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Determining science student teachers' cognitive structure on the concept of "food chain"

Derya Çınar

Necmettin Erbakan University, Turkey.

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The current study aims to determine science student teachers' cognitive structure on the concept of food chain. Qualitative research method was applied in this study. Fallacies detected in the pre-service teachers' conceptual structures are believed to result in students' developing misconceptions in their future classes and will adversely affect their future teaching performance. The data were collected from 48 science student teachers. A free word association test was used as a data collection instrument. The data collected were subject to content analysis. Analyzing the science student teachers' responses to the concept of food chain on the free word association test, these responses were coded and divided into categories. Based on the categories, frequency and percentages were provided. The data collected through the study were divided into 8 categories, which were stated as follows: energy flow- producer, consumer, decomposer organisms- food chain and food pyramid relationship- ecologic factors- matters used in energy flow- terms related to vitality-deterioration in food chain- the characteristics of the population. When the words provided as answers by the science student teachers to the concept of food chain were analyzed, it was noticed that they had more word connections with energy flow and in terms of the elements that compose food chain. Moreover, it was determined that they had some misconceptions about food chain. Similar research can be conducted with different student groups and for the correction of alternative concepts related to the concept of food chain, Extra biology courses should be included in undergraduate curriculums.

Key words: Food chain, free word association test, misconception, cognitive structure.

INTRODUCTION

Issues such as how individuals think, remember and organize information are one of the most important research areas subject to interest of educational researchers for many years. Researchers in this field have attempted to develop various ways to enhance the cognitive structures of students. The cognitive structure is a structure based on assumptions and description of the associations of the concepts in the long-term memory of students. Cognitive structure research aims to help teachers to know the schemata of the individual, to develop teaching strategies suitable for this schemata and to guide their students for the integration of their past experiences and newly-acquired information. Thus, teachers can offer guidance for their students to increase

E-mail: deryacinar42@gmail.com.

their meaningful learning. Knowing the schemata of students helps teachers not only to develop teaching strategies but also to conduct research on their students' conceptual changes (Wandersee et al., 1994). Biology educators also try to make use of the findings of cognitive structure research in practice.

Conceptual learning focuses on the structure and content of the information acquired by students or qualitative differences of concepts. Thus, students' prior knowledge can be learned and correctly structured and as a result learning can be realized by making meaningful connections with newly-acquired information (Tsai and Huang, 2002). Constructivist learning theories emphasize that learners play an important role in the construction of knowledge (Harrison and Treagust, 1996). In every day of their lives, students are in an interaction with the natural world; they observe the properties of the natural world and talk about the experiences and ideas of other people. As a result of their accumulated experiences, students can make their simple and primitive explanations more sophisticated or generalize the mental models of many phenomena involving life, astronomy, light, power and matter. These are intuitional thoughts or children's science (Gilbert et al.,, 1982). This affects students' teachers in the class because individual experiences are numerous and diverse. The effect of schemata on learning varies greatly from student to student. Students' definitions of scientific phenomena are usually exemplified by individual and original occurrences (Gilbert, 2007; Harrison and Treagust, 1996). Mental models are viewed to be an analog presentation constructed along individuals' cognitive functions, a special variety of mental presentations (Vosniadou, 1994). Mental models are also viewed to be interpretations of students' concepts. In the current study, in order to define students' understanding, the term *cognitive structure* was used.

There are many courses in which students experience comprehension difficulties and the reasons behind these difficulties may stem from the student, the teacher, the family, school conditions, the course, system etc. Biology course is also one of the courses students find difficult to understand in terms of its content (Bahar et al., 1999a; Çimer, 2012; Lazarowitz and Penso, 1992; Seymour and Longdon, 1991). In fact, though it is expected to be an interesting course as it involves the examination of living organisms, students may face some difficulties as they cannot comprehend the unity at the level of biologic organization and the course includes some abstract concepts (Jones and Rua, 2006; Lukin, 2013; Kurt, 2013a). While it was determined that students experience difficulties particularly in relation to systems, food chain is also among the topics found to be difficult by students.

One of the reasons lying on the basis of learning difficulties is students' not being able to associate the conceptual structures related to the given topic in their minds. The cognitive structure is an assumption-based structure representing the relationships of the concepts in the long-term memory of a student. At that point, educators should provide guidance for students to increase their meaningful learning. In this regard, knowing the schemata of students helps teachers not only to develop teaching strategies but also to conduct research on their students' conceptual changes (Pines and West, 1986; Tsai and Huang, 2002); erroneous prior knowledge always adversely affects learning (CUSE, 1997; Wandersee et al., 1994). In this connection, biology educators try to make use of the findings of cognitive structure research in practice. Gilbert et al. (1998a, b) maintain that explanation of individuals' cognitive structures can be difficult and elicitation of individuals' opinions about key concepts can be of great importance in this regard. Gilbert and Boulter (1998) state that they see mental models as unreachable and thus concepts represent cognitive models and at that point, the importance of conceptual learning becomes apparent.

Great importance attached to the constructivist learning approach in instructional environments in recent years gave rise to different methods and strategies used to determine conceptual understanding and conceptual change (Vance et al., 1995). Researchers have been directed to methods used not only to reveal students' already acquired knowledge but also students' connections between concepts, cognitive structures, whether they can realize meaningful learning by associating their already acquired knowledge with new information and the extent to which students understand the similarities between the information they constructed in their minds and functioning of the events in the natural world and such techniques have gained great importance (Bahar, 2003; Bahar et al., 2006). Free word association test technique is among the most important measurement tools in this regard. The most general and the oldest one of these techniques and also the one employed in the current study is word association technique. This technique has been reported to be quite effective in eliciting individuals' conceptual structures and conceptual changes (Hovardas and Korfiatis, 2006).

Conceptual structure researches on food chain

Hogan and Fisherkeller (1996) identified the difficulties experienced by students in the disassociation of the matter or its connection with photosynthesis in food cycle. Griffiths and Grant (1985) reported that students hold alternative concepts in food cycle analysis. The students defined photosynthesis processes as a component or an ingredient within the matter's ontological category and frequently mentioned the terminology-based use of the matter (Barak et al., 1999). They did not consider the dynamic nature and flow of the process. Here, ATP has an important role in photosynthesis processes and is

known as one of the basic end-products. Barak et al. (1999) reported that the responses given by the high school students to photosynthesis processes within the category of matter tend to emphasize the importance of one of the end-products. Most of the responses were found to be related to glucose production. They pointed out that the students hold misconceptions about photosynthesis, respiration and energy flow in food chain and they could not transfer their information into the subject of energy conservation (Barak et al., 1999).

High school students were reported to be unsuccessful in identifying the relationship between various concepts related to the subjects of matter cycle and energy flow. The topic the students found the most difficult to understand was the relationship between the living and nonliving worlds. The students' statements were analyzed under three categories. At the level of organism, energy flow and matter cycle can be defined referring to three main participants (producers, consumers and decomposers) and to ecological concepts of food chain. This is the category of information regarding natural phenomena. At the level of cell, energy flow and matter cycle can be involved in the processes of respiration and photosynthesis that are in the category of mechanical information and can be defined in terms of matter and energy existing in the category of physical information (Barak et al., 1999).

The most important difficulty involved in learning biology is its covering three dimensions of thinking; macro, micro and symbolic (Bahar et al., 1999a). In the cases of energy flow and matter cycle, the difference between macro and micro is relatively more complex. Information about natural phenomena is macro in comparison to mechanic and physical information and physical information is macro in comparison to mechanic information and information related to natural phenomena and mechanic information is micro in comparison to information about mechanic information and macro at the same time in comparison to physical information. Photosynthesis and respiration serve the function of a bridge between living world and non-living world in terms of energy flow and matter cycle (Lin and Hu, 2003). The focus of research is to develop the understanding of complex subjects and more emphasis is put on the construction of information on the basis of relationships within the information. Moreover, it focuses on the integration, function and process of biological information (Barak et al., 1999; Hogan and Fisherkeller, 1996; Leach et al., 1996).

Understanding of connections between biological systems at macro and micro levels is of great importance for biological literacy (Bahar et al., 1999a). Students can not realize that both photosynthesis and respiration are energy reactions within biological systems. Photosynthesis and vegetative cellular respiration occur simultaneously within plants through multiple biochemical steps (Lin and Hu, 2003). While categorizing the specialties and functions of organelles, students may not consider the relationships between the processes and may miss the importance of the plant as a function of independent biological systems within the local eco-system as well as the global eco-system. Organism is in an interaction within the eco-system and affects the global environment. A plant is a system. Moreover, a plant is nested parts of a system. Every ecological level has its own features. For instance, green pigmentation cannot be analyzed at cellular level on its own, but when combined with the light, it becomes chlorophyll and its green color becomes apparent.

Photosynthesis and vegetative cellular respiration occur at more than one ecological level and within more than one complex system and students overlook actions occurring continuously and spontaneously at more than one ecological level (not step by step processes) (Chi, 2001). In Lin and Hu (2003), it was reported that pre-service classroom teachers experience mental confusions in defining how cellular respiration happens and photo-synthesis. It was also determined that photosynthesis is viewed to be a source of energy and the students used light energy and food chain as evidence to support their view. One of the students stated that the sun realizes photosynthesis. The student also stated that the sun is a source of energy for plants and plays a productive role in vegetative food cycle. The participants frequently identified sun light as the source of energy but they could not provide its definition at biochemical level in a suitable context. Though all the reactions were considered at biochemical level, none of the participants mentioned the electrons involved in the process. Though they were able to conceptualize photosynthesis as an energy process, they found its definitions scientifically incomplete. The participants defined cellular respiration as an energy process. The pre-service teachers experienced difficulties in defining the relationship between food and energy.

As can be seen in the related literature, research conducted in the field of science education in recent years has revealed that students have alternative concepts in many subjects. In this regard, by means of free word association test technique, students' conceptual structure can be determined and alternative concepts can be solicited. However, in the related literature no study looking into pre-service science teachers' conceptual structures in relation to "food chain" by using free word association test technique was encountered. Thus, the findings of the current study employing free word association test technique are believed to make important contributions to the literature.

METHODOLOGY

In the current study, a qualitative research method was employed.

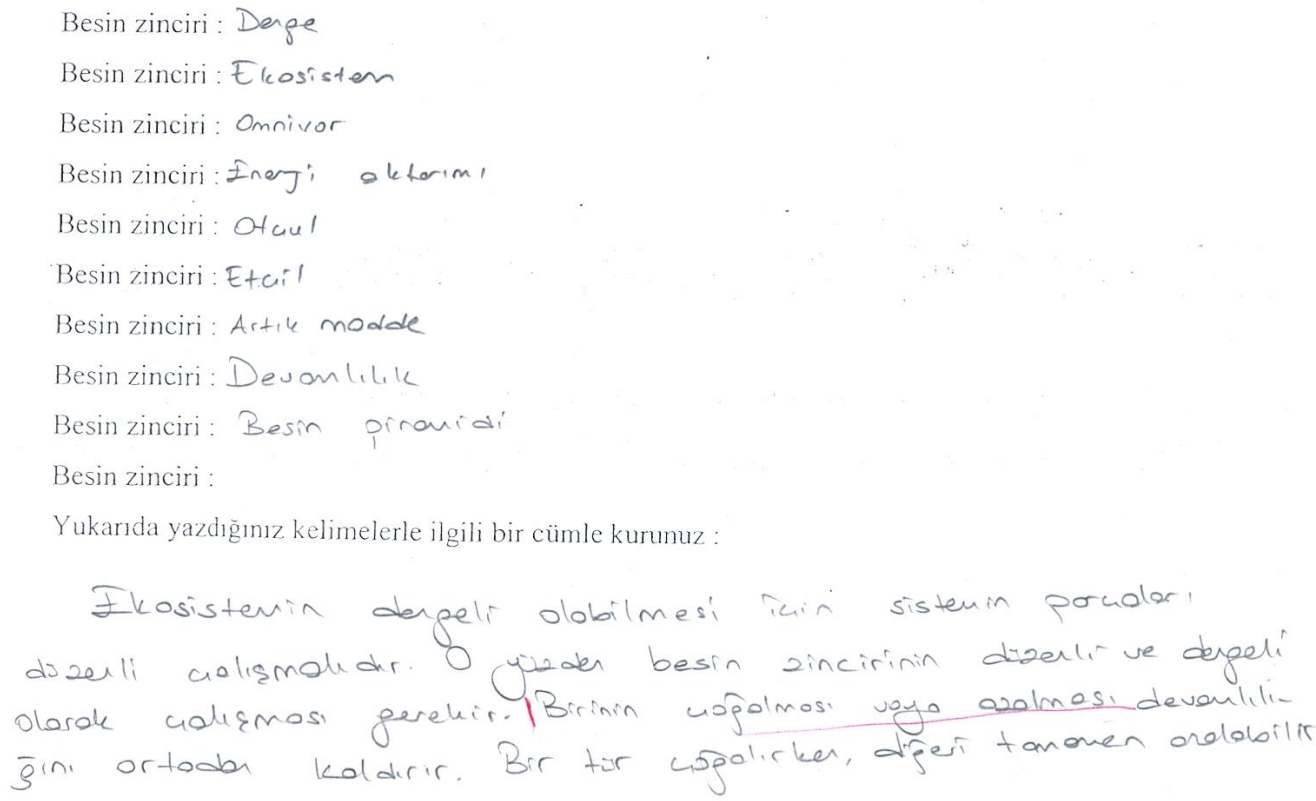


Figure 1. Response paper of *P33*.

According to Yıldırım and Şimşek (2000), qualitative research is a research method aiming to discover individuals' views of a phenomenon and to uncover the processes belonging to this view. In qualitative research, the main purpose is not to reach generalizable results but rather to present a descriptive and realistic picture of the issue under investigation (Patton, 2014; Creswell, 2013). In qualitative research, for the reliability and validity of the research findings, presentation of the data in a detailed and direct manner is of great importance.

Study group

The participants of the current study conducted in 2014 to 2015 academic year are 48 senior pre-service science teachers attending the Department of Science Teaching at the Ahmet Keleşoğlu Education Faculty of Necmettin Erbakan University, Turkey. The participants are in the age group of 20 to 21. The reason for the selection of these pre-service teachers is that biology courses are given to students in the department of science education in each term and it is the science teachers' responsibility to teach these biology subjects to students in the second level of elementary education.

Data collection instruments

In the current study, free word association test was used as a data collection instrument. By using this test, it was intended to collect detailed information about the pre-service teachers' conceptual structures related to food chain. Information is given about this measurement tool.

Free word association test

This data collection technique, widely used in the field of science to collect data (Ad and Demirci, 2012; Aydın and Taşar, 2010; Bahar et al., 1999b; Daskolia et al., 2006; Ercan et al., 2010; Köseoğlu and Bayır, 2011; Nakiboğlu, 2008; Özatlı and Bahar, 2010; Timur and Taşar, 2011; Torkar and Bajd, 2006), has been started to be employed by some social studies in recent years (Işıklı et al., 2011; Kurt, 2013a, b, c; Kurt et al., 2013a, b, c, d).

Free word association test is one of the most widely used techniques to elicit individuals' cognitive structures related to certain concepts and the links between the concepts in this structure; that is, to analyze the information network and to determine whether the relationships between the concepts in the long-term memory are adequate or not (Atasoy, 2004; Bahar and Kılıçlı, 2001; Bahar and Özatlı, 2003; Cardellini and Bahar, 2000; Nartgün, 2006). This technique is based on the idea of expressing the thoughts coming to the mind in relation to the stimulating word without any limitation (Bahar et al., 1999b; Sato and James, 1999). In the present study, the pre-service teachers were asked the concept of "*food chain*" to complete the free word association test. In this test, the concept of food chain is presented as a stimulator in the following format. In Figure 1, one example set of data collected through the free word association technique belonging to the participant K33 is given.

As can be seen in the sample test given in Figure 1, the free word association test is comprised of two stages. *In the first stage;* The participants must express the concepts that are brought to their minds by the stimulating word within a certain time limit that is 40 s for the current study (Gussarsky and Gorodetsky, 1990). The pre-service science teachers were asked to write the first ten words that come to their minds when they read or hear the term "food chain" within 40 s. The test is designed in such a way that the students have to go back to the key concept after writing each related concept so that they are not affected from the associated concepts but from the key concept. Thus, the test serves its intended purpose.

In the second stage; the participants were asked to write sentences related to the key concept within 20 s and in the data analysis process, each sentence was separately analyzed because the response sentence associated with the key concept might be a product of connation at recall level that does not have a meaningful relationship with the key concept. Furthermore, as the related sentence will be more complex and have a more sophisticated structure than a single response word, whether the sentence is scientific or whether it includes misconceptions with different characteristics affects evaluation process.

Analysis of data

To start with data analysis, first the participants' response papers were enumerated. The data were analyzed according to content analysis method. The main purpose of content analysis is to reach concepts and relationships that can explain the data. For this purpose, similar data are gathered around certain concepts and themes and organized and interpreted in such a way as to be understood by the reader (Yıldırım and Şimşek, 2006).

The data collected by means of the free word association technique were analyzed by using the number of words, the number of responses and meaningful relationship technique (Atasoy, 2004). The words connotating the same meaning were classified under the most frequently repeated words. Many words regarded to be unrelated to other words and words repeated only once were not included in the analysis. The words were categorized by using the meaningful relationship criterion and frequencies of the words in each category were calculated. A great deal of research shows that this type of data analysis technique yields reliable results (Daskolia et al., 2006; Kostova and Radoynovska, 2008; Kostova and Radoynovska, 2010). Two important processes were conducted to establish the validity of the research results: data coding and analysis processes (how the conceptual category has been reached) were explained in detail (Hruschka et al., 2004); excerpts believed to best represent each category were selected and presented in the findings section (Yıldırım and Şimşek, 2006).

In order to establish the reliability of the study, the codes and the relationships related to the codes found by two researchers were compared to confirm whether the codes given under the conceptual categories actually represent these conceptual categories. After the research data were separately coded by two experts in the field of science, final form of the list of codes and themes was given considering the opinions of the researcher. The consistency of the codes used by the researchers separately from each other was determined by making markings as "agreement" and "disagreement". Cases in which the researchers used the same codes for the students' opinions were considered to be agreement and cases in which they used different codes were considered to be disagreement. In cases in which one of the researchers ran into a contradiction, coding was performed by seeking the opinion of the other researcher. The reliability of the data analysis conducted in this way was calculated by using this formula; (Agreement / (Agreement + Disagreement) x 100) (Miles and Huberman, 1994; Kurt, 2013a, b, c; Kurt et al., 2013a, b, c, d). Inter-rater reliability was found to be 90%.

On the other hand, in the construction of the model of the students' cognitive structures related to food cycle NVivo9 program was used.

FINDINGS

As a result of the analysis of the pre-service science teachers' cognitive structures related to food chain, totally 8 categories of the words were constructed. These categories and the words involved in each category were listed. When a word was repeated once, it was excluded from the evaluation. Thus, a total of 42 words (10.57%) were not included within the categories. These words are also not presented in Table 1; yet, at the end of each category evaluated, they are mentioned in the related comments section. As a result, the remaining 60 words were assigned into 8 categories. In Table 1, the categories and the words in each category are listed. Totally 397 response words were obtained.

As a result of the collected data, it was observed that the pre-service teachers put the greatest emphasis on the concept of "energy flow" in relation to the concept of food chain; thus, the most prominent category was determined to be "energy flow" (f=190). In this category, while most of the participants focus on words such as "producer", "decomposer", "consumer", "energy", "carnivore", "herbivore", "omnivore", some of them mentioned concepts such as "primary consumer", "secondary consumer", "cycle", "autotroph", "prey-hunter", "green plants", "tertiary consumer", "predator" and "sun light". In this category, there are some words not included in the list of the category as they were only repeated once; "weight", "10% law", "step", "eating each other", "convection" and "chain". These results show that the participants created the most connections with the category of "energy flow" in relation to the concept of food chain.

In the second category, the participants offered associations regarding "producer, consumer, decomposer organisms" (f=98). In this category, most of the participants used the words such as "plant", "weed", "snake", "sheep", "animal", "grasshopper", "eagle", "human" and "lion" and few of the participants focused on the concepts they could see around such as "worm", "mouse", "tenia", "frog", "hawk" and "bacteria". The words not included in this category as they were only once written are; "vulture", "crocodile", "pigeon", "cow" and "rabbit". These results indicate that the participants' cognitive structures related to food chain are quite restricted.

The third category was constructed under the heading of "food chain and food pyramid relationship" (f=37). While most of the participants used to concepts of "food

Table 1. Distribution of science student teachers" cognitive structures about "food chain" by categories.

Categories	Concepts under categories and their frequencies	Total frequencies of categories
Energy flow	Producer (32) Decomposer (25) Consumer (21) Energy (21) Carnivore (19) Herbivore (14) Omnivore (11) Primary consumer (9) Secondary consumer (9) Cycle (7) Autotroph (6) Prey-hunter (4) Green plants (4) Tertiary consumer (3) Predator (3) Sunlight (2)	190
Producer, consumer, decomposer organisms	Plant (15) Weed (12) Snake (10) Sheep (9) Animal (8) Grasshopper (8) Eagle (7) Human (6) Lion (6) Worm (4) Mouse (3) Tenia (3) Frog (3) Hawk (2) Bacteria (2)	98
Food chain and food pyramid relationship	Food pyramid (15) Food (7) Eating (4) Microorganism (4) Parasite (3) The number of living things (2) Triangle (2)	37
Ecologic factors	Ecologic balance (6) Ecosystem (6) Soil (5) Water (4) Ecologic activities (3) Photosynthesis (3) Respiration (3)	37

Table 1. Cont'd

	Continuity (3) Air (2) Earth (2)	
Matters used in energy flow	Waste (2) Co_2 (2) Carbohydrate (2) O_2 (2) Protein (2) Fat (2)	12
Terms related to vitality	Living entity (9) Reproduction (2)	11
Deterioration in food chain	İncrease in the number of members (4) Decrease in the number of members (2)	6
The characteristics of population	Competition (4) Survival of the population (2)	6 -
Total	60 words	397

pyramid", "food", "eating" and "microorganism", relatively fewer participants mentioned the words; "parasite", "the number of living things" and "triangle". Moreover, the words not included in this category as they were only written once are; "commensalism", "small", "mass" and "ordering". In this regard, it can be argued that the conceptual validity of the pre-service science teachers' cognitive structures about "food chain and food pyramid relationship" is not adequate.

In the fourth category, the participants' words related to "ecologic factors" are collected (f=37). In this category, the participants mentioned concepts such as "ecologic balance", "eco-system", "soil", "water", and "ecologic activities". The word not included in this category as it was only written once is "sun". It is seen that the participants' cognitive structures in relation to "ecologic factors" are quite restricted. In the fifth category, the participants' words related to "matters used in energy flow" are gathered (f=12). In this category, most of the participants focused on the concepts of "waste", "CO_2", "carbohydrate", "oxygen", "protein" and "fat". The word not included in this category as it was only written once is "nitrogen".

The sixth category of the words associated with the concept of food chain by the participants was constructed under the heading of "terms related to vitality" (f=11). The words written in association with this theme are "living entity" and "reproduction". The words not included in this category as they were only written once are; "non-living thing" and "growth". From the words written by the participants, it was observed that the participants could not create connections with other concepts.

The seventh category was constructed under the heading of "deterioration in food chain" (f=6). In this regard, the participants used the words "increase in the number of members" and "decrease in the number of members". As the words "harm to the field" and "harm to human" were written once, they were not included in this category. The last category was named as "the characteristics of the population" (f=6). In this category, the participants focused on the concepts of "competition" and "survival of the population". In addition, some excerpts of the pre-service teachers from their explanations about food chain are presented under the related themes together with their analyses below:

The participants' explanations about the category of "*energy flow"*;
"Food chain is the flow of energy among living organisms" (K27)
"…food chain is the flow of energy occurring as a result of cycles taking place among producers, consumers and decomposers" (K28)

The participants' explanations about the category of "*food chain and food pyramid relationship"*;
"The order generally represented by consumers, producers and decomposers in the food pyramid and ensuring vitality and balance can be called food chain" (K37)

"Food chain ensures the natural balance" (K40)

The participants' explanations about the category of *"ecologic factors"*;
"For the eco-system to be in balance, the constituents of the system must function properly. Therefore, food chain should function regularly and in a balanced manner" (K33)
"For the maintenance of the eco-system, food chain should sustain it existence together with its members" (K35)

The participants' explanations about the category of *"deterioration in food chain"*;
"…increasing or decreasing population of one of them may pose a threat to survival. While one species is proliferating, another one may become extinct" (K33)

When the given excerpts examined, it is seen that the pre-service teachers did not write sentences for each category and they wrote more sentences for the category of "energy flow". This clearly shows that the prominent theme is the "flow of energy". This may indicate that the pre-service teachers first try to create a conceptual structure of what food chain is in their minds and they cannot create links between food chain and food pyramid. It can be argued that as result of rote learning, some students could not produce any sentences and some others could not make meaningful sentences. Moreover, the findings of the current study revealed that the pre-service teachers hold some alternative concepts in relation to food chain. Some sample alternative concepts stated by the participants in relation to the category "*energy flow*" are given below:

"transfer of food from plants to animals like a chain" (K29)

this statement shows that the participant has an alternative concept because in plants and animals, energy transfer is out of question. When the words written by this participant are examined, it is seen that he/she used the word "*decomposer*" but did not use it an a sentence and holds an erroneous concept. In this regard, this statement of the participant is incomplete and wrong. Another participant's statement *"food chain starts with producers, producers produce their own food"* (K30) shows that he/she has some missing information because he/she did not mention consumers and decomposers. Yet another participant's statement *"it is a cycle"* shows that he/she has missing and erroneous information because though the term "cycle" is correct, it may mean many things. What are the constituents of the cycle? He/she did not mention these constituents. Some sample alternative concepts stated by the participants in relation to the category "*producer, consumer and decomposer organisms"* are given as:

"at the bottom of food chain are there plants and at the top of it are there animals" (K39)

this statement shows that the participant has missing and erroneous information because he/she did not mention decomposer organisms. Some sample alternative concepts stated by the participants in relation to the category "*food chain and food pyramid relationship"* are given below:

"food chain is like eating" (K35)

this statement is not correct and also no explanation was written for this sentence. The reason for this analogy should be explained. Some sample alternative concepts stated by the participants in relation to the category "*matters used in energy flow"* are given below:

"requirements of life cycle are carbohydrate, protein and fat…" (K42)

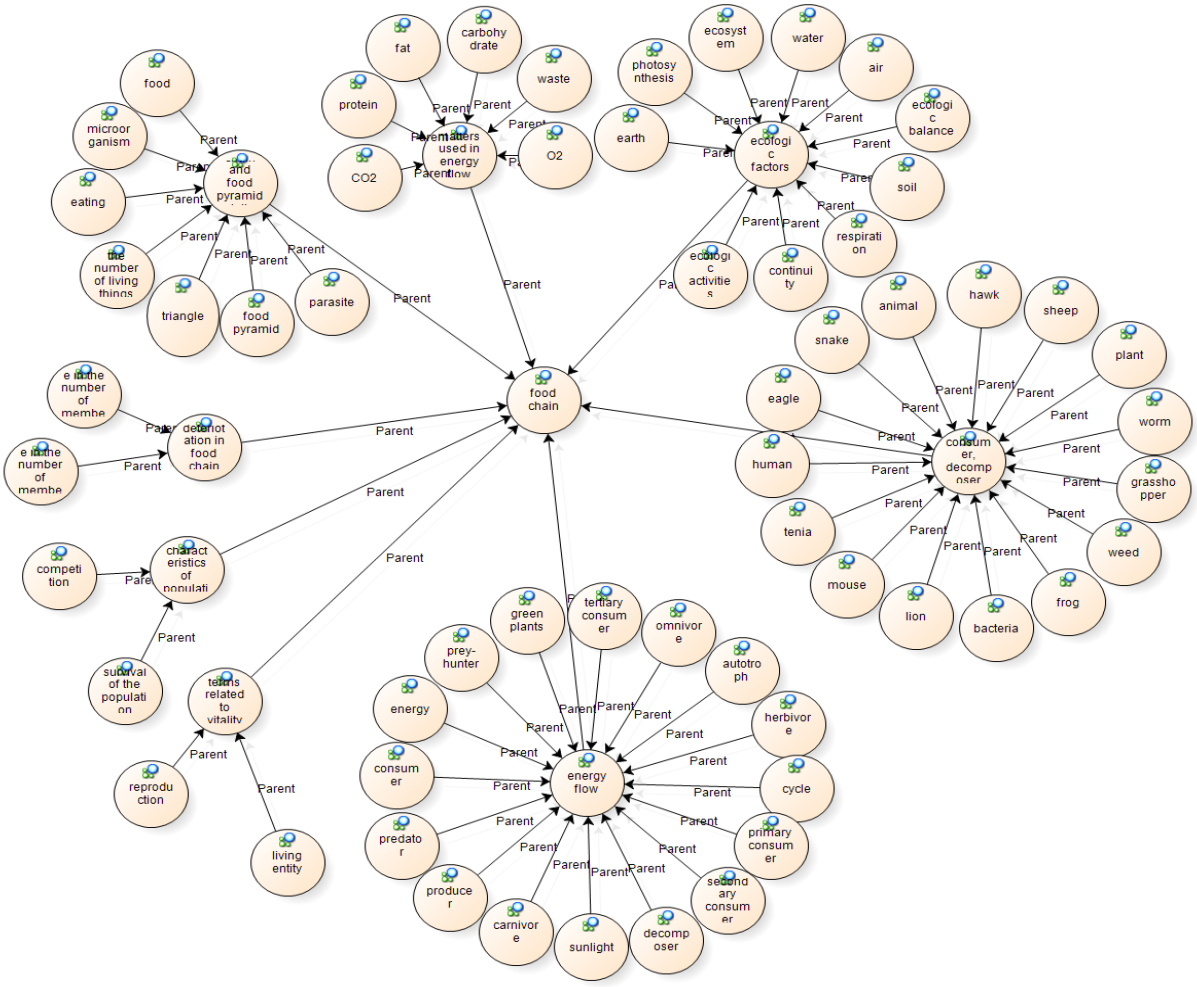
this statement shows that the participant is lacking some information because they are not only these matters. There are some other matters very important for living entities. By evaluating the data of the current study, a model related to the pre-service science teachers' cognitive structures of food chain was constructed (Model 1). As can be seen in the model, the pre-service science teachers' conceptual structures regarding food chain emerged in association with 8 categories.

DISCUSSION

The current study was designed to identify the pre-service science teachers' cognitive structures related to food chain by determining their conceptual constructs. As the pre-service science teachers' conceptual constructs related to the concept of food chain are of great importance for the construction of science-related concepts, the results of the current study are believed to make important contributions to literature.

In the literature, it has been reported that students are unsuccessful in relating to what they have learned from different disciplines of science to their lives and unable to comprehend the relationships between what is scientific and what is not (Enginar et al., 2002; Özmen, 2003; Palmer, 1999; Taşdemir and Demirbaş, 2010; Yiğit et al., 2002) and that pre-service science teachers included positive and negative associations in their response words related to food chain. In this regard, the words produced by the pre-service science teachers reflect their academic concepts, their relating these concepts to daily life and their explaining academic concepts with the terms of daily speech etc. What is more important here?

Correct construction of an academic concept or academically correct expression of it?



Model 1. Cognitive structures science student teachers' about food chain.

In the current study, the words elicited by means of the free word association test were gathered under 8 categories. These are; "energy flow", "producer, consumer and decomposer organisms", "food chain and food pyramid relationship", "ecologic factors", "matters used in energy flow", "terms related to vitality", "deterioration in food chain" and "characteristics of the population".

In light of the results obtained within the themes constructed, it can be argued that the pre-service science teachers most strongly associated the word of "*food chain*" with "*energy flow*". Thus, it cannot be maintained that the pre-service science teachers' cognitive structures related to food chain have a scientific conceptual validity because of their statements related to food chain such as *"transfer of food from plants to animals like a chain"* (K29;40); such statements show that they have alternative concepts. Griffiths and Grant (1985) reported that the students have alternative concepts in the analysis of food chain. Hogan and Fisherkeller (1996) detected the difficulties experienced by the students in the dissociation of the matter or relating it to photosynthesis in food chain. They pointed out that the students have some misconceptions about photosynthesis, respiration and energy flow in food chain and they could not transfer their information into the subject of energy conservation (Barak et al., 1999).

It was also reported that high school senior students are unsuccessful in identifying the relationships between various concepts related to the topics of matter cycle and energy flow. The topic the students found the most difficult to understand was the relationship between the living and nonliving worlds. Photosynthesis and respiration serve the function of a bridge between living and non-living worlds in terms of energy and matter cycle (Lin and Hu, 2003).

In the current study, it was determined that the pre-

service science teachers could not make sense of photosynthesis and sun light within the context of food chain process. It was also determined that the participants could not relate these concepts with these words and could not make meaningful sentences. Lin and Hu (2003) found that photosynthesis is viewed to be a source of energy and the students used light energy and food chain as evidence to support their view. One of the students stated that the sun realizes photosynthesis. The student also stated that the sun is a source of energy for plants and plays a productive role in vegetative food cycle. The participants frequently identified sun light as the source of energy but they could not provide its definition at biochemical level in a suitable context. In the current study, they did not view sun light as a source of energy and did not use it in a suitable context.

The measurement tool revealed the inadequacy of the pre-service science teachers' information about the categories of "*ecological factors*", *"terms related to living organisms", "deterioration in food chain"* and *"characteristics of the population"*. The participants were not able to write sentences in relation to these categories. The relationships of the response words with these categories were found to inadequate. Thus, it can be argued that the participants have missing information. There are many reasons for not being able to construct conceptual structures and one of them is the existence of many similar wrong definitions in text books and this makes the understanding of the concepts difficult and leads to confusion.

In this regard, teacher education programs should promote the conceptual development of pre-service teachers, help them to develop their professional competencies and impart the required qualifications to them so that they can detect their students' learning difficulties during their professional career (Yip, 1998). Given that even when they are given the necessary training, students may have great difficulties in changing the internalized erroneous concepts, it becomes clear that this is process that should be taken seriously.

Conclusion

Attaching importance to concept teaching and conceptual learning at every level of schooling and organization of the required educational-instructional activities for this purpose are of great importance for meaningful learning to occur. On the other hand, through the provision of training about how to use cognitive strategies accurately, pre-service science teachers can learn the concepts successfully, and thus their cognitive structures of the concepts can be rendered permanent and accurate.

Conflicts of interest

The author has not declared any conflict of interests.

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