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INVESTIGATION OF PRE-SERVICE SCIENCE TEACHERS' KNOWLEDGE ABOUT FOOD WEB

Research article

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Abstract

Biology is a complex science that includes different subjects. As a result, misconceptions, confusion and misleading are common problems in biology education. In this study, it was aimed to determine the learning of pre-service science teachers about food web. The research, using the case study, was conducted in 2019-2020. The study group of the research consists of 76 pre-service science teachers. The structured interview form and focus group interview were used to collect the data. As a result of the research, it was determined that pre-service science teachers have misconceptions, confusion and misleading about food web. When the reasons for the pre-service science teachers' misconceptions, confusion and misleading about food web were examined, it was found out that teachers, textbooks, supplementary textbooks and individual errors were the reasons. Pre-service science teachers should be supported with scientific training in order to learn the food web correctly. In addition, international scientific books should be used in the preparation of textbooks on food web.

Keywords: food web, food chain, misconception, pre-service science teachers,

1. Introduction

The species is defined as a population group whose members has the potential to reproduce among them and can produce offspring (Reece et al., 2013, p.446; Simon et al., 2017, p.271). Today, the number of species on Earth is estimated to be between 7 million and 10 million. However, as a result of the researches, approximately 2 million species have been identified (Miller & Spoolman, 2018, p.77). Each species has a role in its ecosystem. Ecologists define this role as an ecological niche (Molles, 2016, p. 200; Miller & Spoolman, 2018). Even a living thing that does not attract our attention or even dislike can be very important for our life and for the continuity of ecosystems on a global scale. Most people do not think about where a fish we bought from the fishing counter was caught and what they ate until it reached that size. However, it is necessary to know the relationship between living things in order to protect the ecological balance and to ensure its sustainability. At this point, a trophic structure emerges. Nutritional relationships between various species in a community are defined as trophic structures. The trophic nature of the community determines the transition of energy and nutrients from photosynthetic organisms to herbivores and then to predators. The food transfer sequence between trophic levels is called the food chain. In other

words, the food chain; It is a linear ranking showing who eats whom in a certain community (Sadava et al., 2014, p.1190; Simon et al., 2017, p.434; Urry et al., 2014, p.853).In natural ecosystems, most consumers feed on more than one organism. Most organisms are eaten or segregated by multiple consumers. Therefore, organisms in ecosystems form interconnected food chains called food web (Miller & Spoolman, 2018). According to Wyner and Blatt (2019), food webs are multiple food chains formed at the trophic level to show the energy transfer between living things in an ecosystem.

In Turkey, food chain and food web concepts are studied in 8th grade Science Course (MoNE, 2018a) and 10th grade in Biology Course curriculum (Ministry of Education, 2018b).

When the Science Course curriculum is examined, "F.8.6.1. Food Chain and Energy Flow" outcome is recognized (MoNE, 2018a, p.52). In the secondary school Biology curriculum, "*10.3.1.3. Analyzes the flow of matter and energy in the ecosystem. 10.3.1.3.b. Matter and energy flow in ecosystems; It is illustrated in relation to the food chain, food web and food pyramid. 10.3.1.3.ç. Students are able to construct a food web that shows the nutritional relationships between living things*"(MoNE, 2018b, p.21). In order to teach these gains to students and to achieve the goals in the curriculum, the biggest responsibility falls on teachers who are well-equipped in terms of field knowledge.

When the "General Competencies for Teaching Profession" published by the Ministry of National Education (2017) is examined, there are three competency areas as "professional knowledge", "professional skills" and "attitudes and values" and 11 competencies associated with them. One of these competencies is field knowledge. Due to the general competencies of the teaching profession prepared, teachers are expected to have an inquisitive perspective, advanced theoretical, methodological and factual knowledge (MoNE, 2017, p.11). However, studies have shown that both students and teachers have misconceptions, confusion and misleading. For example, in the study conducted by Johnson and Činčera (2019), secondary school students' misconceptions about the matter cycle and energy flow in ecology were determined. Butler, Mooney Simmie, and O'Grady (2015) analyzed the misconception studies on ecology. Torkar and Krašovec (2019) determined the relationship between secondary school students' attitudes towards forest ecosystem, their ecological knowledge levels and perceptions. In their study, Wyner and Blatt (2019) made use of social learning theory, and determined that there was a disconnection between high school students and pre-service science teachers' school knowledge on food web and daily life activities. In the study conducted by Yücel and Özata (2015), it was determined that 7th grade students do not understand the ecosystem issue sufficiently and have misconceptions about the food chain. According to Ürey, Şahin, and Şahin (2011), prospective teachers have misconceptions about basic ecological concepts. As a result of the research conducted by Yörek et al. (2010), it was determined that 9th grade students could not understand the nutritional relationships in the ecosystem. In addition, research has shown that textbooks and supplementary books contain incorrect information about food web and food chain issues (Gündüz, Yılmaz, Çimen & Karakaya, 2019; Gündüz, Yılmaz & Çimen, 2016; Karakaya, Adıgüzel, Çimen & Yılmaz, 2020a; Yılmaz et al. 2018; Yılmaz, Gündüz, Çimen & Karakaya, 2017). Karakaya et al. (2020a) stated as a result of their research that erroneous textbooks cause misconceptions of students.

Teachers who have scientifically incomplete or incorrect information will cause their students to fall into the same mistakes. According to Burgoon, Heddle, and Duran (2010), a teacher with misconceptions cannot identify students' misconceptions and causes new misconceptions to occur. Therefore, teachers and prospective teachers should not have

scientific deficiencies, misinformation and misconceptions. When the literature was examined, it was determined that there were not enough studies to determine the learning and misconceptions of pre-service science teachers about food web. From this point of view, it was aimed to determine the learning of pre-service science teachers about food web. In line with the purpose of the research, the following questions were sought:

- What is the pre-service science teachers' learning about food web?
- What are the sources of the pre-service science teachers' learning about food web?

2. Method

2.1. Research pattern

In this study, a case study, one of the qualitative research designs, was used in order to investigate the subject in depth and versatility. Case study refers to the detailed explanation of the situation or events that occur within a system (Creswell, 2007). The greatest benefit of case studies is that they focus on the multi-faceted and in-depth examination of the subject to be researched (Yılmaz et al. 2018).

2.2. Participants

In the spring semester of 2019-2020 academic years studying at a state university in Turkey 76 fourth grade the pre-service science teachers participated in this study. Teacher candidates studying in the fourth grade were chosen because they are about to complete undergraduate education and will take part in the education system one year later. In the research, a focus group meeting was held in order to determine the learning and sources about the food web. It was stated by Yıldırım and Şimşek (2016, p.161) that there should be between 6-8 participants for the focus group meeting. Groups of six to ten people are thought to be ideal in focus group interviews (Glesne, 2013, p. 180). The fact that the group has more than 10 people both decreases the dynamics of the group and the interaction between the participants (Edmunds, 2000). In this study, six (6) pre-service science teachers participated in the focus meeting on a voluntary basis.

2.3. Data collection tools

In the study, drawing form and focus group interview form were used in order to determine the learning of the pre-service science teachers about food web. The drawing form was prepared according to the knowledge-based drawing approach introduced by Schussler and Winslow (2007). In this context, pre-service science teachers were asked to draw a food web including Human. The focus group interview form was prepared by taking the opinions of two different field experts working in biology and science education. Expert opinions were received in order to ensure the validity of the data collection tools.

2.4. Data collection process

The data collection process of the study was carried out by Lampert et al. (2020), taking into account the model based on drawings and explanations used in their research. This model enables individuals to reveal their knowledge and misconceptions. Within the scope of the research, the data were collected in two steps. In the first step, pre-service science teachers were asked to draw a food web. In the second step, a focus group meeting was held in order to determine in detail the learning and resources of pre-service science teachers about food web. The focus group interview was conducted with six (6) pre-service teachers on a voluntary basis. An ideal focus group interview takes 1-2 hours (Kitzinger, 1995). In this study, the focus group meeting was held in 130 minutes in order for the participants to give

ideal answers to the research questions. Each participant was given an average of 4 minutes to answer the research questions. In order to avoid data loss in the focus group interview, the answers of the teacher candidates were written by two researchers. The focus group interview process was carried out by taking into account the implementation process suggested by Krueger (1998). The focus group interview process is given in Figure 1.

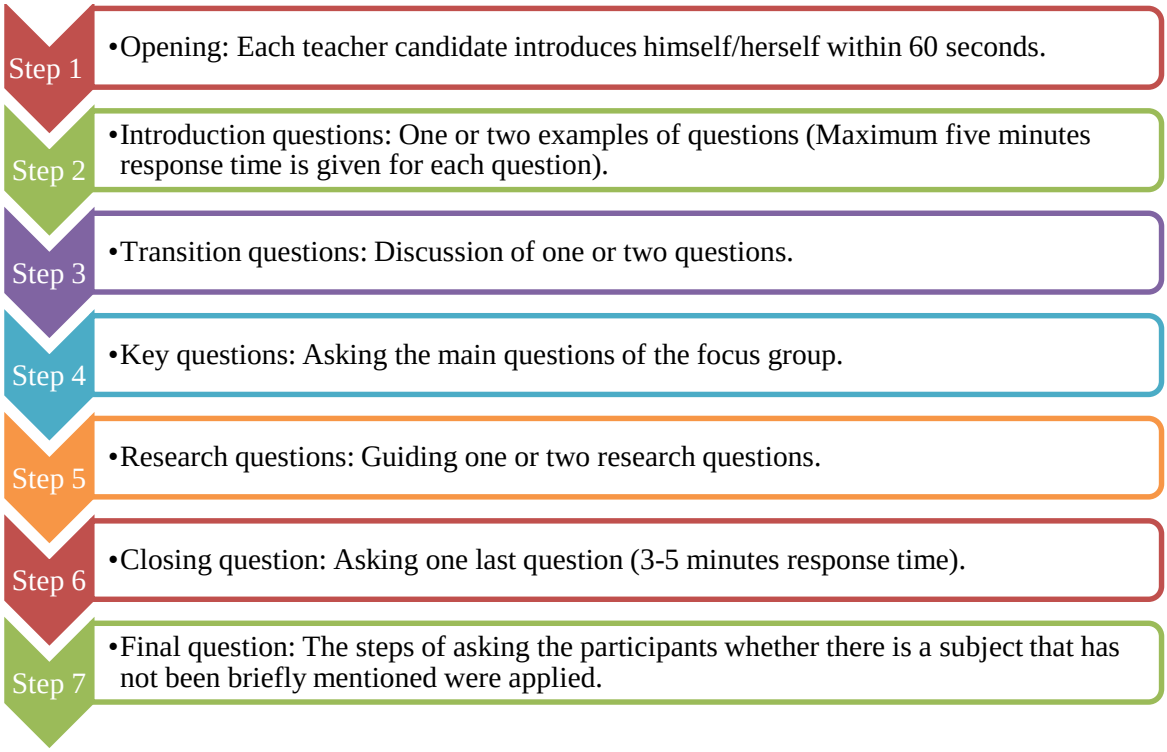

Figure 1. The focus group interview process (Krueger, 1998).

2.5. Data Analysis

Food webs drawn by pre-service teachers were analyzed according to the instructions created with the opinions of field experts. The instruction steps used in the analysis of the drawings for the food web are given in Table 1.

Table 1. *Analysis instruction for food web drawings*

No	Instruction questions
1	Is the drawn food web scientifically correct?
2	How many food chains does the drawn food web consist of?
3	Are the direction of the arrows showing nutritional relationships scientifically correct?
4	At what trophic level does man exist?
5	Has the drawn food web been confused with other concepts?

What matters in reporting the focus group interview is not the numbers but what the individuals say (Creswell, 2007). For this reason, the opinions of the teacher candidates were analyzed descriptively in the focus group meeting. The answers given by the teacher candidates to the questions were presented in the form of sentences that they used directly without changing them. The names of the pre-service science teachers who participated in the focus group interview, T-1, T-2,…. It is coded as T-6. Each data was first read by two different researchers and a holistic understanding was tried to attempt. The third researcher

checked the consistency of the themes obtained and the compatibility of the literature. In order to determine whether there is consistency among the researchers, the formula introduced by Miles and Huberman (2015) was applied, which is Reliability= Consensus/All opinions. Reliability of two encoders was calculated as = %94.

2.6. Ethical Statement of the Study

T.R. Gazi University Ethics Commission Assessment and Evaluation Ethics Sub-Working Group discussed at the meeting dated 03.03.2020 and numbered 03 and decided that the study was ethically and scientifically appropriate.

3. Findings

In this section, the learning and resources of pre-service science teachers about food web are given. In the study, pre-service science teachers were asked to draw a food web including humans. In the analysis of the data, the analysis instruction for the food web drawings was used. Within the scope of the instruction, firstly, the answer to the question "Is the food web drawn by pre-service science teachers scientifically correct?" was sought. The findings obtained are given in Table 2.

Table 2. *Findings for the scientific accuracy of the food web drawing*

Scientific accuracy	f	%
True	7	9.22
False	69	90.78

When the findings in Table 2 were examined, it was determined that 9.22% (f = 7) of the pre-service science teachers participating in the study were correct and 90.78% (f = 69) made the food web drawing including the human scientifically wrong. Food web drawing examples of pre-service science teachers are given in Figures 2 and 3.

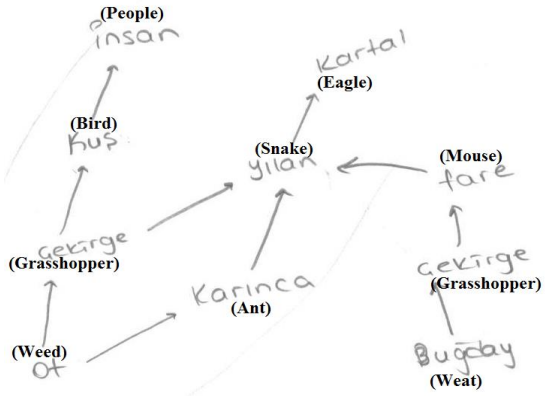

Figure 2. Example of correct food web drawing

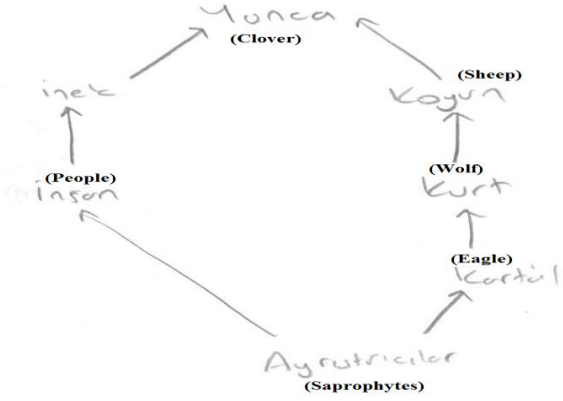

Figure 3. Example of incorrect food web drawing

In the study, the answer to the question "How many food chains does the food web drawn by pre-service science teachers consist of?" was sought. The findings obtained are given in Table 3.

Table 3. *Findings about the number of food chains in the food web*

Number of food chain	f	%
Zero	2	2.60
One	38	50.0
Two	26	34.2
Three	6	7.90
Four and more	4	5.30

When the findings in Table 2 are examined, 50% (f = 38) of the pre-service science teachers participating in the study drew up a chain nutrition system, including humans. Food chain drawing examples of pre-service science teachers are given in Figure 4a., b., c.

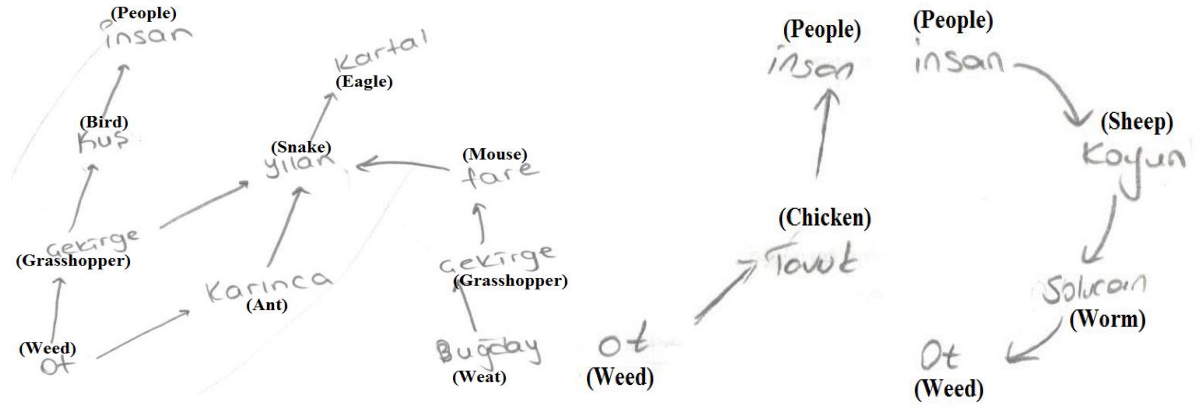

Figure 4a. *Figure 4b.* *Figure 4c.*

Figure 4. Examples of food chain drawing

In the study, the answer to the question "Is the direction of the arrows showing the nutritional relationships between living things in the drawings of pre-service science teachers scientifically correct?" was sought. The findings obtained are given in Table 4.

Table 4. *Findings regarding the scientific accuracy of the direction of the arrows in the drawings*

Direction of arrows	f	%
True	56	73.6
False	16	21.1
No arrow drawing	4	5.30

When the findings in Table 4 were examined, it was determined that 73.6% (f = 56) of the pre-service science teachers draw the direction of the arrows showing the nutritional relationships between living things correctly and 21.1% (f = 16) draw the wrong direction. In addition, it was determined that 5.3% (f = 4) of the candidates did not show nutritional relationships in their drawings. Arrow drawing examples showing the nutrition relationships of pre-service science teachers are given in Figures 5 and 6.

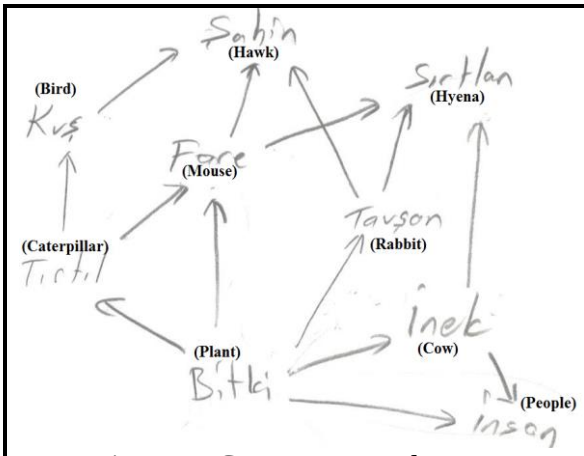

Figure 5. Correct arrow direction representation

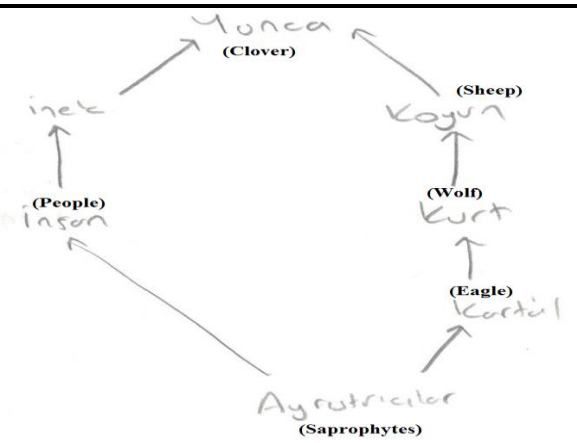

Figure 6. Wrong arrow direction representation

In the study, the answer to the question "At what trophic level does people take place in the drawings of pre-service science teachers?" was sought. The findings obtained are given in Table 5.

Table 5. *Findings regarding the human trophic level*

Trophic level	f	%
Two	1	1.30
Two-Three	12	15.8
Three	52	68.4
Three-Four	1	1.30
Four	6	7.90
Four-Five	1	1.30
>Five	3	4.00

When the findings in Table 5 were examined, it was determined that pre-service science teachers included humans in their drawings mostly (f = 52) at the third trophic level. Drawing examples of pre-service science teachers showing the trophic level of humans are given in Figures 7, 8 and 9.

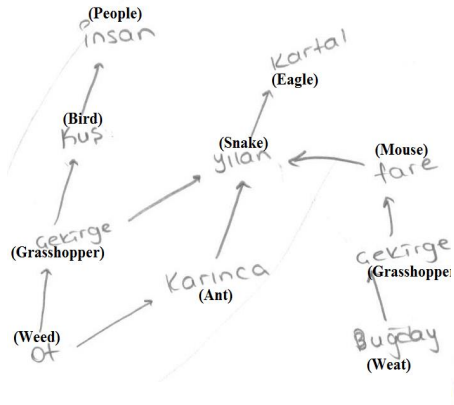

Figure 7. Fourth trophic level

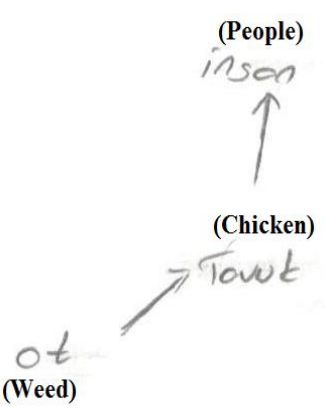

*Figure 8.*Third trophic level

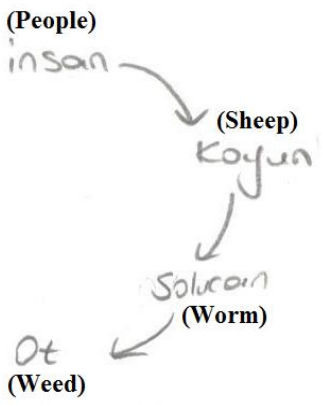

Figure 9. First trophic level

In the study, the answer to the question "Is the food web confused with other concepts in the drawings of pre-service science teachers? was sought. The findings obtained are given in Table 6.

Table 6. *Findings of confusing the food web with other concepts*

Confusing situation	Confused concepts	f	%
Yes	Food chain	53	69.8
	Food pyramid	2	2.60
No	-	21	27.6

Examining the findings in Table 6, it was determined that 69.8% (f = 53) of the pre-service science teachers confused the concept of food web with the concept of food chain. In addition, it was determined that 2.60% (f = 2) confused the food web with the food pyramid. However, it was determined that 27.6% of the pre-service science teachers perceived the food web correctly. Pre-service science teachers' drawing examples of confused concepts of food web are given in Figures 10 and 11.

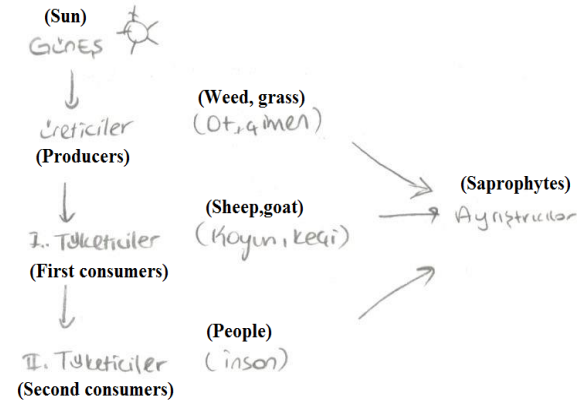

Figure10. Example of drawing food chain

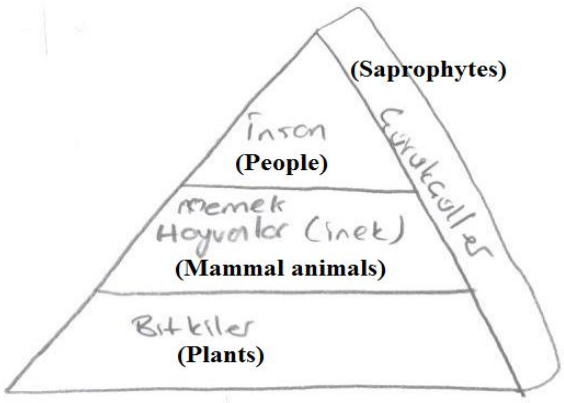

Figure 11. Example of drawing food pyramid

In the study, a focus group meeting was conducted to determine the learning and resources of pre-service science teachers about food web. In the focus group meeting, firstly, it was determined at what trophic level the pre-service science teachers thought human in a terrestrial food chain. The findings obtained are given in Table 7.

Table 7. *Findings regarding the human trophic level*

Codes	T-1	T-2	T-3	T-4	T-5	T-6
Second trophic level	-	√	√	-	-	-
Third trophic level	√	-	-	√	√	-
Fourth trophic level	-	√	-	-	-	√

When the findings in Table 7 were examined, the teacher candidates participating in the study stated that generally humans are at the third trophic level in a terrestrial food chain. Sample opinions of pre-service science teachers are given below:

T-1: Human is located at the third trophic level of the food chain.

T-2: Third in general, but it can be at second or third.

T-5: Third. Because there are parsers at the fourth level.

In the study, the sources of information about the trophic levels of humans in a terrestrial food chain were determined. The findings obtained are given in Table 8.

Table 8. *Findings about the information sources of the human trophic level*

Codes	T-1	T-2	T-3	T-4	T-5	T-6
Teachers	√	√	-	-	-	√
Textbooks	-	-	√	√	√	-

When the findings in Table 8 were examined, pre-service science teachers stated that their opinions about the trophic level of humans in a terrestrial food chain stemmed from teachers and textbooks. Sample opinions of pre-service science teachers are given below:

T-2: Often in schools, teachers wrote human in the chain while using the food chain or web terms (teacher).

T-3: In the food chain examples in textbooks, the human is the last consumer (textbooks).

T-4: Our knowledge comes from the examples in the textbooks (textbooks).

T-6: In both the food chain and the food pyramid drawn by the teachers, the human being was at the fourth level (teacher).

In the study, the awareness of pre-service science teachers about the concepts of food web and food chain was determined. The findings obtained are given in Table 9.

Table 9. *Awareness of food web and food chain concepts*

Codes	T-1	T-2	T-3	T-4	T-5	T-6
The same two concepts	√	√	√	-	√	√
Different two concepts	-	-	-	√		-

When the findings in Table 9 were examined, it was determined that pre-service science teachers thought food chain and food web as the same two concepts. However, a pre-service teacher who participated in the focus group interview stated that the concepts were different. Sample opinions of pre-service science teachers are given below:

T-1: Our teachers told that the food chain and food web are the same thing, there is no difference. Even they said not to be surprised if food web is written in some sources, they're the same.

T-2: I think they are the same concepts. Even I was asked to make a food chain or food web, I would do it the same way.

T-3: I learned that food chain and food web are the same concepts.

T-4: I remember the food web as the many food chains.

T-5: As far as I memorize they are the same concepts.

T-6: I use the food chain and food web as the same concept, I know them synonymously.

In the study, the sources of knowledge of pre-service science teachers about the concepts of food web and food chain were determined. The findings obtained are given in Table 10.

Table 10. *Information sources on food web and food chain concepts*

Codes	T-1	T-2	T-3	T-4	T-5	T-6
Teachers	√	√	-	-	√	√
Textbooks	-	-	√	√	-	-
Supplementary Book	√	√	-	-	-	√
Individual mistakes	√	√	√	√	√	√

When the findings in Table 10 were examined, it was determined that teachers, textbooks, test books and individual errors were effective in pre-service science teachers' thinking of food chain and food web as the same two concepts. Sample opinions of pre-service science teachers are given in Table 11:

Table 11. *Sample opinions of pre-service science teachers*

Themes	Sample Opinions
Teachers	*T-1: Our teachers did not teach us that the concepts are different.* *T-2: The differences are not explained.* *T-5: Teachers do not follow up-to-date information. For this reason, they did not tell us the differences between the concepts.* *T-6: No one was even aware of this because the teachers told us that they thought it was true. As aresult, the teacher was not even aware of the need to correct himself.*
Texbooks	*T-3: These concepts are expressed as they are the same in textbooks. In addition, the preparation of information in textbooks by heart causes us to learn concepts incorrectly.* *T4: The resource textbooks including the incorrect information and their not being checked causes us to learn incorrectly.*
Test books (Supplementary book)	*T-1: We reinforced our misinformation with the questions in the test books.* *T-2: We did not pay attention to these expressions in the test books we solved while preparing for the university exam.* *T-6: We considered every information in the test books to be correct.*
Individual errors	*T-1: As a student, we are content with only the information provided by the teacher, we do not check this information from scientific sources and investigate whether it is correct.* *T-2: We are also wrong. We believe that whatever information is given is the correct. We do not do any research.* *T-3: We do not have the habit of reading from scientific sources.* *T-4: We take everything teachers say to be true.* *T-5: As students, we do not investigate whether a piece of information is scientifically correct or not.* *T-6: We don't feel the need to learn with the thought that the teacher would tell us this if it was important.*

4. Discussion and Results

In this study, it was aimed to determine the learning of pre-service science teachers about food web. In order to determine the learning about the food web, pre-service science teachers were asked to draw a food web including human. When the findings of the research were examined, it was determined that the pre-service science teachers did not draw the food web including the human scientifically correctly. In addition, it was observed that pre-service science teachers misprinted the nutritional relationships of living things and the directions of the arrows showing this relationship. This may be explained with the reason that pre-service science teachers have misconceptions and misleading's about food web. The complex and cyclical relationship of the food web showing nutritional relationships between living things cannot be understood by students (Hogan, 2000). This situation causes misconceptions of the students. When the literature on the subject was examined, it was determined that there were studies showing similarities with the findings of the study. For example, Sander, Jelemenská, and Kattmann (2006) determined their misconceptions about students' community and ecosystem being the same concepts. In the study conducted by Yücel and Özkan (2015), it was determined that middle school 7th grade students had misconceptions about ecosystem-related concepts. In addition, as a result of the research, it was found that very few students were able to draw a complete food chain (Yücel & Özkan, 2015). As a result of the research conducted by Butler, Mooney Simmie, and O'Grady (2015), it was determined that biology teacher candidates and students in Ireland have unacceptable misconceptions about ecological concepts. Moreover, when the literature was examined, it was found that there were studies in which students misinterpreted the food chain and the energy flow between living things (Butler et al., 2015; Johnson & Činčera, 2019; Rizaki & Kokkotas, 2013). According to Putri and Rusti (2021), students believe that changes in the population of the food web do not directly affect population levels of any other food web organism. These results support the findings of the study.

In the study, it was determined that pre-service science teachers drew food chain and food pyramid instead of food web. As a matter of fact, as a result of the focus group discussion, pre-service science teachers stated that the concepts of food web and food chain are the same. According to the research findings, it can be said that pre-service science teachers have confusion about the concept of food web. When the literature on the subject is examined, it is seen that there are studies supporting the findings of the research. For example; As a result of their research, Ürey et al. (2011) found that pre-service teachers think that the concepts of food chain and food web are the same. In the research conducted by Yilmaz, Üçüncü, Karakaya and Çimen (2019), it was determined that the awareness level of science teachers regarding the concept of food chain is not sufficient. Adıgüzel and Yılmaz (2020), on the other hand, stated that pre-service teachers have conceptual confusion regarding biology concepts. According to Karakaya, Yilmaz, Çimen and Adigüzel (2020b), the true conception of terms of biology is of crucial importance for both education and personal development of individuals. These results support the findings of the study.

Within the scope of the study, the sources of misconceptions, confusion and misleading of pre-service science teachers about food web were examined. Research findings showed that the misconceptions, confusion and misleading of pre-service science teachers about food web were caused by teachers, textbooks, supplementary books and individual errors. Misconceptions may be due to the many different reasons (van den Broek & Kendeou, 2008). Teachers and textbooks are some of the sources that create and spread misconceptions of students (Butler et al., 2015). Transferring wrong information to students in the education process creates a snowball effect. Supplementary books prepared for central exams and insufficient in terms of scientific content cause both the formation of misconceptions and the

persistence of existing errors of students. In the research conducted by Manolas and Filho (2011), it was emphasized that memorizing the concepts leads to misunderstandings. It can be said that the nature of the science of biology and the fact that it includes different concepts, memorizing the concepts will cause mistakes. According to Yates and Marek (2014), teachers who have misconceptions convey their misconceptions to their students. Teachers who have great responsibilities in the education and training process are not sufficient in identifying and eliminating misconceptions (McComas, 2005), causing students' misconceptions to be permanent. In the research conducted by Kabapınar (2007), it was determined that there are misconceptions of students from primary education to undergraduate level and that the education and textbooks taken before undergraduate education are effective factors in the occurrence of this situation. Yılmaz et al. (2018) determined in their research that there are scientific errors about the food web in the 8th grade textbooks. Errors in textbooks cause misconceptions in both students and teachers (Karakaya et al.2020a; Yılmaz et al., 2017). These results support the findings of the study.

As a result, the research has shown that pre-service science teachers have misconceptions, confusion and misleading learning about the food web. It is recommended to carry out studies to solve this situation. In-service trainings can be given by science experts to overcome the misconceptions of science teacher candidates about food web. In addition, it can be ensured that textbooks and supplementary textbooks are prepared by scientists who are experts in their fields in a way that is appropriate for student levels, easily understandable and does not cause misconceptions.

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