 2004; Barras, 1984; Storey, 1992). If misconceptions are not identified and corrected, they go on for long years and form important obstacles within subsequent education process. In some biology education studies in Turkey, it has been found out that the students have misconceptions in various areas of biology (Alparslan, Tekkaya & Geban, 2003; Tekkaya, 2003; Sungur, Tekkaya & Geban; Ascı, Ozkan & Tekkaya, 2001).

Molecules carrying genetic information is an important subject and is hard to teach and learn in schools. Fisher (1985) has found that most university students have misconceptions about the products of translation. Fisher has also asked students, "where do amino acids come from?" He explained that while some of the students have correct concepts concerning the origin of amino acids, the remaining majority have various misconceptions. Some of the students stated that amino acids are always present and they come from a holy source or they derive from a leading sea. Some students think that amino acids are synthesized by ribosomes and m-RNA through the translation process. Other students stated that they have no opinion about the source of amino acids and its origin.

Ozkan and his colleagues (2004) have examined the effects of conceptual change texts on 7th grade students' understanding the concepts about ecology. In this study, the ecology subject was given to the experimental group through conceptual change texts, the control group was taught using traditional teaching methods (involving lessons using lecture/ discussion methods to teach concepts) . A statistically meaningful difference was found in favour of the experimental group about understanding ecology concepts.

People learn concepts being units of the thought and the words being their names, classify the concepts, find out the relations among them beginning from childhood. Therefore they rearrange by acquiring meaning to their information. They just create new concepts and information. The concepts should be learned through meaningful techniques. Otherwise the problems concerning the permanence of information occur (Kinchin, David & Adams, 2000). One advocate of meaningful learning is David Ausubel. He sees the essential element of learning as students' joining information they learned before with new information (Amir & Tamir, 1995).

One of the conceptual change strategies involves the use of conceptual change texts. The texts are used to suplement classroom instruction. The teacher directs students to read the text silently. At the end of a paragraph, a question is posed and students are asked to stop reading. The evidence is presented that a misconception is incorrect, or a concept is explained scientifically. Then, the teacher discusses the statements in text with students. Conceptual change texts are very useful in changing and developing conceptual information structure.

(Kinchin, David & Adams, 2000; Sungur, Tekkaya& Geban, 2001;Türkmen, Cardak & Dikmenli, 2005).

Because of the importance of concept maps in the literature review, this study examines the effects of concept maps together with conceptual change texts.

Concept maps first developed during a study carried out by students graduating from Novak and Cornell Universities (Horton et al., 1993). Concept maps help describing how related concept systems are connected to each other (Cliburn, 1990). To prepare a concept map, the first step involves finding related concepts and then they must be shown in a meaningful style (Lloyd, 1990). Having an individual conceptualize a subject allows a teacher or researcher to better understand the individual's initial concepts and misconceptions.

Hazel and Prosser (1994) have used concept maps to identify first year undergraduates students' conception of photosynthesis. In this study, concept maps have been used before and after teaching about photosynthesis. The students were asked to integrate the 13 concepts into hierarchy and to briefly describe the connections of related concepts. An analysis of concepts connected correctly and the results taken from 10 multiple choice test questions on photosynthesis, researchers have identified students' misconceptions about photosynthesis.

Songer and Mintzes (1994) have used concept maps and interviews to try to determine students' misconceptions concerning respiration; they found that the students have some misconceptions concerning the relationship between photosynthesis and respiration, energy transfer and oxygen's role in respiration.

The concept mapping strategy provides a linkage to prior information with acquired information. In a study to better understand the human heart's structure and function, the control group was educated without concept maps, but concept maps were used in the experimental groups. The statistics showed the positive effect of concept maps on students (Smith & Dwyer, 1995).

Concept maps help students meaningfully learn concepts. Each concept has a state connected with other ones. The student can draw a meaningful line to link related concepts on the map. He better organizes his learnings and reflects them. This aspect of concept maps is useful in organizing and integrating information, in most parts of the application process, and in connecting the present information structure with the effect of new concepts. Concept maps are effective in showing the connections among concepts. Namely they are tools to be used first in science lessons. Information stays in memory for long time when using concept maps. Because the students differentiate information's structure and process, meaningful learning can be advanced (Alparslan, Tekkaya & Geban, 2003; Tekkaya, 2003; Novak, Gowin & Johansen; Okebukola, 1990; Sungur, Tekkaya& Geban, 2001; Cakır, Geban & Yürük, 2002; Stoddart, Abrams, Gasper & Canaday, 2000; Slotte & Lonka, 1999).

Bagci-Kilic (2003) has stated that concept maps have been often used by European and American educators, and have focused on the problems sourced from language differences between English and Turkish in the use of concept maps. The researcher has stated that concept maps must be formed by making them appropriate to Turkish language structure and asserted some methos concerning this (Bagci- Kilic, 2003).

Teaching with concept maps provides comprehensive learning and decreases misconceptions. Concept maps are more effective than traditional educationals methods in understanding of concepts. In addition, students exhibited positive attitudes toward concept map use during biology lessons (Sungur, Tekkaya & Geban, 2001).

Concept maps are meaningful learning tools which can be used in the planning, teaching and evaluation in the education of science concepts. (Novak & Canas, 2004). Concept maps made by small groups have the advantage of information transfer from student to student. Concept maps are important tools in stimulating student discussion. The use of concept maps in t groups plays important role in socialization and cognitive development. There is a great deal of room for improvement in conceptual change from existing alternative conceptions. Further experimentation is needed to explore the potential of the conceptual change approach in the educational field may be realized more effectively.

Purpose

The aim of this study is to investigate the contrubution of concept maps and conceptual change texts on the 11th class (grade?) students' success in the teaching about molecules carrying genetical information. The specific questions of this study are:

1-What is the effect of traditional teaching method on the students' understanding of the concepts of molecules carrying genetic information?

2-What is the effect of concept maps given together with conceptual change texts on the students' understanding of molecules bearing genetic information concepts?

Material and Methods

This research is in a testing model. The experimental group (CCT, CMI) in Table I, represents the group of students using the concept and the conceptual change text. The control group (TBI) represents the group using traditional teaching method (teacher-directed strategy), T_1 shows the Biology Achievement Test (BAT).

Table I. The study's research pattern

Groups	Pre-test	Treatment	Post-test
Experimental Group (CCT, CMI)	T_1	(CCT, CMI)	T_1
Control Group (TBI)	T_1	(TBI)	T_1

The Biology Achievement Test was applied on both of the groups before teaching about molecules carrying genetical information in order to see whether there is a considerable amount of difference between the groups. The first step of the study was to randomly choose 5 students to interview before taking the course. In accordance with the data acquired by the interview analyses and the dialogues conducted among teachers, a biology achievement test was formed. Before applying the concept maps on the experimental group, the students were informed about the concept map and conceptual change texts during the preceding unit. A researcher gave the classroom instruction for both groups. The researchers, in the course of study, prepared concept maps and the researchers again used them during the lesson. Also, the students prepared some concept maps during the teaching process. Conceptual change texts were prepared by the researchers and handed out to the students during the lesson. The questions and explanations, which took place in conceptual change texts, were discussed among the researchers and students. During the discussion, the misunderstood concepts were clarified and the correct usage of those concepts were explained to the students.

Sample

The sample of study was randomly selected from 11th grade high school students in the province center of Konya, a big size city at the Central Anatolian Region of Turkey. The total number of students was 50 and was split into two equal classes (see Table II). The ages of students were between 16 and 17.

Table II. The groups involved in the study and the number of students

Groups	No of students (N)
Experimental Group (CCT, CMI)	25
Control Group (TBI)	25
Total	50

Instrument

There was only one written instrument used in this study. This instrument was the Biology Achievement Test (BAT). The data acquired by this surveying instrument was transferred to the computer and assessed by using SPSS 10.00 package programme. This test, which was developed by the researchers, consisted of 30 multiple-choice questions. There was only one correct answer and 4 misleading answers for each question. While preparing the misleading answers, the misconceptions acquired by the students were taken into account. Test was examined by a group of experts in biology education, biology, measurement and evaluation regarding content validity, and format. The internal consistency reliability of this test was found to be 0.79. This test was applied to 11th grade high school students. During the analysis of the data, the "t" test was applied and percentage expressions were used. a = 0.05 was used as significance level.

Treatment

This study was conducted for 5 weeks in the second semester of 2003-2004 academic year. A total 50 students, from two different 11th grade classes attending biology lessons from the same teacher participated in the research. One of the classes was assigned as the experimental group, and the other was assigned as the control group. Two different practices were used in this study. While applying traditional biology teaching method on the control group; concept maps, given together with conceptual change texts, were applied on the experimental group. Biology lessons were given regularly three hours a week.

The methods of teaching for the control group included teacher explanations and discussions in accordance with the course books. The control group received the traditional instruction involving lessons using lecture/discussion methods to teach concepts. Teaching strategies relied upon teacher explanation and textbooks, with no consideration of the students' alternative conceptions. In this group, the teacher provided instruction through lecture and discussion methods to teach the concepts. The teacher structured the entire class as a unit, wrote notes on the chalkboard about the definition of concepts, and passed out worksheets for students to complete. The primary underlying principle was that knowledge as fact to students. After the teacher's explanation, some concepts were discussed, prompted by teacher directed questions. Worksheets were specifically developed by the researchers for each lesson. They required written responses and reinforced the concepts presented in the classroom sessions. They were collected and corrected by the teacher. This classroom typically consisted of the teacher presenting the right way to solve problems. The majority of instruction time (70%) was devoted to instruction and engaging in discussion stemming from the teacher's explanations and questions. This classrom typically consisted of the teacher presenting the 'right way' to solve problems.

The researcher gave the classroom instruction for both groups. Students in the experimental group worked with conceptual change text and concept maps. Because of the complex process of making a concept map, some pre-arrangements were made for students in order to make a concept map. The students were given some examples of concept maps used in the preceding unit of the subject molecules carrying genetical information, and the researcher made some explanations. In the course of this process; the steps to be performed in order to form a concept map were listed as follows:

Concepts of the teaching subject were listed. The most general concept was written on the heading of the page. Concepts were written in a box. Correlation of the concepts, generalizations and principles were listed apart from the concept list. Two boxes were linked to each other through a line and the type of the relation was named. Concept maps of subunits were prepared. These concept maps were the sample maps prepared by the students. The students were charged with preparing concept maps for the subjects taking place in the unit. In the beginning, in order to help students for prepare their first concept map, a concept list was given to students. Then, the necessary steps to make a concept map were explained.

The experimental group used conceptual change texts together with the concept maps. Conceptual change texts (13 conceptual change texts) were prepared by the researchers in order to focus on and correct the students' misconceptions about the subject of molecules carrying genetical information. In the conceptual change texts prepared after the interviews with the students, these subjects were taken into account: the importance of nucleic acids, the types and functions of nucleic acids, their placements according to cell types; the functions of DNA and RNA, their similarities and differences; the crucial functions of DNA and RNA; DNA's pairing and the following processes; the transfer of genetic characters from generation to generation; the types and functions of DNA and RNA; the fulfilment stages of protein synthesis; the structures and functions of ribosomes; amino acids forming the structure of proteins; the reasons for the differences between living creatures; genetic code; data flow in the cells. Then conceptual change texts were handed out to the students regularly in their lesson hours every week. Most of the concepts taking place in conceptual change texts were explained to the students. The aim of preparing the conceptual change texts was to replace misconceptions with the correct concepts. The texts offered a set of guidelines to help students gain experience in grasping the concepts. These guidelines provided a special learning environment, such as identifying common alternative conceptions, activating students' alternative conceptions by presenting examples and questions, presenting descriptive evidence in the text that the typical alternative conceptions were incorrect, and providing a scientifically correct explanation of the situation. The teacher provided opportunities for students to be involved in discussion and question and answer sessions while studying the conceptual change text. In the conceptual change text, students were asked explicitly to predict what would happen in a situation before being presented with information that demonstrated the inconsistency betwen common alternative conceptions and the correct scientific conceptions. In each of the texts, the topics were introduced with questions, and students' possible answers that were scientifically unaccepted were mentioned directly. Then scientifically acceptable explanations that are more plausable and intelligible were described. Also, examples and figures were included in the texts with the intention of further helping students understand the scientic concept and realize the limitations of their own ideas.

Interviews

In this section, some misconceptions of students about the unit called "Molecules Carrying Genetic Information" were defined.

Question: How many types of nucleic acids are there in living creatures? Student 1:3 types Question: Can you tell me their names?

Student 1: DNA, RNA, ATP

Question: Do all the living creatures have to have their own DNA? Student 5: No, they don't. Because only human beings and animals have DNA.

Question: Why?

Student 5: Because the others don't have cell-cores. Question: Can you give me the examples of living creatures without cell-cores?

Student 5: Plants, single-celled organisms, fungus.

Question: In which ways do DNA replications emerge? Student 5: DNA replicates itself before the cell dichotomy and protein synthesis.

Question: Well, is it necessary to have DNA replication in order to have protein synthesis?

Student 5: Yes. Question: Why?

Student 5: Because, by matching itself, DNA transfers the genetic information to m-RNA and to the new cells. Question: Is there any difference between adenine nucleotide molecule of DNA and adenine nucleotide molecule of RNA?

Student 1: No, there isn't. They're the same. Question: Do all living creatures make protein synthesis? Student 1: Some of them don't make it. For example, parasites and decomposers. Question: Why? Student 1: Because they get all of their nutrients, including protein, from their environment.

Question: The permutation of metionine amino acid in human beings is AUG. Can we say that it is the same in mice?

Student 1: No, we can't. Question: Why? Student 1: Because they are totally different living creatures.

Question: How many genetic codes does a DNA molecule contain in order to encode 20 types of amino acids taking place in the nature?

Student 2: It contains 20 types of code countering 20 types of amino acids.

Question: When a protein, consisting of 100 amino acid is synthesised, how many peptide core and H2O molecule do emerge?

Student 1: 200 Peptide bond and 99 H2O molecules emerge.

Student 3: 100 peptide bond against 100 H_2O molecules.

Results

Before the application, biology achievement test was given to the experimental group and the control group as a pre-test. The results of the pre-test are that: For the experimental group, the average number of right answers is 14.12; for the control group the average number of right answers is 13.12 (see Table III).

Table III. T-test results of experimental and control group students in the biology achievement test concerning pre-test points

Test	Groups	N	Mean	Sd	t	p
Biology Achievement Test	Experimental Group	25	14.12	3.05	0.898	.378
	Control Group	25	13.12	4.52		

As seen in Table III; there was no considerable difference between the experimental group and the control group concerning biology achievement test success (p=.378).

After the application, there was a difference between percentages of the answers that were given by the students in biology achievement test. The BAT correct answer average of the experimental group was 61.6%; while the BAT correct answer average of the control group was 53.6%. A similar difference can be clearely seen in the questions numbered 8, 9, 14, 20, 23, 25.

It was seen in the 8^{th} question, for instance, that there were some errors related with the factors effective in determining the types of amino acid used in accordance with the protein before the protein synthesis. 48% of the control group students and 76% of the experimental group students gave a correct answer to this question. In the 9^{th} question, very few students marked the answer stating that protein types of cells belonging to different tissues of the same person can be different and protein similarities cannot be generalized for all cells. 12% of the control group students and 40% of the experimental group students gave a correct answer to this question. In the 20^{th} question, which was about the ribosome functioning crucially in protein synthesis of all livings, 100% of the experimental group students and 64% of the control group students and marked the answer stating that ribosome can be seen in every living cell. In the 23rd question, which was about the factors providing the difference between protein molecules in primary structure, 12% of the control group students and 44% of the experimental group students gave a correct answer. The students were asked to find out the wrong statement about the characteristics of DNA in the 25^{th} question. Only 28% of the control group students and 64% of the experimental group students found that there are not twice as many DNA in reproductive cells than in the body cells.

After the application, the control group students and the experimental group students were given the Biology Achievement Test again. The correct answer average of the experimental group students was 18.48; while the correct answer average of the control group students was 16.08. "P" value was defined as .762 according to the data acquired by the "t" test (see Table IV). While the "p" value was bigger than .05, there was no such considerable difference between the groups. The experimental group students were advantageous in terms of the high numbers in correct answer averages.

Tablo IV. T-test results of experimental group and control group students in biology achievement test as a post-test.

Test	Groups	N	Mean	Sd	t	p
Biology Achievement Test	Experimental Group	25	18.48	3.92	2.40	.762
	Control Group	25	16.08	6.16		

Most of the students had little success in the subject of molecules carrying genetical information before the application; but afterwards, the experimental group made considerable gains because of the educational method. Students gained a lot in terms of understanding the concepts in most of the questions. While the correct answer average of the experimental group in the pre-test of the biology achievement test was 47.06%; after the application, the correct answer percentage rose to 61.60 % and students made gains of 14.54%.

The rise in the success of the experimental group, in terms of the BAT, can be seen here in order of the questions: 32% in the 3rd question, 44% in the 4th question, 52% in the 5th question, 48% in the 7th question, 28% in the 8th question, 36% in the 10th question, 56% in the 12th question, 40% in the 13th question.

Table V. T-test results of experimental group students in biology achievement test as a pre-test and as a post-test.

Test	Experimental Group	N	Mean	Sd	t	p
Biology Achievement Test	Pre-test	25	14.12	3.05	-2^{*}	$.000^{*}$
	Post- test	25	18.48	3.92		

As seen in Table V; the experimental group of students, on whom the teaching method consisting of concept maps given together with the conceptual change texts was applied, received higher averages from the BAT post-test than the pre-test. While their correct answer average in the pre-test was 14.12; after four weeks of using the teaching method consisting of concept maps and conceptual change texts, their post-test average became 18.48. The "t" test was used to see whether there was a difference between the experimental group students' grades in the BAT pre-test and final test. As a result of "t" test, "p" value was $p < .05$, which means there was a considerable difference between pre-test and post-test ($p = .000$).

This difference showed that the teaching method consisting of concept maps given together with the conceptual change texts positively affected students understanding of the concepts of the subject of molecules carrying genetical information.

The correct answer average of the control group in the biology achievement test as a pre-test was 43.73%; after the application, the correct answer percentage rose to 53.60% and students gained 9.87%. For example, there was an increase in the correct answers of some questions: 20% in the 7th question, 24% in the 10th question, 24% in the 11th question, 28% in the 12th question, 40% in the 13th question, 32% in the 14th question.

Table VI. t-test results of control group students in biology achievement test as a pre-test and as a post-test.

Test	Control Group	N	Mean	Sd	t	p
Biology Achievement Test	Pre-test	25	13.12	4.52	1.759	.091
	Post- test	25	16.08	6.16		

As seen in Table VI; the control group students on whom the traditional biology teaching method was applied had a higher average from the BAT post-test than the pre-test. Their correct answer average in the pre-test was 13.12; after the traditional biology teaching method was applied for four weeks, their post-test average became 16.08. The "t" test was used to see whether there was a difference between the control group students' grades in the BAT pre-test and post-test. In the $p< .05$ level of "p" value, there wasn't a considerable difference between pre-test and post-test averages ($p= .091$).

Discussion and Implications

The aim of this study was to investigate the effects of the teaching method consisting of concept maps given with the conceptual change texts in teaching about molecules carrying genetic information to the 11th grade high school students. 25 control group students and 25 experimental group students made a total 50 students who took place in the study. The teaching method consisting of concept maps given together with the conceptual change texts was applied on the experimental group and traditional biology teaching method was applied on the control group.

During the application, the control group students were instructed in the traditional biology teaching method using their course books. The experimental group students took lessons that used concept maps and conceptual change texts. Results showed that conceptual change texts and concept maps are useful in teaching about molecules carrying genetic information.

Turkmen et al. in their study "Determining the Misconceptions of Freshman High School Students About The Diversity and Classifications of Living Things and Correcting These Misconceptions with Concept Maps", found misconceptions, and out the result, that concept maps given together with conceptual change texts are more effective than the traditional biology teaching method (Türkmen, Cardak & Dikmenli, 2005).

Marbach studied students of different ages in order to find their understanding of genetic concepts like gene-protein, gene-enzyme, gene-character, DNA-protein, DNA-enzyme and

DNA-character and their perception level of understanding the relations between these concepts. In the study, the students applied concept maps, interviews and questionnaire; then it was found that they had some alternative conceptions. In our study, as a result of tests and interviews, some similar misconceptions related to these concepts were defined (Marbach, 2001).

As it was stated above, the biology achievement test was prepared by taking all of the aims into account before application on the students. During the study, students were motivated by researchers to read conceptual change texts. The benefits of concept maps and how to make a concept map were told to the students before the subject began. During the unit on molecules carrying genetical information, students were inspired to make concept maps. Students found it difficult to make a concept map on their first try.

When the statistical values of the experimental and control group were checked before the application, it was seen that there was no considerable difference in the biology achievement test as a pre-test (for BAT, see Table III). According to the pre-test results, both groups had almost the same level of success with the concepts of the subject of molecules carrying genetic information. The BAT was given to the student groups as a post-test after the application to compare and examine the effects of two different teaching methods (CCT, CMI and TBI) in understanding the concepts of molecules carrying genetic information.

It was seen that the experimental group students had more information about and an understanding of the scientific concepts than control group students. Both experimental group and control group students gained information according to the statistical post-test data (see Table IV). Although both group gained a lot, in terms of understanding concepts, the experimental group was more successful than control group (for BAT see Table 5, Table VI). These results confirm the findings of previous studies in that a text- based conceptual change approach can facilitiate learning of scientific concepts (Alparslan, Tekkaya & Geban, 2003; Tekkaya, 2003; Kinchin, Davids & Adams, 2000; Smith & Dwyer, 1995; Türkmen, Cardak & Dikmenli, 2005; Ozkan, Tekkaya & Geban, 2004; Amir & Tamir, 1995; Sungur, Tekkaya & Geban, 2001). These findings can prove that by correcting the misconceptions, the experimental group was more successful than control group. While the advantage of control group was 9.87%, the advantage of experimental group was 14.54% in terms of the biology achievement test.

The results of this study provided future evidence to support the findings in a growing body of literature indicating that students hold misconceptions on a variety of biology concepts. In addition, it was concluded that concept maps given together with conceptual change texts supported students in understanding the concepts. When misconceptions are found and are taken into account, the learning process becomes more effective. Stating the misconceptions and using concept maps together with conceptual change texts during the teaching process is one successful ways to improve education. The suggestions for additional study include the following:

A similar study can be conducted on different lessons and different levels of classes. The total number of students in this study is 50. In order to have more meaningful results in future, this number can be multiplied. Concept maps and conceptual change texts can be used to gauge and evaluate the level of the dwelling in students' memory. The effects of concept maps and conceptual change texts can be compared with the teaching methods such as problem solving, co-operative teaching, demonstration, problem-based teaching and computer assisted teaching, etc. The attitudes of students against the concept maps and conceptual change texts can be examined.

References

Abimbola, I.O. & Baba, S. (1996). Misconceptions & alternative conceptions in science textbooks: The role of teachers as filters.*The American Biol. Teach*., *58*, 14-19.

Alparslan,C., Tekkaya, C. & Geban, O. (2003). Using the conceptual change instruction to improve learning. *J. Biol. Educ., 37*, 133-137.

Amir, R. & Tamir, P. (1995). Proposition generating task (PGT): A measure of meaningful learning and of conceptual change.*J. Biol. Educ*., *29*, 111-118.

Ascı, Z., Ozkan, S. & Tekkaya, C. (2001). Students' misconceptions about respiration.*Educ. Sci*., *26*, 29-36.

Bahar, M. (2003). Misconceptions in biology education and conceptual change strategies, *Educ. Sci. Theory & Prac*. 3, 55-64.

Bagcı- Kılıc, G. (2003). Concept maps and language: a Turkish Experience, *Int. J. Sci. Educ*. 25, 1299-1311.

Barras, R. (1984). Some misconceptions and misunderstandings perpetuated by teachers and textbooks of biology, *J. Biol. Educ*. 18, 201-206.

Bishop, B. A. & Anderson, C. W. (1990). Student conceptions of natural selection and its role in evolution, *J. Res. Sci. Teach*. 27, 415-427.

Cakır, S. O., Geban, O. & Yürük, N. (2002). Effectiveness of conceptual change text-oriented instruction on students' understanding of cellular respiration concepts, *Biochem. Mol. Biol. Educ*. 30, 239-243.

Cliburn, J. W. (1990). Concept maps to promote meaningful learning, *J. College Sci. Teach*. 19, 212-217.

Dikmenli, M. & Cardak, O. (2004). A study on misconceptions in the 9 th grade high school biology textbooks, *Eurasian J. Educ. Res*. 17, 130-141.

Driver, R. (1989). Students' conceptions and the learning of science, *Int. J. Sci. Educ*. 11, 481-490.

Fisher, K. M. (1985). A misconception in biology: amino acids and translation, *J. Res. Sci. Teach*. 22, 53-62.

Hazel, E. & Prosser, M. (1994). First-year university students' understanding of photosynthesis, their study strategies and learning context, *The American Biol. Teach*. 56, 274-279.

Horton, P. B., McConey, A. A., Gallo, M., Woods, A. L., Senn, G. J. & Hamelin, D. (1993). An investigation of the effectiveness of concept mapping as an instructional tool, *Sci. Educ*. 77, 95-111.

Kinchin, I. M., David, B. H. & Adams, A. (2000). How a qualitative approach to concept map analysis can be used to aid learning by illustrating patterns of conceptual development, *Educ. Res*. 42, 43-57.

Lloyd, C. L. (1990). The elaboration of concepts in three biology textbooks: Facilitating student learning, *J. Res. Sci. Teach*. 27 (10), 1019-1032.

Marbach, G. (2001). Attempting to break the code in student comprehension of genetic concepts, *J. Biol. Educ*. 35, 183-189.

Novak, J. D., Gowin, D. B. & Johansen, G. T. (1983). The use of concept mapping and knowledge mapping with junior high school science students, *Sci. Educ*. 67, 625-645.

Novak, J. D. & Canas, A. (2004). Building on new constructivist ideas and Cmap tools to create a new model for education, *Proc. of the First Int. Conference on Concept Mapping*, Pamplona, Spain 2004.

Okebukola, P. A. (1990). Attaining meaningful learning of concepts in genetics and ecology; an examination the potency of the concept-mapping techingue, *J. Res. Teac*. 27, 493-504.

Ozkan O., Tekkaya, C. & Geban, O. (2004). Facilitating conceptual change in students' understanding of ecological concepts, *J. Sci. Educ. Tech*. 13, 95-105.

Slotte, V. & Lonka, K. (1999). Spontaneous concept maps aiding the understanding of scientific concepts, *Int. J. Sci. Educ*. 21, 515-531.

Smith, K. M.& Dwyer, F. M. (1995). The effect of concept mapping strategies in facilitating student achievement, *Int. J. Instruct. Media*. 22, 25-31.

Songer,C. J. & Mintzes, J. J. (1994). Understanding cellular respiration: An analysis of conceptual change in college biology. *J. Res. Sci. Teach*. 31, 621-637.

Stoddart, T., Abrams, R., Gasper, E. & Canaday, D. (2000). Concept maps as assesment in science inquiry learning – a report of methodology, *Int. J. Sci. Educ*. 22, 1221-1246.

Storey, R. D. (1992). Textbook errors and misconceptions in biology: Cell energetics, *The American Biol. Teach*. 54, 161-166.

Sungur, S., Tekkaya, C. & Geban, O. (2001). The contribution of conceptual change texts accompanied by concept mapping to students' understanding of the human circulatory system, *Sch. Sci. Math*. 101, 91-101.

Tekkaya, C. (2003). Remediating high schools' misconceptions concerning diffusion and osmosis through concept mapping and conceptual change text, *Res. Sci. Tech. Educ*. 21, 5-16.

Türkmen, L., Cardak, O. & Dikmenli, M. (2005). Using concept maps changing the misconceptions of the first year high school students in biology courses in classification of living things and their diversity, *J. Gazi Faculty of Educ*. 25, 155-168.

Wandersee, J. H., Mintzes, J. J. & Novak, J. D. (1994). Research on alternative conceptions in science, In D.L. Gabel (Ed.), *Handbook of Research on Science Teaching and Learning*. (pp. 177-210). New York: Macmillan.

Westbrook, S. L. & Marek, E. A. (1991). A cross-age study of student understanding of the content of diffusion, *J. Res. Sci. Teach*. 28, 649-660.