

# Science Student Teachers' Cognitive Structure on the Concept of "Food Pyramid"

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## Abstract

The current study aims to determine science student teachers' cognitive structure on the concept of food pyramid. 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 pyramid 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 7 categories, which were stated as follows: -relationship between producer, consumer and decomposer in matter and energy flow-concepts related to nourishment pyramid-definition of food pyramid-energy and matter transfer-producer, consumer and decomposer-elements of ecosystem and ecological factors- scientific disciplines related to food pyramid. When the words provided as answers by the science student teachers to the concept of food pyramid were analyzed, it was noticed that they had more word connections with relationship between producer, consumer and decomposer in matter and energy flow. It can be argued that some students could not produce any sentences and some others could not make meaningful sentences. Moreover, it was determined that they had some misconceptions about food pyramid. Similar research can be conducted with different student groups and for the correction of alternative concepts related to the concept of food pyramid, extra biology courses should be included in undergraduate curriculums.

**Keywords:** food pyramid, free word association test, misconception, cognitive structure

## 1. Introduction

The cognitive structure is organized in a hierarchical manner. New information is acquired by building it on the former knowledge. The learning occurring in this way; that is, by linking the new information to the already acquired conceptual knowledge, is called meaningful learning (Novak, 1990). According to Novak (2002), conceptual knowledge is the sum of organized information about a subject. He states that the main constituents of information are thoughts and concepts. Concepts should be learned through a meaningful method. Otherwise, problems would be experienced in the retention of information. Thus, scientific concepts should be comprehended in accordance with definitions (Kinchin, David, & Adams, 2000).

The individual is exposed to interaction with his/her environment via his/her five senses. Information is sent to the brain and then the brain attempts to produce meaningful information by means of sensual receptions. This construction process depends on the individual's prior experiences because the brain tries to connect the incoming information with something that has already been acquired. According to many researchers, this something is previous experiences and judgments. An individual views the world not as it is but as he/she has constructed it in his/her mind. This is one of the basic tenets of constructivism. The reality of an individual might not be true or certain; this individual can produce only explanations on the basis of his/her experiences. The second tenet may have important indications for education. Information is not passively received; in contrast, it is actively constructed by the student (Pereira, 1996). These principles are related to the need of receiving information (preparedness). This process starts with the information level of the student, draws on the information infrastructure, concepts suitable for information reception are presented, and thus, new information

is constructed on the existing experiences and conceptions. In this way, students are helped to create connections between concepts and to convert these connections into multi-dimensional structures of information.

It should be kept in mind that for the success of teaching, the concept should be ready to use by the student. The student hierarchically constructs the target concepts in his/her cognitive structure from general to detail, from concrete to abstract and thus forms the conceptual roof. This hierarchical cognitive structure made up of more than one concept is called the conceptual system such as respiration or digestion. For the construction of conceptual systems, the concepts constituting the system should be in connection with each other. While learning conceptual systems, the student makes some arrangements in his/her cognitive structure. The student finds the opportunity of constructing information in his/her cognitive structure (Yager, 2000).

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 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, Mintzes & Novak, 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 & Huang, 2002).

Vosniadou's (1994) study (as cited in Kurt, 2013b, e) mental models are viewed to be an analog presentation constructed along individuals' cognitive functions, a special variety of mental presentations. Mental models are also viewed to be interpretations of students' concepts. In the current study, in order to define students' understanding, the term *mental model* was used.

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 & West, 1986; Tsai & 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, Boulter, and Rutherford (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.

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, Nartgün, Durmuş, & Bıçak, 2006). Free word association test and drawing-writing technique are 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 & Korfiatis, 2006).

### 1.1 Conceptual Structure Researches on Food Pyramid

Hogan and Fisher-Keller (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, Sheva, & Gorodetsky, 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 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, Johnstone, & Hansell, 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 & Hu, 2003).

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 & Hu, 2003). In Lin and Hu (2003), it was reported that pre-service classroom teachers experience mental confusions in defining how cellular respiration happens and photosynthesis. 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.

### *1.2 The Aim and Importance of the Study*

The aim of the study is to investigate the pre-service science teachers' cognitive structures regarding "food pyramid" by using free word association technique.

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 pyramid" 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.

## **2. Methodology**

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

## 2.1 Study Context

The participants of the current study conducted in 2014-2015 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. The participants are in the age group of 20-21. 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.

## 2.2 Data Collection

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 pyramid. Information is given about this measurement tool below.

### 2.2.1 Free Word Association Test

This data collection technique, widely used in the field of science to collect data (Ad & Demirci, 2012; Aydın & Taşar, 2010; Bahar, Johnstone, & Sutcliffe, 1999b; Daskolia, Flogaitis, & Papageorgiou, 2006; Ercan, Taşdere, & Ercan, 2010; Köseoğlu & Bayır, 2011; Nakiboğlu, 2008; Özatlı & Bahar, 2010; Timur & Taşar, 2011; Torkar & Bajd, 2006), has been started to be employed by some social studies in recent years (Işıklı, Taşdere, & Göz, 2011; Kurt, 2013a, b, c; Kurt, Ekici, Aksu, & Aktaş, 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 & Kılıçlı, 2001; Bahar & Özatlı, 2003; Cardellini & 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 & James, 1999). In the present study, the pre-service teachers were asked the concept of "food pyramid" to complete the free word association test. In this test, the concept of food pyramid 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 K30 is given.

Food pyramid-1.....

Food pyramid-2.....

.

.

Food pyramid-10.....

Besin piramidi : Besin zinciri

Besin piramidi : Üretici

Besin piramidi : Tüketici

Besin piramidi : Yeşil bitkiler

Besin piramidi : Avcular

Besin piramidi : Besin zinciri

Besin piramidi : Dengeli

Besin piramidi : Predatörler, yırtıcılar

Yukarıda yazdığımız kelimelerle ilgili bir cümle kurunuz : Besin piramidinin en alt basamağında daha çok canlı bulunur.

Figure 1. Response paper of P30

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 seconds for the current study (Gussarsky & 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 pyramid” within 40 seconds. 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 seconds 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 connotation 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.

### 2.3 Data Analysis

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 & 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 connoting 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 & Radoynovska, 2008; Kostova & Radoynovska, 2010).

Two important processes were conducted to establish the validity of the research results: (a) data coding and analysis processes (how the conceptual category has been reached) were explained in detail (Hruschka, Schwartz, St. John, Picone-Decaro, Jenkins, & Carey, 2004) (b) Excerpts believed to best represent each category were selected and presented in the findings section (Yıldırım & 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;  $[\text{Agreement}/(\text{Agreement} + \text{Disagreement}) \times 100]$  (Miles & Huberman, 1994; as cited in Kurt, 2013a, b, c; Kurt et al., 2013a, b, c, d). Inter-rater reliability was found to be 92%.

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

### 3. Results

As a result of the analysis of the pre-service science teachers’ cognitive structures related to food pyramid, totally 7 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 86 words (21.71%) 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 53 words were assigned into 7 categories. In Table 1, the categories and the words in each category are listed. Totally 310 response words were obtained.

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

Categories	Concepts under categories and their frequencies	Total frequencies of categories
1. relationship between producer, consumer and decomposer in matter and energy flow	producer (23)	119
	consumer (17)	
	decomposer (16)	
	herbivores (10)	
	carnivores (10)	
	primary consumer (9)	
	secondary consumer (8)	
	prey-hunter (6)	
	predatory (4)	
	omnivores (4)	
	green plants (4)	
	autotroph (3)	
	heterotroph (3)	
2. concepts related to nourishment pyramid	body size (2)	73
	carbohydrate (12)	
	fat (12)	
	protein (11)	
	milk and milk products (9)	
	meat products (7)	
	vitamin (4)	
	fruit (4)	
	vegetable (3)	
	glucose (3)	
	edible legume (2)	
the think that should be taken daily (2)		
3. definition of food pyramid	mineral (2)	39
	sweets (2)	
	triangle (9)	
	energy (8)	
	food chain (8)	
	living things (5)	
	stages of nutrition (3)	
4. relationship between energy transfer and life	cycle (2)	27
	pyramid(2)	
	the number of living things (2)	
	energy transfer (10)	
5. relationship between energy transfer and life	food (9)	27
	life (4)	

4. energy and matter transfer	% 10 law (4)	
	plant (11)	
	animal (4)	
5. producer, consumer and decomposer	microorganism (4)	27
	human (3)	
	bacteria (3)	
	mushroom (2)	
	water (7)	
	sunlight (5)	
6. elements of ecosystem and ecological factors	ecosystem (3)	22
	natural balance (3)	
	photosynthesis (2)	
	population (2)	
7. scientific disciplines related to food pyramid	ecology (3)	3
<b>Total</b>	<b>52 words</b>	<b>310</b>

When the collected data were analyzed, it was found that the responses given by the pre-service science teachers in relation to the concept of food pyramid in the first category were most intensely gathered under the category of “*relationship between producer, consumer and decomposer in matter and energy flow*” and thus this emerged as the dominant category (f=119). In this category, while many participants were focusing on the terms “*producer*”, “*consumer*”, “*decomposer*”, “*herbivores*”, “*carnivores*”, “*primary consumer*”, “*secondary consumer*”, some of them mentioned the terms “*prey-hunter*”, “*predator*”, “*omnivores*”, “*green plants*”, “*autotroph*”, “*heterotroph*” and “*body size*”. There are some concepts, though written in this category, not included in the category as they were only written once such as “*tertiary consumers*”, “*grains are at the bottom*”, “*fat is at the top*” and “*weak ones*”. This findings show that the participants mostly formed close connections with the category of producer, consumer and decomposer relationship in matter and energy flow in relation to the concept of food pyramid.

In the second category, the participants generated associations in relation to the category of “*concepts related to nourishment pyramid*” (f=73). In this category, while the associations stated by most of the participants are “*carbohydrate*”, “*fat*”, “*protein*”, “*milk and dairy products*” and “*meat products*”, few of the participants were seen to be focusing on the concepts they could continuously see around such as “*vitamin*”, “*fruit*”, “*vegetable*”, “*glucose*”, “*edible legume*” and “*the think that should be taken daily*”, “*mineral*” and “*sweets*”. The concepts not included in the category as they were stated only once by the participants are: “*heat loss*”, “*drinks*”, “*kilo*”, “*edible legume*”, “*obesity*”, “*omega*”, “*portion*”, “*health*”, “*whole wheat bread*”, “*flour*”, “*food*” and “*accumulation of poisonous material*”. These results show that the participants deal with the concept of food pyramid within a different dimension.

The third category was constructed as “*definition of food pyramid*” (f=39). While most of the participants associated the concepts of “*triangle*”, “*energy*”, “*food chain*” and “*living things*” with this category, few of them stated that concepts of “*stages of nutrition*”, “*cycle*”, “*pyramid*” and “*the number of living things*”. The concepts not included in the category as they were stated only once by the participants are: “*food web*”, “*balance*”, “*trefoil pyramid*”, “*corn pyramids*”, “*trefoil model*”, “*relationship between living things*” and “*the number of offsprings*”. Thus, it can be claimed that the conceptual validity of the pre-service science teachers’ cognitive structures about “*definition of food pyramid*” is not adequate.

In the fourth category, the concepts stated by the participants in relation to “*energy and matter transfer*” were included (f=27). Within this category, the participants mostly focused on the concepts of “*energy transfer*”, “*food*”, “*life*” and “*%10 law*”. The concepts not included in the category as they were stated only once by the participants are: “*growth*”, “*development*” and “*life triangle*”. The participants’ cognitive structures in relation to “*energy and matter transfer*” were found to be restricted.

In the fifth category, the response statements of the participants including associations with “*producer, consumer and decomposer*” were included (f=27). Most of the participants focused on the concepts of “*plant*”, “*animal*” and “*microorganism*”. The concepts not included in the category as they were stated only once by the participants are: “*fish*”, “*gazelle*”, “*lion*”, “*cow*”, “*carrion*”, “*monkey*”, “*parasite*” and “*sport*”.

The sixth category was constructed by gathering the concepts stated by the participants in relation to “*elements of eco-system and ecological factors*” (f=22). The concepts stated by the participants in this category are “*water*” and “*sun light*”. The concepts not included in the category as they were stated only once by the participants are: “*nature*”, “*habitat*”, “*competition*”, “*niche*”, “*life balance*”, “*struggle to survive*” and “*natural life*”. The response words stated by the participants are not associated with the concepts related to the concepts of this category and thus, conceptual validity is weak here.

The last category is “*scientific disciplines related to food pyramid*” (f=3). Here, the participants focused on “*ecology*” concept. The concepts not included in the category as they were stated only once by the participants are: “*nutrition course*” and “*plant physiology*”. It is seen that the pre-service science teachers’ associations with this category is adequate yet inadequate within general concepts.

On the other hand, some excerpts taken from the statements of the pre-service teachers are given under the related themes with their analysis.

Some statements of the participants about the category of “*producer, consumer, and decomposer relationship in matter and energy flow*” are as follows;

“*There are producers, consumers and decomposers in food pyramid*” (K31)

“*At the bottom of the pyramid, there is the producer, then comes the consumer and at the top, you can find the decomposer*” (K32)

An excerpt in relation to the category of “*concepts related food pyramid*” is as follows:

“*Balanced diet relies on some certain stages to be followed. First, required grain products, then flour, milk, egg and after these, meat and sweets come*” (K33)

Some statements of the participants related to the category of “*definition of food pyramid*” are given below:

“*Starting from the bottom level of the food chain, vertical sequencing is called food pyramid*” (K37)

“*For the survival of ecosystem, food pyramid should maintain its existence together with its components*” (K39)

Some statements related to the category of “*energy and matter transfer*” are given below:

“*...Energy is transferred upward in the pyramid by 10% decrease*” (K32)

“*There is an energy flow in the food pyramid from down to up...*” (K34)

One excerpt related to the category of “*scientific disciplines connected with the food pyramid*” is given below:

“*The food pyramid is mentioned in the concept of ecology*” (K36)

When the above-given excerpts are 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 “*relationship between producer, consumer and decomposer in matter and energy flow*”. This clearly shows that the prominent theme is the “*relationship between producer, consumer and decomposer in matter and energy flow*”. This may indicate that the pre-service teachers’ first try to create a conceptual structure of what food pyramid 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 pyramid. Some examples of the these alternative concepts are given below;

Same sample alternative concepts stated by the participants in relation to the category of “*relationship between the producer, the consumer and the decomposer in matter and energy flow*;

“*at the bottom level of the food pyramid are there producers*” (K43); this statement shows that the participant has some missing information because the participant only mentioned producers and did not mention the other levels in the food pyramid. When the words in the statement are examined, it is seen that though words included in the food pyramid, they were not used within a sentence. Another participant stated “*the food pyramid is a food chain comprised of herbivorous, carnivorous, saprophyte, primary consumer, and heterotrophic living things*”



(K42) and this statement shows that the participant has some erroneous information because it is clear that he/she felt confused about the concepts related to the food pyramid. The concepts of consumer and heterotrophy are synonyms.

Some sample alternative concepts stated by the participants in relation to the category of “*concepts related to the food pyramid*”;

“*the food pyramid shows the ways of healthy diet*” (K44). This statement shows that the participant has erroneous and missing information because the participant confused the food pyramid with the nutrition pyramid. The food pyramid is built on the relationship among the living things. Another participant stated “*the food pyramid is not suitable for our country. The food trefoil is more suitable ...*” (K39) and this shows that the participant has erroneous and missing information because the participant was confused about the concepts of the food pyramid and the food trefoil. Another participant stated “*the food pyramid starts with grains and carbohydrates and at the top are there vitamins*” (K38) and this statement shows that the participant has erroneous and missing information because he was confused about the food and nutrition pyramids.

Some sample alternative concepts in the category of “*the definition of the food pyramid*” stated by the participants;

“*The food pyramid is mentioned within the concept of ecology*” (K36). Though this statement is not true, it is mentioned within the concept of ecology. Thus, it can be claimed that the participant has some missing information because though the food pyramid is related to ecology, the concept of ecology is a very broad concept. The concept of the food pyramid should be given within a more specific definition.

Some sample alternative concepts stated by the participants in relation to the category of “*Energy and matter transfer*”;

“*energy gets lost from bottom to top*” (K41). This statement shows that the participant has missing information because energy never gets lost according to law of conservation of energy but is converted to another form.

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 7 categories.



teachers mostly associated the concept of the food pyramid with “*the relationship between the producer, the consumer and decomposer in item and energy flow*”. The pre-service science teachers’ cognitive structures related to the definition of the food pyramid can be claimed to have conceptual validity. However, they also have some alternative concepts related to this theme such as “*there are consumers at the bottom level of the food pyramid*” (K43).

The statement “*energy gets lost from bottom to top*” within the theme of “*energy and matter transfer*” (K41) shows that the participant has some missing information. 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 & Hu, 2003).

In the theme of “*elements of the ecosystem and ecological factors*”, the participants were found to be inadequate in terms of the words related to this category (Table 1). It was determined in the current study that the pre-service science teachers could not make sense of the concepts of photosynthesis and sun light within the process of the food pyramid. 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 that inadequacy of the pre-service science teachers’ information about the categories of “*producer, consumer and decomposer*”, “*elements of ecosystem and ecological factors*” and “*scientific disciplines related to food pyramid*”. 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.

As a 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 is 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.

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