BIBLIOGRAPHY

BAKER, L. Metacognition, reading and science education. In: MINNICK SANTA, C. and ALVERMANN, D. E. (ed.): *Science learning. Processes and application.* International Reading Association, Newark, 2-13, 1991.

BALOGH, L. *Learning strategies on basic of psychological development.* (In Hungarian) Kossuth Egyetemi Kiadó, Debrecen, 1998.

BAR, V. Children's views about the water cycle. *Science Education* **73** (4), 481-500, 1989.

BLYTHE, T. *The Teaching for Understanding Guide*. San Francisco: Jossey-Bass Publishe, 1999.

BROPHY, J.; ALLEMAN J. Primary-grade students' knowledge and thinking about the supply of utilities (water, heat, and light) to modern homes. *Cognition and Instruction* **21** (1), 79-112, 2003.

BRUNER, J. S. *Processes of cognitive growth: Infancy.* Worcester, MA, Clark University Press, 1968.

CAREY, S. *Conceptual change in childhood*. Cambridge, MA: The MIT Press, 1985.

CHARLES, C. M. *The Synergetic Classroom. Joyful Teaching and Gentle Disscipline*. New York, Longman, 2000.

CLARKE, S. *Unkocking Formative Assessment. Practical strategies for enhancing pupils' learning in the primary classroom.* London, Hodder & Stougthon, 2001.

DE CORTE, E. School learning. (In Hungarian) *Magyar Pedagógia*, **101** (4), 413-434, 2001.

DISESSA, A. A. The third revolution in computers and education. *Journal of Research in Science Teaching*, **24**, 353-367, 1987.

FISHER, K. M.; LIPSON, J. I. Twenty question about student errors. *Journal of Research in Science Teaching*, 783-803, 1986.

FLAVELL, J. Cognitive monitoring. In: DICKSON, W. P. (ed), *Children's oral communication skills.* Academic Press, New York, 35-60, 1981.

GORDON GYÖRI, J. Teaching and learning of thinking.(In Hungarian*) Iskolakultura*, **11** (2), 93-100, 2001.

JOHNSON, P. Children's understanding of changes of state involving the gas state. Part 1: Boiling water and the particle theory. *International Journal of Science Education* **20** (5), 567-583. 1998.

JOHNSTONE, A. H., MAHMOUD N. A. Pupils' problems with water potential. *Journal of Biological Education* **14** (4), 325-328, 1980.

KOLIOPOULUS, D., PAPANDREU, M., RAVANIS, K., TANTAROS, S. Preschool children's ideas about floating: a qulitativ approach. *Journal of Science Education*, **5** (1), 21-24, 2004.

OSBORNE, R., CORGROVE M. Children's conceptions of changes of state of water. *Journal of Research in Science Teaching* **20** (9), 825-838, 1983.

RUSSELL, T.; HARLEN W.; WATT D. Children's ideas about evoporation. International *Journal of Science Education,* **11** (6), 566-576, 1989.

STAVRIDOU, H., MARINOPOULOS D. Water and air pollution: Primary students' conceptions about "Itineraries" and interactions of substances. *Chemistry Education: Research and Practice in Europe* **2** (1), 31-41, 2001.

WYGOTSKY, L. S. *Mind and Society. Cambridge*, MA, Harward University Press, 1978.

Received: 15.01.2007 / Approved: 20.04.2008

Reducing students' alternative conceptions on the reproduction and development in living things by means of conceptual teaching

Reducción de los conceptos alternativos en los estudiantes sobre la reproducción y el desarrollo de seres vivos a través de la enseñanza conceptual

OSMAN CARDAK, MUSA DIKMENLI

Selcuk University Faculty of Education, Department of Science Education, Konya, Turkey
ocardak@selcuk.edu.tr, mdikmenli@selcuk.edu.tr

Abstract

In primary science education, there are different instruction methods used by science educators and teachers in order to change alternative conceptions held by students. One of the common methods used to change alternative conceptions is concept maps. The purpose of this study was to change alternative conceptions held by 6th grade Turkish primary school students in the context of the reproduction and development of living things in a primary school science and technology course. This study was completed with two 6th grade primary school science and technology classes consisting of 36 students in fall 2006. Concept maps, semantic feature analysis and conceptual change texts, and traditional science instruction were applied to the experimental and control groups over a period of six weeks. An achievement test over the reproduction and development in living things was given to both groups as pre- and post-tests to compare the two instruction methods. After analyzing the data, it was determined that students who learned reproduction and development in living things with the concept maps and semantic feature analysis showed statistically higher achievement than those students who learned the same subject material with the traditional method (P<0.05).

Key words: *reproduction and development, living things, conceptual instruction, biology, primary school.*

Resumen

*Hay varios métodos usados p*or educadores de ciencia y por los profesores para cambiar los conceptos alternativos que los estudiantes poseen sobre ciencia, en la escuela primaria. Los mapas de conceptos, por ejemplo, pueden ser utilizados para cambiar las concepciones alternativas. El objetivo de este estudio es cambiar las concepciones alternativas sobre procreación, el crecimiento y el desarrollo de los seres vivos en alumnos de una escuela primaria. Este estudio fue realizado con 36 estudiantes de sexto año de una escuela primaria durante un semestre de 2006. El grupo experimental utilizó mapas de conceptos, análisis semántico y textos para el cambio conceptual, en el grupo de control fue utilizado el método clásico. Este estudio se extendió durante seis semanas. Los dos grupos fueron evaluados al principio y al final de las actividades. El análisis de los datos indicó que el grupo experimental que usó mapas de conceptos, análisis semántico y textos para el cambio conceptual, acertó mas que el grupo de control que usó el método clásico (P<0.05).

Palabras clave*:* reproducción, conceptos de crecimiento, cambio conceptual, biología, escuela primaria.

INTRODUCTION

In recent years, many researchers in science education have focused on students' conceptual development and cognitive processes (KWON & LAWSON, 2000). It was basically accepted that each student had a different cognitive structure because of his/her different abilities, backgrounds, and attitudes (PIAGET, 1969). Many studies in the science education arena deal with alternative concepts related to science subjects taught in primary and secondary schools around the world. Children learn new information daily and tend to comment this learned information in the direction of beliefs and ideas they develop through intuition before formal instruction. As a consequence, children begin to restructure scientific events. Educators now generally agree that students come to class with established ideas, but mostly different from those usually accepted by scientists. These different conceptions, generated by students, have been called alternative conceptions (ARNAUDIN & MINTZES, 1985), children science (GILBERT, OSBORN & FENSHAM, 1982), naive theories (MINTZES, 1984), or misconceptions (FISHER, 1985). Misconceptions, being quite widespread in formal education, are very resistant to change (WANDERSEE, MINTZES & NOVAK, 1994). Students seem to have difficulties learning concepts as well as to change preconceptions already held in science courses, including biology (BAHAR, 2003; KINCHIN, 2000; TREAGUST, 1988; BLOOM, 1990). There may be several reasons why students hold on to alternative conceptions, including going back to the first years in school or even earlier (BELL, 1981; PINES & WEST, 1986). Alternative conceptions held by students are not easily changed throughout the school years and may adversely affect meaningful learning of new concepts and making connections with other concepts in science courses (STRIKE & POSNER, 1982).

Ozkan *et al.* (2004) examined the effects of conceptual change text on primary school 7th grade students' understanding ecology concepts. In this study, ecology subjects were given to the experimental group of students by means of conceptual change texts, those have given to the control group students by using traditional teaching methods. Results from the t-test statistics revealed a statistically significant difference between the control group and the experimental group. In terms of understanding ecological concepts the experimental group students scored higher than the ones in the control group.

There are some methods—for example, concept maps—to help students make connections with sub-concepts related to the main concept and to determine relationships with the concepts (Kinchin, David & Adam, 2000). The concept map technique as a teaching, learning, and evaluation tool has been used commonly as an effective tool to provide meaningful learning in science education. The concept map, developed as a research tool by Novak and his friends in the 1970s, has been theoretically based on Ausubel's (1968) meaningful learning theory, which emphasized the importance of the individual's available knowledge in the realization of learning.

According to Ausubel's theory (1968), concept maps are defined as schemes forming a bridge between pre-information and new-learned information by individuals. Due to the existence of a hierarchic relationship between the concepts, it has been emphasized they are different from the echo diagram and concept web. A concept map is composed of categories. Novak & Musonda (1991) stated that the majority of these categories in the concept maps shows the profoundness and wealth of an individual's knowledge and thought structure. In addition, in the concept maps there are cross connections showing the relationships between different branches formed in hierarchy. The existence of cross connections can show how an individual synthesizes the branches composing different concepts by connecting them with each other and the level of creative thought. It has been stated by many researchers that the concept map technique, an effective learning technique, develops students' thinking, analyzing, problem-solving, and creative techniques (Novak, Govin & Johansen, 1983). Trowbridge and Mintzes (1985) determined that the concept map technique provides students with the ways to determine the subjects they didn't know and understand, to understand the subject's content by organizing information and to increase the permanence of information; that the students had made a concept map with their own increased self-confidence. White and Gunstone (1992) have said that students who made a concept map in groups created more talking and discussing of the subject by strengthening the communication among them. The concept map is effective in measuring understanding and learning levels of the students because it can show an individual's knowledge and thought structure schematically and it can give an opportunity to teachers to determine the truth of students' knowledge, concept errors, and mistakes, while discussing with students about the concept map (Novak, Govin & Johansen, 1983). There is opportunity for improvement in effecting conceptual change from existing alternative conceptions. It is clear that further experimentation should explore ways in which the potential of the conceptual change approach in the educational field may be realized more effectively.

Purpose

The main theme of this study was to identify of the effectiveness of conceptual change text-oriented instruction over traditional instruction on 6th grade students' understanding of concepts regarding reproduction and development in living things. The main research question of this study was: Does conceptual instruction, which explicitly deals with students' alternative conceptions, produce greater achievement in understanding of reproduction and development in living things concepts, than traditionally-designed instruction, for undergraduate students enrolled in an introductory science- technology course?

Assumptions

The following situations were assumed true:

1. Students responded to the questions honestly and seriously.
2. There was no interaction between experimental and control groups of students.

Limitations

This study was only limited to 6th grade Turkish students in a province center primary school. The course unit dealt with reproduction and development in living things.

MATERIALS AND METHODS

This study was designed as a cross-sectional experimental model (2x2) to determine the effect of concept maps, semantic feature analysis, and conceptual change texts method on a class unit about reproduction and development in living things. This was accomplished by comparing an experimental group with a control group taught by the traditional science teaching method.

Subjects: The study's sample was randomly selected from a primary school's 6th grade class, whose school was located in the province Manavgat of Antalya, a large city in the Mediterranean Region of Turkey, during fall 2006. This study involved 36 students from two classes of equal size (18). Students' ages ranged from 12 to 13 years. One instructional method was randomly assigned to each class; e.g., one class was randomly assigned as the control group and the other was the experimental group. Duration of the lessons was three 40-min periods. The language for the text for both the experimental and control class was written in Turkish. The experimental and control groups were administered a science achievement pre-test on the reproduction and development in living things to compare their achievements on the subject matter and the same test was used for the post-test.

Instrument: There was only one written instrument used in this study, the science achievement test. The science achievement test was developed by the researchers and consisted of a multiple-choice test, covering the reproduction and development in living things on the primary school science and technology course. There was only one right choice and the remaining four choices were mostly related to alternative concepts on the same topic. A panel of judges, who were from the same disciplines, evaluated the science achievement test for content validity. Before conducting the study, review literature pertinent to alternative conceptions on the reproduction and development in living things helped develop questions about the science achievement test.

During the development stage of the test, the following steps were taken into consideration. First, instructional objectives related to reproduction and development in living things were developed, based on the national curriculum. This step identified the content of the test. Literature related to students' alternative concepts about the reproduction and development in living things was examined. Finally, the science achievement test was ready for this research, after testing its reliability and controlling its validity with some revisions. Each item in the test was examined by a group of experts in science education, biology, measurement and evaluation regarding content validity and format. The panel of experts examined the qualitative test. The internal consistency reliability of the scale was found to be 0.83.

Treatment: This study was conducted for six weeks during fall semester 2006 in a primary school in the province Manavgat of Antalya, located in the Mediterranean Region of Turkey. The classroom instruction for both groups was given by the same teacher. In order to facilitate the proper use of conceptual change texts, semantic feature analysis, and concept mapping in the experimental section, the teacher involved in the study was given four 40-min training sessions prior to beginning of the study.

The experimental group was instructed using conceptual change text. The control group received traditional science instruction. Before beginning class instruction, the science achievement test was administered to both groups. After the test, the teacher explained to the experimental group how to make concept maps, semantic feature analysis, and gave conceptual change texts to change their alternative conceptions for each class period of the experiment. Also, there was some meaningful dialogue related to alternative conceptions between students and the teacher. For the control group, after the pre-test, the teacher applied traditional science teaching method for the same time period.

The control group received traditional instruction involving lessons using lecture/discussion methods to teach concepts. Teaching strategies relied on teacher explanation and textbooks, with no consideration of the students' alternative conceptions. The teacher structured the entire class as a unit, wrote notes on the chalkboard about the definition of concepts, and handed out worksheets for students to complete. The primary underlying principle was this knowledge was fact to the students. After teacher explanations, some concepts were discussed, prompted by teacher-directed questions. The researchers developed worksheets specifically for each lesson. They required written responses and reinforced the concepts presented in the classroom sessions. These responses 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 explanation and questions.

Students in the experimental group worked with conceptual change texts, semantic feature analysis, and concept mapping. The researchers prepared conceptual change texts, in light of the information obtained from literature. These texts provided learning environments, 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. Prior to the beginning of concept mapping application, the concept mapping strategy was introduced to the students. They learned the characteristics of concept maps, semantic feature analysis, and directions on how to draw a map. Students categorized information in memory so it could be retrieved easily. By capitalizing on this process, semantic feature analysis helped students learn better. This strategy helped students organize information using a graphic organizer.

Semantic mapping enabled students to not only visualize relationships, but to categorize them as well. The teacher taught concepts by concept maps and semantic feature analysis. The students were asked to complete some exercises, such as filling in a map to construct a concept map. In the light of the knowledge obtained from the literature, the teachers, and the panel of experts who previously taught this lesson, the researchers prepared four conceptual change texts, including subjects such as reproduction, growth and development in living things. The teacher presented these texts to the students in the experimental group during the lesson. While these texts were prepared, the subjects the students had greatest difficulty were especially highlighted. Scientific explanations were made about the subjects, which the students discussed conceptually. Conceptual change texts also covered the pictures and figures. These pictures and figures were thought to organize the knowledge acquired by students effectively. For example, one of the conceptual change texts was related to flowers in plants. The teacher informed the students the parts of the flower. Next, the students were asked to determine the male and female organs. It was explained that these were related to reproduction and they are called 'andrekeum' and 'gynokeum'. Their parts and functions were also explained. As a result of the alternative answers received from the students, accurate explanations were explained. A flower figure was drawn for the conceptual change text. Afterwards, the teacher reviewed with the students the conceptual change texts. The students were given explanations according to alternative answers. In addition to this, lessons were performed in the experimental group by making a conceptual map and meaning analyzing chart about the subjects such as ovular cell, sperm cell, parts of the flower, internal pollination, external pollination, and types of fruit produced.

Meetings with the teacher were held during the study to ensure she was conducting the treatments to both groups consistently. The teacher was contacted several times a week to enable the researchers to answer any questions or to address problems and to review the treatment procedures. At least five random visits by the researchers were conducted to each group during the classroom instructional phase. The researchers confirmed that the lessons were delivered competently. At the end of the third 40-min class session, the experimental and control groups completed the science achievement test that was administered as the pre-test.

Analysis of Data: For the analysis of the data, a 't' test was applied and percentage expressions were used. The significance level was á = 0.05. Also, percentages, frequencies, and central tendency measures, e.g., means and standard deviations, were determined using SPSS software.

RESULTS

Before applying the concept maps, semantic feature analysis, and conceptual changing texts to the experimental group and traditional science teaching method to the control group, some of the alternative conceptions related to the reproduction and development in living things were given as follows.

Kangaroos metamorphose. Internal fertilization is seen in fish. Snakes are mammals. The frog is included in the reptile family. In a flower an ovary is the structure which protects male reproduction cells. The cell is only found in humans. Seed can make its food. Vacuoles are found only in plant cells. Loyalty to the parents increases in adolescence age. Ovary (egg) is the female reproduction organ. Life circle of a flowering plant: pollination - seed and fruit - young and mature plant - germination. The frog reproduces by giving birth. Kangaroos reproduce by ovulating. Life circle of living things means returning to the life. Bees show internal fertilization. Internal fertilization is seen only in living things, which reproduce by giving birth. There isn't need of water for a seed to germinate. A bean is a false fruit.

The results showed that students had some alternative conceptions related to false fruit, seed germination, internal fertilization, ovulating, female reproduction organ, cell organelles, reproduction cells, etc.

Before starting the application, the science achievement test was applied as a pre-test to understand if there is a meaningful difference between the control and experimental groups of students. For the pre-test, it was determined no significant difference existed between the experimental and control groups ($t=1.185$, $p>0.05$) It was determined that the knowledge of the students about the concepts for reproduction and growth in living things was balanced before the pre-test. The average, standard deviations, and t-test results are given in Table 1.

Table 1
Performance on the science achievement test in the pre tests

Test	Groups	N	X	SD	t	P
Science and technology	Experimental group	18	29.33	9.30		
Achievement	Control				1.185	0.252
Test	Group	18	25.33	9.30		

$P<0.01$

According to the data from the post-test after the application, when looked at the effect of the two different strategies applied on experimental and control groups, it was determined a meaningful difference existed between them. For the topics concerning the concepts of reproduction and growth in living things, there was a meaningful difference between the performances of the students from the experimental group and the students from the control group ($t=6.465$, $p< 0.05$). The students from the experimental group were more successful than the students from the control group (Table 2).

Table 2
Performance on the science achievement test in the post-test

Test	Groups	N	X	SD	t	P
Science and technology	Experimental group	18	50.72	15.52		
Achievement	Control				6.465	0.001
Test	Group	18	22.88	10.87		

$P<0.01$

The students had alternative concepts about the topic reproduction and growth in living things. While the percentage average of true answers of the students from the experimental group was 59.3%, it was only 28.93% for the control group. For example, for a question concerning internal fertilization, various options were given to the students. They had to select the correct answer. For this question, 83.3% of the experimental group students gave the correct answer, but only 11.1% of the control group students gave the correct answer. A great majority of the control group students gave alternative answers—not really concerned with internal fertilization such as seen in frogs—but internal fertilization as seen only in living things that reproduce by giving birth including fish species, and sperm and egg cell of internal fertilization that joins outside the female reproduction system. In addition, for the question concerning false fruit, it was determined that 22.2% of both experimental and control group students gave the correct answer. Alternative wrong answers the students gave concerning false fruit were that orange, lemon, and melon were false fruit. For a question concerning seeds, 83.3% of the experimental group students gave true answers, but only 11.1% of the control group gave the correct answer. Alternative wrong answers included seeds can produce oxygen, seeds don't need water in germination, germination is not possible without sunlight, and seeds can make the food they need, etc.

DISCUSSION AND IMPLICATIONS

The main focus of this study was to research the effect of teaching made with a combination of a concept map, meaning analysis table, and conceptual change texts on learning in secondary school 6th class students' understanding of topics concerning reproduction and growth in living things.

The results from this study show that in science teaching, conceptual change texts given together with concept maps and semantic feature analysis are more effective than traditional science teaching. The results from this study reveal that traditional science teaching is ineffective in eliminating alternative concepts occurring in students. Traditional teaching is realized by making the teacher the center for learning and the students remain passive. The conceptual change approach definitely dealt with students' alternative conceptions; whereas, the traditional instruction did not. The students remaining passive cannot integrate new information learned before the lesson with information presented in the alternative classroom. The conceptual change approach is necessary for placing correct and integrated concepts by removing alternative concepts. For the conceptual change approach, effective results occurred when conceptual change texts were used together with concept maps. In addition, positive results could be obtained when semantic feature analysis was used, too. In this study, it was determined that alternative concepts were removed when using the conceptual change approach. The students replaced their alternative concepts with new and true concepts.

Although the experimental group was taught by using conceptual change texts, conceptual maps, and meaning analyzing charts throughout the study, the students in the control group were taught by following the textbooks, using the traditional teaching method. According to this study's findings, the education gained by the conceptual change approach significantly contributed to the students' learning and eliminated their alternative answers. These results also supported the idea that alternative concepts cannot be eliminated by using the traditional teaching approach. The difference between traditional teaching and conceptual change used in this study was that while the students' alternative answers and those in which they had difficulty were taken into consideration in conceptual teaching approach, was more effective than traditional teaching.

Alternative concepts and traditional teaching approaches cannot be determined by textbooks and in standard science classrooms. Students' incorrect concepts are resistant to change. Traditional teaching is insufficient for changing concepts (Fredette & Lockhead, 1980). It is essential to eliminate incorrect concepts in order to provide meaningful learning. Meaningful learning requires reorganizing existing concepts. This is called as "conceptual change" (Chambers & Andre, 1997).

In a similar study to this one, Sungur, Tekkaya and Geban (2001) determined that the teaching approach with conceptual maps given together with conceptual change texts are effective in eliminating conceptual fallacies and learning in students' understanding of the concepts about the circulatory system. In another study, Cakir, Geban and Yuruk (2002) discovered that the approach of conceptual change is an effective teaching approach in students' understanding concepts about cell respiration.

This study reveals that concept maps, semantic feature analysis, and conceptual change texts successfully and significantly changed students' alternative conceptions and increased their achievement pertinent to reproduction and growth in living organisms (Table 2). Lord (1999), Kinchin & David (2000), Amir & Tamir (1995), Smith & Dwyer (1995), Turkmen, Cardak & Dikmenli (2005), Dilber & Düzgün (2007) reported the same types of results.

In this study, it was found out that several alternative answers still continue after the practice, even in the experimental group. For example, orange is a fake fruit, fish produce by bearing young, etc. Certain alternative answers continue after the practice supports the findings by Cakir, Geban & Yuruk (2002).

CONCLUSIONS

In summary, this study shows that concept maps and semantic feature analysis given together with conceptual change texts are more effective than traditional teaching of concepts concerning reproduction and growth in living things. A conceptual change approach designed in an orderly and suitable manner is a suitable teaching approach in changing alternative concepts students may have and in eliminating alternative concepts. Teachers must be informed, especially about existing pre-information the student may have, in order to incorporate conceptual change texts in their teaching. While education-teaching activities are being planned, alternative concepts should be considered in the planning.

BIBLIOGRAPHY

Amir, R. & Tamir, P. Proposition generating task (PGT): A measure of meaningful learning and conceptual change. *Journal of Biological Education*, **29** (2), 111-119, 1995.

Arnaudin, M. V. & Mintzes, J. J. Students' alternative conceptions of the human circulatory systems: A cross age study. *Science Education*, **69** (5), 721-733, 1985.

Ausubel, D. P. *The Psychology of Meaningful Verbal Learning*. New York: Grune & Stratton, Inc, 1968.

Bahar, M. Misconceptions in biology education and conceptual change strategies. *Educational Science Theory & Practice*. **3**, 55-64, 2003.

Bell, B. F. When is an animal, not an animal. *Journal of Biological Education*, **15** (3), 213-218, 1981.

Bloom, J. W. Contexts of meaning: young children's understanding of biological phenomena. *International Journal of Science Education*, **12** (5), 549-561, 1990.

Chambers, K. S. & Andre, J. Gender, prior knowledge interest, and experience in electricity and conceptual change text manipulations in learning about direct current, *Journal of Research in Science Teach*, **34,** 107-123, 1997.

Cakir, O. S.; Geban, O. & Yuruk, J. Effectiveness of conceptual change text-oriented instruction on students' understanding of cellular respiration concepts. *Biochemistry and Molecular Biology Education*, **30** (4), 239-243, 2002.

Dilber, R. & Duzgun, B. An Investigation of effectiveness of conceptual change text-oriented instruction on student's understandings of brightness concepts. *Journal of Science Education*, **8** (1), 46-52, 2007.

Fredette, N. H. & Lockhead, J. Student conceptions of simple circuits, *The Physics Teach.* **18**, 194-198, 1980.

Kellert, S. R. Attitudes toward animals: Age related development among children. *Journal of Environmental Education*, **26** (3), 215-223, 1985.

Kinchin, I. M. Concept mapping in biology. *Journal of Biological Education*, **34** (2), 61-68, 2000.

Kinchin, I. M.; David, B. H. & Adams, A. How a qualitative approach to concept map analysis can used to aid learning by illustrating patterns of conceptual development. *Educational Research*, **42** (1), 43-57, 2000.

Kwon, Y. & Lawson, A. E. Linking brain development with the development of scientific reasoning ability and conceptual change during adolescence. *J Res Sci Teach*, **37,** 44-62, 2000.

lord, T. R. A comparison between traditional and constructivist teaching in environmental science. *Journal of Environmental Education*, **30** (3), 22-28, 1999

Novak, J. D. & Musonda, D. A twelve year longitudinal study of science concept learning. *American Educational Research Journal*, **28** (1), 117-153, 1991.

Novak, J. D.; Gowin, D. B. & Johansen, G. T. The use of concept mapping and knowledge vee mapping with junior high school science students. *Science Education*, **67** (5), 625-645, 1983.

Ozkan, O.; Tekkaya, C. & Geban, O. Facilitating conceptual change in students' understanding of ecological concepts. *Journal of Science Education & Technology*, **13**, 95-105, 2004.

Piaget, J. The child's conception of the world, Adams & Co., Littlefield, NJ., 1969.

Pines, A. & West, L. Conceptual understanding and science learning: An interpretation of research within a source of knowledge framework. *Science Education*, **70** (5), 583-604, 1986.

Smith, K. M. & Dwyer, F. M. The effect of concept mapping strategies in facilitating student achievement. *International Journal of Instructional Media*, **22** (1), 25-32, 1995.

Strike, K. A. & Posner, G. J. Conceptual change and science teaching, *European Journal of Science Education*, **4**, 231-240, 1982.

Sungur, S.; Tekkaya, C. & Geban, O. Contribution of conceptual change texts accompanied by concept mapping to students' understanding of the human circulatory system. *School Science and Mathematics*, **101** (2), 91-101, 2001.

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

Treagust, D. F. Development and use of diagnostic tests to evaluate students "misconceptions in science", *International Journal of Science Education*, **10** (2), 159-169, 1988.

Trowbridge, J. E. & Mintzes, J. J. Students' alternative conceptions of animals and classification: A cross-age study, *Journal of Research in Science Teaching*, **85** (4), 304-316, 1985.

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

White, R. T. & Gunstone, R. F. *Probing Understanding*. London: Falmer, 1992.

Received: 20.01.2007 / Approved: 20.04.2008