Educational Research Association The International Journal of Research in Teacher Education
2014, 5(2): 1-10
ISSN: 1308-951X

http://www.eab.org.tr

http://ijrte.eab.org.tr

How Are Knowledge Structures of Pre-Service Biology Teachers on "Organic" Concept?

("Organik" Kavramıyla İlgili Biyoloji Öğretmen Adaylarının Bilgi Yapıları Nasıldır?)

Mustafa Serdar KÖKSAL [1]
Esra AÇIKGÜL FIRAT[2]
Milan KUBIATKO[3]

Abstract

The purpose of this study is to investigate knowledge structures of pre-service biology teachers on the "organic" concept. The study included two different samples for the first and second stages of the study, respectively. In the first stage, the participants (n=108) completed a word association task and they produced 172 concepts. 22 of the concepts indicated in higher frequency than 10 were given to the second group participants (n=20). The second group participants selected and used 9 of 22 concepts to develop concept maps in which "organic" concept was placed on the center. In addition, they wrote their definitions of organic and gave examples for it. By focusing on the concept maps and their definitions; knowledge structures of the participants were determined based on types of the maps, main titles found in the maps, links represented as sentences, definitions and the examples. The findings showed that two different types of the maps were determined as branched and hierarchical, also five main titles (food, chemistry, biology, health and agriculture) were found. Moreover, their definitions and examples also provided similar titles (food, chemistry, biology, health, *textile* and agriculture) except for textile. The links between the concepts in the concept maps, definitions and examples regarding organic concept showed that pre-service biology teachers had compartmentalized knowledge structures regarding "organic" concept. In conclusion, on associations between different concepts regarding "organic" concept, problems in terms of coherency were also determined.
Keywords: Pre-service biology teachers, knowledge structures, organic

Özet

Bu çalışma, biyoloji öğretmen adaylarının "organik" kavramıyla ilgili bilgi yapılarını incelemek amacıyla yapılmıştır. Çalışma, araştırmanın birinci ve ikinci aşamaları için iki farklı örneklemi içermektedir. Birinci aşamada, katılımcılar (n=108) bir sözcük çağrışımı görevini tamamlamış ve 172 kavram üretmişlerdir. Daha sonra 10'dan fazla frekansa sahip olan 22 kavram ikinci grup katılımcılara (n=20) verilmiştir. İkinci grup, verilen 22 kelimenin 9'unu seçerek bu 9 kelimeyi "organik" kavramının merkezde yer aldığı bir kavram haritası geliştirmek için kullanmışlardır. Buna ek olarak, organikle ilgili kendi tanımlarını yazmış ve örnekler vermişlerdir. Kavram haritaları ve tanımlara odaklanılıp; haritalardaki ana başlıklar, cümleler, tanımlar ve örneklerin temsil ettiği bağlantıların bulunduğu haritaların türlerine dayanılarak katılımcıların bilgi yapıları belirlenmiştir. Bulgular, dallanmış ve hiyerarşik olmak üzere iki farklı harita türünün olduğunu göstermiş ve ayrıca haritalardan beş ana başlık (gıda, kimya, biyoloji, sağlık ve tarım) elde edilmiştir. Katılımcıların tanımları ve örneklerinin incelenmesi sonucunda da tekstil dışında benzer başlıklar (gıda, kimya, biyoloji, sağlık, tekstil ve tarım) elde edilmiştir. Organikle ilgili kavram haritaları, tanımlar ve örneklerdeki kavramlar arasındaki bağlantılar, biyoloji öğretmen adaylarının "organik" kavramına ilişkin olarak bölümlenmiş bilgi yapılarına sahip olduklarını göstermektedir. Sonuç olarak, "organik" kavramı ile ilgili farklı kavramlar arasındaki ilişkilerde anlaşılırlık bakımından sorunların olduğu söylenebilir.
Anahtar Kelimeler: Biyoloji öğretmen adayları, bilgi yapıları, organic.

[1] Assoc. Prof., İnönü Üniversity, Turkey. bioeducator@gmail.com
[2] Res. Assist. Adıyaman Üniversity, Faculty of Education.Turkey. esraac@hotmail.com
[3] Masaryk University, Faculty of Education. Czech Republic, kubiatko@ped.muni.cz

Introduction

Organic concept is common in today's media and is frequently used in society. But organic concept is not used with similar meanings, it is used differently for defining different titles; the number of different uses of the concept is so high that meaning of the concept cannot be understood enough. For example; people define "organic food" as free food from "chemicals", "GM ingredients" and "growth hormones" (Davies, Titerrington& Cochrane, 1995; Harper &Makatouni, 2002). As another definition; "organic farm" is defined as the process of establishing a healthy balance between nature and farming (HDRA, 1998, p. 2). As another example; "organic chemistry" is addressed as a discipline focusing on organic compounds including hydrocarbons and their derivatives (Lin &Liu, 2003). When looked at the definitions, they are not similar moreover they have rather different meanings. In addition to the definitions, some of the studies also showed confusions and misunderstandings of people on "organic" concept. Aarset et al. (2004) studied on a group of 196 participants from UK, Germany, Spain, Norway and France and they found that majority of the participants were confused about the meaning of the "organic" concept. Davies, Titterington & Cochrane (1995) revealed that "organic" concept is confused with natural concept and it is understood as matters without chemicals and growth hormones. Harper and Makatouni (2002) determined definitions of "organic food" made by 24 participants and they found three different understandings; naturally produced foods, pure foods from pesticides, hormones and other ingredients, and healthful and safe foods.

Knowing about meaning of "organic" concept is very important for learning biology subjects such as photosynthesis, structure of proteins, hormones and carbohydrates, chemical bonds and compounds in biological molecules. Therefore meaning of organic concept should be developed in a coherent knowledge structure. Lack of scientifically acceptable knowledge structure might constrain future learning related to concept on which unacceptable knowledge structures were established (Özdemir& Clark, 2007). DiSessa, Gillespie and Esterly (2004) mentioned about two important factors of coherency in knowledge structure; context and relational structure. For the organic concept, number of contexts in which the concept is used, is very high since we use the concept in different areas from agriculture to science. Based on this difference, relationship of the concept with other concepts in these contexts is also very complicated. Establishing a coherent (use of related concepts together in a unique context) knowledge structure on the organic concept is a requirement for future learning in biology context.

Therefore, learning "organic" concept in line with scientific definitions might contribute to learning these biology subjects in a meaningful way. To provide such learning, the beginning point is to determine knowledge structures of pre-service biology teachers since their knowledge structures will probably affect their planning and instruction processes on teaching subjects including "organic" concept. In fact, quality of teaching on "organic" concept is dependent on three major factors; course materials, curriculums, and teacher (Öztürk, 2003). Teachers as implementer of curriculum and decision maker on course materials are the most effective factor in biology teaching. Biology teachers' teaching activities have been affected by their knowledge structures of disciplines (Brickhouse, 1990) and their understandings about different scientific

concepts such as organic (Harlen, 1997). In particular, their understandings about organic concept are predictors of effectiveness of teaching on this concept (Harlen, 1997; Roehrig & Kruse, 2005). In learning biology subjects, knowing concepts and making connections between the concepts and life is a requirement and establishing coherent knowledge structures on "organic" concept is the basic level to achieve higher-order learning in biology subjects including photosynthesis, structure of proteins, hormones and carbohydrates, chemical bonds and compounds in biological molecules. Biology teachers have formally been learning about organic concept and developing knowledge structures regarding the concept during their education beginning from high school years to teacher education programs, but use of the concept has been taken place in teacher education programs. So the biology teacher education programs might be a check point for knowledge structures of pre-service biology teachers before their inappropriate use of organic concept in teaching. Biology teacher education programs should help to develop coherent and scientifically acceptable knowledge structures on organic concept and give the ability of establishing coherency between appropriate knowledge structure and teaching. Roehrig & Kruse, (2005) have also shown that pre-service teachers' knowledge structure about a concept is effective on how to learn and teach it.

In the literature, it is shown that pre-service biology teachers do not have acceptable knowledge structure about different concepts of biology (Cakır& Crawford, 2001; Tekkaya, Çapa&Yılmaz, 2000; Sinan, 2009; Sinan, 2010). Cakır and Crawford (2001) studied with six pre-service biology teachers by using concept maps as data collection tool, their findings showed that the pre-service teachers did not have acceptable knowledge structures on "division of zygotes through meiosis" and "allels' false definition and positions". In another study, knowledge structures of 186 pre-service biology teachers were investigated by using a concept test, the participants made mistakes in defining "respiration", "diffusion", "stages of cell division" and "enzyme activity in special cases" (Tekkaya, Çapa&Yılmaz, 2000). Sinan (2009) studied on knowledge structures of pre-service teachers including 42 pre-service biology teachers by using survey for data collection. The results showed that meanings of "radical group", "amphoteric matter", "acids" and "bases" concepts could not be defined by some of pre-service biology teachers. One year later, Sinan (2010) studied on knowledge structures of pre-service teachers including 42 pre-service biology teachers and he found that some of the pre-service biology teachers classified vitamins as inorganic matters and could not define "organic matter" concept. For instance; in minds of the participants "organic" concept referred to "products synthesized by plants". In biology related concepts should be linked together to establish coherent and meaningful knowledge structure, but false or multiple definitions in minds of the pre-service teachers might cause to compartmentalized knowledge structure (Haidar, 1997).Having such a knowledge structure on "organic" concept might be a problem in future teaching on the subjects including "organic" concept. Since Coherent knowledge structures help the students form knowledge framework that affect how learners see new knowledge and how they give meaning to the knowledge (Bischoff, Avery, Golden, &French,2010). At the same time, having coherent knowledge structures is positively correlated with problem solving behaviors and cognitive learning (Malone, 2008).

In the literature, the "organic" concept is not studied well to see clearer picture on the knowledge structures of the pre-service teachers. Therefore, in this study, the purpose is to determine knowledge structures of pre-service biology teachers on the "organic" concept.

Research Questions

In this study, research question is "how are knowledge structures of pre-service biology teachers on the "organic" concept?".

Methodology

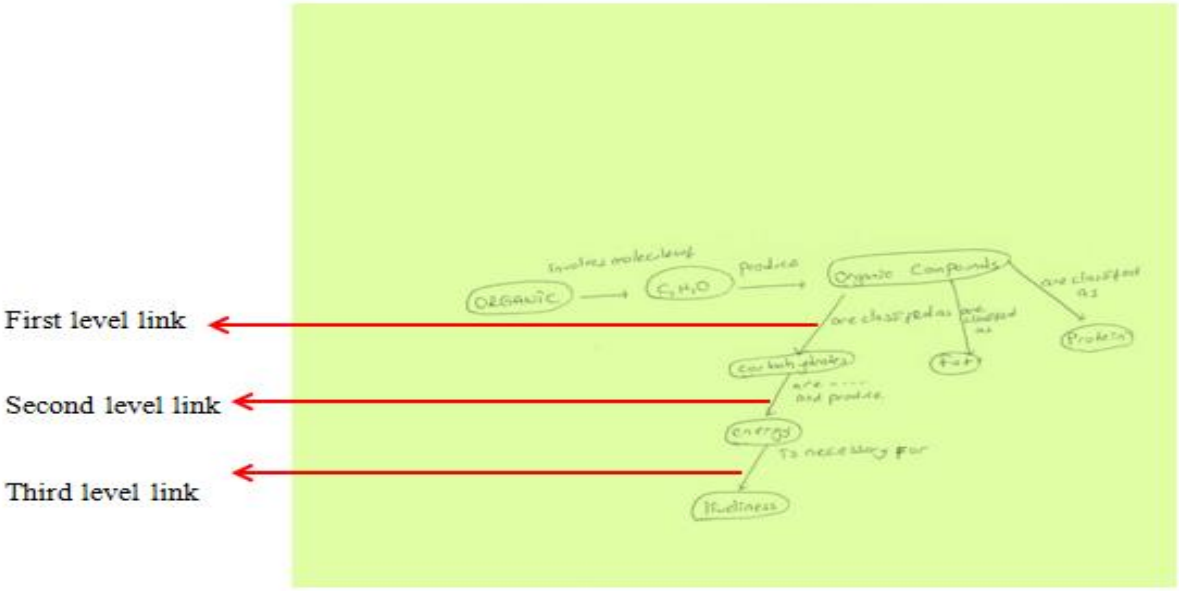
The study included two different groups of the participants including senior pre-service biology teachers. In the first group (n=108), 26 were male while 82 were female and the mean of their age was 24 while the second group, 20 participants (14 female and 6 male) were involved. Only seniors are included because they might reflect the highest number of the concepts regarding knowledge structures because of their more experience in biology subjects. For the purpose of the study, word association and concept mapping techniques were utilized for data collection. The first group completed word association task while the second group members constructed concept maps including nine concepts determined by selecting highest frequent concepts in 22 concepts emerged in word association application. By this way, we tried to find variety of concepts (elements of knowledge structures) associated with "organic" concept and to examine details of the knowledge structures of the participants. At the same time, we asked the second group participants to write their definitions of organic down and gave examples for it. Therefore two stages with two different samples for each stage were used to collect data; one for word association and one for concept mapping and giving definitions and examples.

Data Collection and Analysis

For collecting data in the first phase, the participants were asked to complete a word association task. In the task, the "organic" concept was placed at the beginning of a page and it was used as a stimulus for the following nine concepts. The word association technique is used to collect data to determine knowledge structures of a person or a group (Dikmenli, 2010). The technique is based on information processing theories so number (9) of the concepts (stimulus) is determined based on capacity of short-term memory (7+/- 2 items). Nine stimuli were found enough for considering age and cognitive development of the participants (Schunk, 2000). After the determination of the concepts which have highest frequencies and finding categories, concept map activity including nine chosen concepts from 22 concepts that were had higher frequencies than 10, was made by the participants. Concept maps are useful in determining components of an understanding and a knowledge structure (Hay, 2007; Hay &Kinchin, 2006).

The complexity level (branched, number of concepts and links) of concept maps shows the level of understanding and apprehending of scientific concepts (Slotte & Lonka 1999; Hay &Kinchin, 2008). For analysis of the maps, structure of the maps, main titles (concepts) found in the maps, and the sentences indicated in the maps by linking two titles (concepts) were examined and summarized. In addition, first level links with "organic" concept and, second, third and further level links were also examined and classified. The

first level link means the concepts in this type of link are directly linked to the "organic" concept while the second level link means the concepts are linked to the concepts which have direct link with the organic concept. The links are represented in the following figure (P12,M means participant 12 and male):

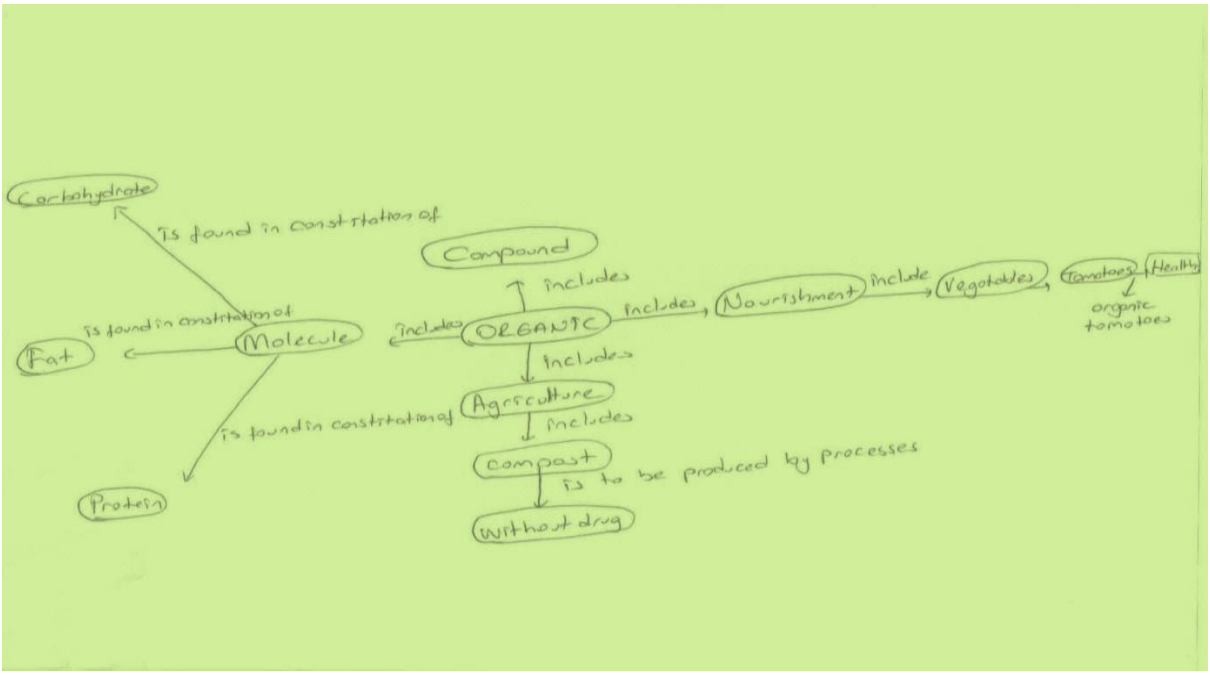


(P12,M), **Figure 1.** *An example of branched concept map including first, second and third level links.*

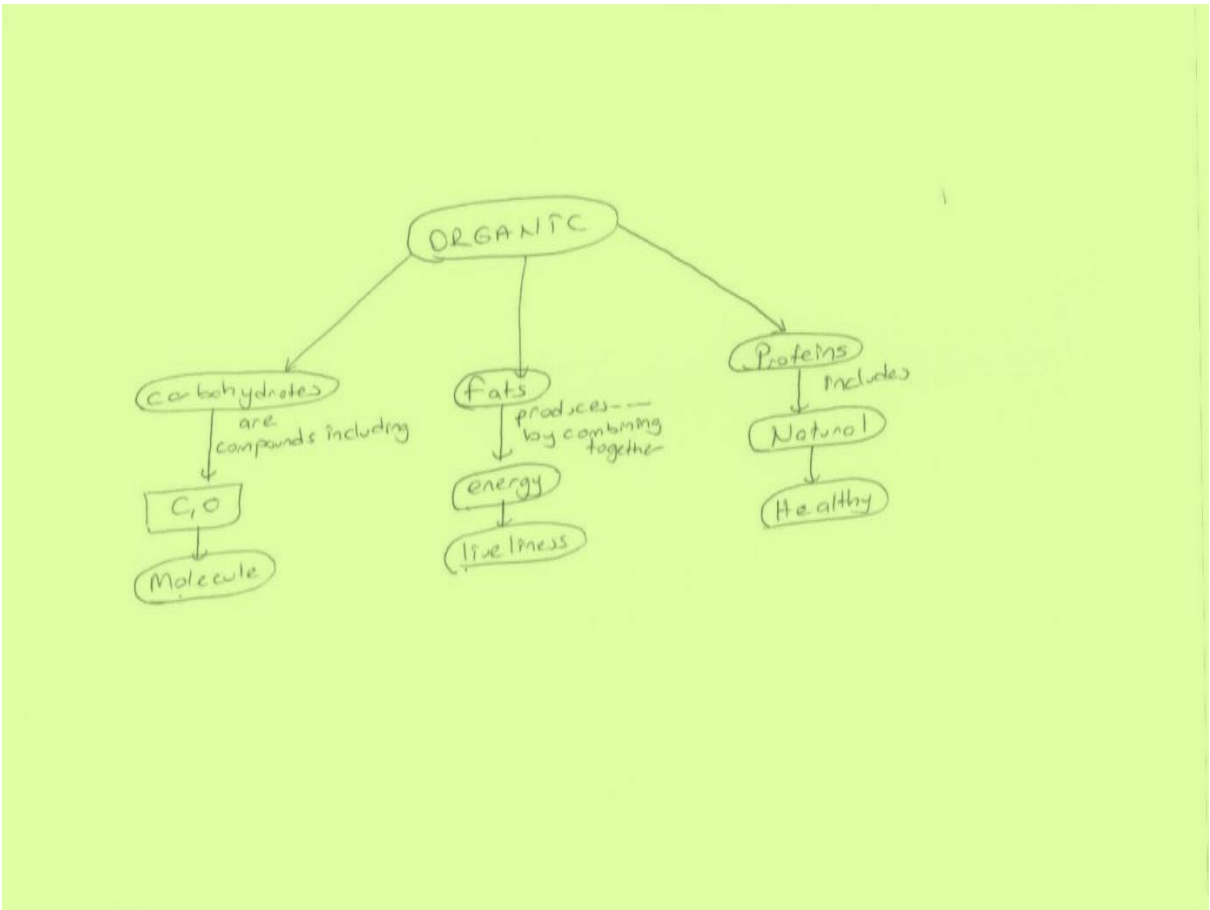
At the same time, definitions and examples given by the participants were also examined to find titles (concepts) regarding organic concept and they were represented as descriptive examples.

Findings

The findings of the study showed that all of the concepts in the first stage were classified into eight categories: *Concepts regarding Scientific Disciplines, Concepts regarding Society and Technology, Concepts regarding Agriculture, Concepts regarding Processes, Concepts regarding Biology, Concepts regarding Chemistry, Examples of Organic Products, Adjectives*. Under these categories, the participants produced 172 concepts which established the range in knowledge structures of the participants on the "organic" concept. In the second stage of the study, the participants produced two types of concept maps; hierarchical and branched. The examples of them can be seen in the following figure (Figure 2).



(P19, F), Branched **Figure 2.***An example of branched concept map.*



(P5, F), Hierarchical **Figure 3**.*An example of hierarchical concept map.*

The concept maps included five different titles (concepts) associated with the "organic" concept. *Food, Chemistry, Health, Agriculture and Biology* are the titles found in concept maps. Among the titles, the example sentences for each link level are presented in table 1.

Table 1.

Sentence examples representing link levels in the concept maps of the participants

Link Level	**Food**	**Chemistry**	**Health**	**Agriculture**	**Biology**
First	Organic foods are highly preferred by people (P4, F)	C,H,O are organic matters. (P1,M)	Organic is natural and healthy (P6,F)	Organic farming is healthy (P7,M)	Organic compounds are made of protein, carbohydrates and lipids (P20, F)
Second	Feeding with organic tomatoes gives energy (P9, F)	Organic matters involve C,H,O. (P7,M)	Feeding with organic tomatoes is healthy (P9,F)	Organic farming is done without using any drug (P1, M)	Organic compounds such as lipids are found in cell membrane.(P2, F)
Third	Tomatoes are examples for organic foods (P18,M)	Organic brings organic chemistry course into my mind (P14, F)	----------	Organic tomatoes are produced naturally in garden (P4, F)	C, H, O as organic matters are fundamental atoms of livings (P3, F).

The definitions and examples of the participants included six different titles associated with the "organic" concept. *Food, Chemistry, Health, Agriculture, Textile and Biology* are the titles found in concept maps. Among the titles, definitions and examples for organic concept are presented in table 2.

Table 2.

Definitions and examples regarding "organic" concept

Variables	**Food**	**Chemistry**	**Health**	**Agriculture**	**Textile**	**Biology**
Definitions	Organic is food that is free from chemicals and artificial matters. (P3, M)	Organic matters are molecules including C,H,O. (P1, M)	Organic matters are free from toxic effects (P6, F)	Organic farming includes growing plants in natural environments (P5, F)	---------	Organic molecules are molecules produced by living organisms (P14, F)
Examples	Drinking organic milk is beneficial (P9, F)	Organic brings organic chemistry course into my mind (P14, F)	Organic products get me think that I am protected for future possible illnesses (P11, F)	Wheat harvested at the age of my grandfather is organic (P7, M)	Organic textile provides more comfortable life (P3, F)	As organic matters, biomolecules such DNA and protein can be taught (P2,F)

Conclusion and Discussion

The findings of the study showed that the knowledge structures of pre-service biology teachers on "organic" concept included partially independent parts representing *Scientific Disciplines, Society and Technology, Agriculture, Processes, Biology, Chemistry, Organic Products, Adjectives.* For determining details of the parts, they were investigated by examining concept maps regarding them. Analysis of the concept maps showed two types of knowledge structures; hierarchical and branched. To see more detailed associations among elements (titles; *Food, Chemistry, Health, Agriculture and Biology*) of knowledge structures, links between titles or elements were examined and it was found that majority of the titles were liked to each other up to the third level links. Then, the participants were asked to define organic and to give examples for it. Similar to examining links, definitions and examples were also examined and it was found that there were six titles (*Food, Chemistry, Health, Agriculture, Textile and Biology*) associated with "organic" concept. These

findings showed compartmentalized knowledge structures of the pre-service biology teachers on "organic" concept since the titles determined in the links of concept maps, definitions and examples were not represented as associated parts. They were generally taken into account as separate knowledge structures. Jones, Ross, Lynam, Perez and Leitch (2011) claimed that new information is filtered by individuals with their value and belief system; if information does not fit individuals might structure knowledge as compartmentalized chunks.

The literature also showed compartmentalized knowledge structures of pre-service teachers and students. Bischoff, Avery, Golden and French (2010) studied with pre-service science teachers on oxidation and reduction concepts. The authors' findings showed that pre-service science teachers represented fragmented knowledge structures on these concepts, but they reached more coherent knowledge structures in following times. In another study, Haidar (1997) studied with 173 pre-service chemistry teachers on knowledge structures regarding "mole" concept. The author also found that the pre-service teachers had fragmented or compartmentalized knowledge structures on "mole" concept. In a similar study, BouJaoude (1991) by studying with 20 eight graders found that knowledge structures of the students on the concept of burning was fragmented and compartmentalized. Hauslein, Good and Cummins (1992) focused on knowledge structures of pre-service biology teachers, in-service biology teachers, scientists in biology, senior majors in biology on 37 concepts; they also found fragmented knowledge structures on biological concepts. The fragmented or compartmentalized knowledge structures might be related to insufficiency in acquiring meaningful learning of a concept (Haidar, 1997). But also nature of concepts should also be taken into account, the concepts as "organic" have different definitions and associated concepts in different fields (agriculture, biology, chemistry) of scientific study, hence knowledge structures of the pre-service teachers are changed by different sources. This situation might have contributed to insufficiency in meaningful learning on organic concept. Aarset et al. (2004) determined that the participants in their study (pre-service teachers also) were confused about what "organic" concept means. Majority of the participants connected this concept with the organic food; few of the respondents knew that this concept had got wider meaning. The problem determined in this study warns us about inability of pre-service biology teachers for relating organic concept to appropriate context or for defining organic concept in teaching on biology. By overcoming this problem using network mapping applications might be an effective way (Anderson & Contino, 2010).

This study is based on concept maps, definitions and examples provided by limited number of pre-service biology teachers. By using the findings of this study, observing in-class use of organic concept might be useful to understand the knowledge structures in action. Also resources of the knowledge structures should also be asked to the pre-service biology teachers for investigating effective means of structuring knowledge on organic concept.

References

Aarset*et al.* (2004). The European consumers' understanding and perceptions of the "organic" food regime: The case of aquaculture. *British Food Journal, 106 (2),* 93–105.

Anderson, O.R. &Contino, J. (2010). A study of teacher-mediated enhancement of students' organization of Earth science knowledge using web diagrams as a teaching device. *Journal of Science Teacher Education, 21*(6), 683 – 701.

Bischoff, P. J., Avery, L., Golden, C. F., & French, P. (2010).An analysis of knowledge structure, diversity and diagnostic abilities among pre-service science teachers within the domain of oxidation and reduction chemistry. *Journal of Science Teacher Education, 21,* 411–429.

Brickhouse, N.W. (1990). Teachers' beliefs about the nature of science and their relationship to classroom practice. *Journal of Teacher Education, 41,* 53–62.

BouJaoude, S. (1991).A study of the nature of students' understandings about the concept of burning.*Journal of Research in Science Teaching*, 28, 689–704.

Cakır, M., & Crawford, B. (2001).*Prospective biology teachers' understanding of genetics concepts.*(Report No. SE 065883).(ERIC Document Reproduction Service No. ED 463956).

Davies, A., Titterington, A.J.& Cochrane, C (1995). Who buys organic food? A profile of the purchasers of organic food in Northern Ireland, *British Food Journal, 97(10),* 17-23.

Dikmenli, M. (2010).Biology student teachers' conceptual frameworks regarding biodiversity. *Education*, 130 (3), 479-489.

diSessa, A. A, Gillespie, N., &Esterly, J. (2004).Coherence versus fragmentation in the development of the concept of force. Cognitive Science, 28, 843–900.

Harlen, W. (1997). Primary teachers' understanding in science and its impact in the classroom, *Research In Science Education, 27,* 323–337.

HDRA (1998). What is organic farming?, HDRA Publishing, UK.

Harper, G.C. &Makatouni, A. (2002), Consumer perception of organic food productions and farm animal welfare, *British Food Journal, 4,* 287-299

Haidar, A.H. (1997) Prospective Chemistry Teachers' Conceptions of the Conservation of Matter and Related Concepts, *Journal of Research in Science Teaching*, 34(2), 181-197.

Hauslein, P. L., Good, R. G. , Cummins, C. L. (1992). Biology content cognitive structure: from science student to science teacher. J*ournal of Research in Science Teaching, 29*(9), 939-964.

Hay, D.B. (2007) Using concept maps to measure deep, surface and non-learning outcomes. *Studies in Higher Education 32(1),* 39-57

Hay, D.B., Kinchin, I.M. (2008). Using concept mapping to measure learning quality. *Education and Training, 50(2),* 167-182.

Hay, D.B. &Kinchin, I.M. (2006) Using concept maps to reveal conceptual typologies. *Education and Training 48(2-3),* 127-142.

Jones, N. A., Ross, H., Lynam, T., Perez, P. & Leitch, A. (2011). Mental models: an interdisciplinary synthesis of theory and methods. *Ecology and Society, 16* (1), 46-46.

Lin,Y., &Liu,Z. (2003). Using appropriate strategies to improve teaching and learning in organic chemistry and organic chemical experiment courses, *The China Papers*, July, 34-38.

Malone, K.L.(2008). Correlations among knowledge structures, force concept inventory, and problem-solving behaviors, *Physical Review Special Topics – Physics Education Research, 4(2),* 1-15.

Özdemir, G. & Clark, D.B. (2007) An overview of conceptual change theories. *Eurasia Journal of Mathematics, Science & Technology Education, 3(4),* 351–361.

Öztürk, E. (2003). *An assessment of high school biology curriculum implementation*. Unpublished doctoral dissertation, METU, Ankara.

Roehrig G H, Kruse R A, Kern A.(2007) Teacher and School Characteristics and Their Influence on Curriculum Implementation, *Journal of Research in Science Teaching, 44(7),* 883-907.

Schunk, D. H. (2000).*Learning theories: An educational perspective*. New Jersey: Prentice-Hall.

Slotte, V., &Lonka, K.(1999).Spontaneous concept maps aiding the understanding of scientific concepts. *International Journal of Science Education 21,* 5, 515–31.

Sinan, O. (2009) Differences in prospective science teachers' descriptions of the same concepts used in chemistry and biology classes, *Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education, 3 (2),* 1–21.

Sinan, O. (2010) Differences in prospective science teachers' descriptions of the same concepts used in chemistry and biology classes-II, *Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education, 4 (1),* 85–107.

Tekkaya, C., Çapa, Y. & Yılmaz, Ö. (2000). Biyoloji öğretmen adaylarının genel biyoloji konularındaki kavram yanılgıları [Alternative conceptions of prospective biology teachers on general biology subjects].*HacettepeÜniversitesiEğitimFakültesiDergisi, 18,* 140–147.

