European Journal of Education Studies
ISSN: 2501 - 1111
ISSN-L: 2501 - 1111
Available online at: www.oapub.org/edu

DOI: 10.46827/ejes.v11i11.5662 Volume 11 | Issue 11 | 2024

IDENTIFICATION OF 8TH GRADE STUDENTS' COGNITIVE STRUCTURES RELATED TO THE CONCEPTS OF BIODIVERSITY, SPECIES AND ECOSYSTEM[i]

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Abstract:
Human beings have tried to investigate, explore, and define the environment they live in since the moment they came into existence. Humans have utilized these creatures to discover answers to their changing requirements and to further their own interests by acknowledging their surroundings, adapting their way of life to suit them, and integrating them into their daily existence. Biodiversity is a quite broad concept that covers all living things in the environment we live in. This study aims to reveal the conceptual schemas existing in the cognitive structures of 8th grade students in order to determine their conceptual knowledge levels related to the subject of biodiversity. The study sample consisted of 286 students studying in the 8th grade in the 2022-2023 academic year. The research is a qualitative study conducted using the survey model. "Word Association Test (WAT)" was used as a data collection tool.

Keywords: science education, students, biodiversity education, cognitive structures, conceptual knowledge level, word association test

[i] This article was produced from a master's thesis titled "Conceptual Knowledge Levels of 8th Grade Students About Biodiversity".
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1. Introduction

The universe we live in has gone through various processes, adding a new one every day to its 4.5 billion years of development and providing a suitable environment for the development of life (URL, 1). This diversity of living things, which left Pangea, a single mainland, 200 million years ago and dispersed to the continents, integrated with the current locations and climates of the continents and either adapted to them completely or disappeared due to various factors (Polat, 2017). Today's seven habitats were formed by the separation of the mainland Pangea due to various tectonic and plate movements and the drift of each part in different directions (Sakınç, 2022). The formation of these habitats lasted for centuries, and it is necessary to go back approximately 45 million years before the present day for it to take its current form (Kabaklı, 2017). This separation caused severe plate collisions with the movements of the continents in the opposite direction and their existing energies, and these collisions caused the emergence of elevations called mountains on the earth's surface along with earthquakes (Güçlü, 2021). Through these elevations and depressions, various habitats were formed, and in some regions, living things were displaced and moved towards more favorable conditions (Polat, 2017). The formation of different climates and vegetation has also contributed to the emergence of new species by developing living things adapted to life (Kabaklı, 2017). According to Charles Darwin, this vitality culminated in the emergence of multicellular organisms through the evolution of unicellular organisms, followed by the formation of primitive animals and plants, ultimately leading to the living communities that exist today. These living populations have produced new offspring by mating among their own species and have led to the formation of today's communities (Ateş, 2009).

1.1. What is Biodiversity?

Biodiversity is a quite broad concept that covers all living things in the environment we live in (Bastı, 2010). According to Article 2 of the Convention on Biological Diversity, biodiversity, which is referred to as living diversity and is equivalent to human life since the beginning of existence (Seven, 2020), is defined as "*the differentiation among living organisms in all resources, including, inter alia, terrestrial, marine, and other aquatic ecosystems and ecological complexes of which these ecosystems are a part, including diversity within and among species and ecosystem diversity*" (Convention on Biological Diversity, 1996).

Biodiversity consists of three parts; "Genetic Diversity", "Species Diversity" and "Ecosystem Diversity" (Biodiversity Monitoring and Assessment Report, 2012). There is also "Diversity of Ecological Events", which is referred to as the fourth part of the literature and connects these three parts (Sivri, Kalkan, and Oksay, 2008).

The duties of individuals come to the fore in order to maintain the existence of living species and to make our existing environment more livable (Yörek, 2006). This process needs to be addressed within the framework of education from an early age in order to develop social awareness, even if some institutions have undertaken this task as a duty (Demir & Yalçın, 2014). An analysis of the curricula reveals that basic information

about biodiversity education is included in the curricula starting from the preschool period, and the learning outcomes start with being aware of the environment (the Ministry of National Education, 2013).

1.2. The Aim of The Study

In this study, it was tried to reveal the conceptual schemas existing in the cognitive structures of 8th grade students in order to determine their conceptual knowledge levels about biodiversity, species, and ecosystems.

2. Material and Methods

2.1. Model of The Study

The research is a qualitative study conducted using the survey model. In the research, an existing situation was tried to be described in a realistic and holistic manner by analyzing documents as they exist.

2.2. Sample of The Study

This study was performed with 8th grade students studying in the 2022-2023 academic year. A total of 286 students,147 female and 139 male, who were studying in a district of Erzurum province, participated in the study.

2.3. Data Collection

In the study, a word association test (WAT) was used to determine the cognitive structures and schemas of 8th grade students about biodiversity, species, and ecosystems. In this way, it was tried to determine the relationships between the concepts in students' minds.

Various methods are used to determine the conceptual cognitive structures of individuals regarding a subject and whether a relationship is established between concepts. The word association test (WAT) is one of the oldest and most common methods. In word association, one or more stimulus words are given, and the students are asked to write concepts (words) related to the stimulus word in a short period of time (Atasoy, 2004).

In this study, biodiversity, species, and ecosystems were given as stimulus words. The terms “biodiversity,” “species,” and “ecosystem” were repeated five times in a row, and the students were asked to write the first five words that came to their minds for each concept within 30 seconds. Then, they were asked to make a sentence about these words. For this, students were given another 30 seconds.

2.4. Analysis of the Data

Content analysis and descriptive analysis methods were used to analyze the data. Analyzing the students' responses to the stimulus words in the word association test, categories were formed by considering the semantic relationship criteria and frequency

of use. Frequency tables were created in this direction. While creating the frequency tables, the condition that the words associated with the stimulus word were repeated at least twice was sought. The words in the frequency table were defined as subconcept categories. Then, related subconcepts were brought together to form metaconcept categories. Related literature was examined, and concept relationships were revealed while creating these categories.

Concept networks were also created by looking at the frequency tables prepared according to the students' responses to the KIT. The cut point (CP) technique was used in the preparation of concept networks. In this technique, the words with the highest and lowest frequency values among the answers given for the stimulus word in the word association test were taken into consideration, and the K.N. range was determined as 10. The concept network was started to be formed according to the highest frequency values. Then, K.N. was lowered by looking at the frequency values, and the same procedure was applied until all the words related to the stimulus word were revealed (Ercan, Taşdere, & Ercan, 2010). This technique has been used in many studies in the literature (Bahar et al., 1999; Ercan, Taşdere, & Ercan, 2010; Kurt & Ekici, 2013; Yüce & Önel, 2015; Tokcan & Yiter, 2017; Hakyoldaş, 2019; Çam, 2022).

3. Findings

Frequency tables and conceptual diagrams were created according to the data obtained from the concepts in the word association test.

3.1. Concepts Associated with Biodiversity

3.1.1. Frequency and Percentage Distributions of Concepts Associated with Biodiversity

As a result of the data analysis, a total of six metaconcept categories and twenty-four subconcept categories were identified for the concepts associated with biodiversity in the word association test. Table 1 presents the frequency and percentage distributions of the concepts in each category.

Table 1: Frequency and Percentage Distributions of Concepts Associated with the Concept of Biodiversity in the Word Association Test

Metaconcept	Concept	1st Word	2nd Word	3th Word	4th Word	5th Word	f	%	Total f	Total %
Biotic Element	Animal	41	40	17	9	5	112	7,8%	428	30%
	Human	21	9	15	10	5	60	4,19%		
	Plant	9	13	21	7	9	59	4,12%		
	Living being	31	15	3	5	1	55	3,84%		
	Bird	8	3	5	8	4	28	1,95%		
	Dog	7	8	5	3	1	24	1,67%		
	Tree	2	4	6	7	1	20	1,39%		
	Flower	4	8	1	2	3	18	1,25%		
	Cat	5	3	4	1	4	17	1,18%		
	Insect	2	2	3	1	-	8	0,55%		
	Fish	1	1	4	1	-	7	0,48%		
	Weed	-	-	-	4	2	6	0,41%		
	Terrestrial	2	-	2	2	-	6	0,41%		
	Mushroom	-	-	1	2	2	5	0,34%		
	Aquatic	-	2	1	-	-	3	0,20%		
Systematic	Species	8	6	3	2	1	**20**	1,39%	20	1,4%
Ecological Functionality	Variety	15	6	4	3	3	31	2,16%	31	2,2%
Habitat	Nature	7	7	3	2	4	23	1,60%	43	3%
	Environment	5	2	2	1	-	10	0,69%		
	Forest	2	1	3	1	1	8	0,55%		
	Ecosystem	2	-	-	-	-	2	0,13%		
Genetic Diversity	Variation	-	-	2	-	-	2	0,13%	2	0,1%
Protection/Awareness	Global Warming	1	1	-	-	-	2	0,13%	4	0,3%
	Garbage	-	-	-	-	2	2	0,13%		
Number of Words Associated with Biodiversity							528	37%	528	37%
Number of Words Not Associated with Biodiversity							902	63%		
Total Number of Words Expected to be Associated with Biodiversity							1430	100%		

The students participating in the study associated 24 different subconcepts related to biodiversity, whereas six metaconcepts were associated with these subconcepts. The metaconcept with the highest frequency among these concepts is the one related to the biotic element (f=428). In this category, participants emphasized the concepts of animal, human, plant, living creature, and bird. The first three concepts most frequently repeated by the participants within the metaconcept of the biotic elements are animal (f=112), human (f=60) and plant (f=59). These results revealed that students made direct associations with biodiversity, mostly between animals, plants, and humans. *The biotic element* includes all living beings that can be considered as microorganisms (Özügül, 2018). From this point of view, when the concepts in this category that the students associated with living things were examined, it was seen that all of them were included under the metaconcept of biotic elements. In line with the answers given by the students, it was found appropriate to combine these concepts as the meta concept of "*Biotic element*". Looking at the sentences that students associated with biodiversity, S63 gave the example of *"Biodiversity is related to living things."* Another student, *S84, gave the sentence "There is a variety of living things in biodiversity"*.

Considering the other most repeated category, it is seen that students associated biodiversity with the concept of living environment (f=43). Students emphasized the concepts of nature, environment, forest, and land-dwelling within the metaconcept of living environment. The first three concepts that the participants repeated the most were nature (f=23), environment (f=10) and forest (f=8). These results indicated that students directly associated biodiversity with nature, environment, and forest. *Environment* can be defined as the area where a living being must exist in order to continue its life (Akçay, 2006). A *Forest* is an endless sea of trees (Sevgi, 2013). The concept of ecosystem, a key concept, is also a concept that emerged in this category. *An ecosystem* hosts living things together with non-living elements and provides them with a suitable living environment (Şişman, 2016). When the concepts are examined, it can be considered appropriate to use "*Living Environment"* as a metaconcept since all concepts can be associated with the living environment. An analysis of the examples given by the students showed that *S67 established a connection between the environment and biodiversity by giving the example of "Our environment is important in biodiversity"*. At the same time, *S126 made the sentence "Biodiversity means the diversity of living things in the environment."* while S28 established the sentence *"There is not much biodiversity left in the environment." S145 "If biodiversity increases, nature will be smoother."* He made a connection between nature and biodiversity. When the third category with the highest frequency is examined, it is seen that biodiversity and ecological functionality (f=31) are associated. In this category, students only emphasized the concept of diversity (f=31). At the most basic level, *diversity* encompasses all choices and possibilities related to the characteristics and gene structure of a living group (URL 2). This result suggests that students established a direct relationship between biodiversity and the concept of diversity. An analysis of the concept shows that this concept can be associated with the metaconcept of ecological functionality since it is related to the functional part of biodiversity. Analyzing the examples given by

the students, it is seen that *S83 gave the example of "The abundance of living species such as animals, plants, etc. shows biodiversity"*, while S181 gave the sentence "*Intraspecies diversity"*. The fourth category is the metaconcept of systematic, which emphasizes the systematics of living things. Here, only the concept of species (f=20), which is one of the key concepts, emerged as a subconcept. *Systematic* is a scientific classification done in a methodical and systematic way (Yüce & Önel, 2015). *A species* is a living thing that comes from a common lineage and has the potential to continue its generation (Doğan, Özçelik, Dolu, & Erman, 2010). We can conclude that the students established a direct connection between the concepts, and it can be said that it can be associated with the metaconcept of systematic. An analysis of the sample sentences given by the students shows that *S2* said *"Some animals are about to become extinct"* while *S52* gave the example of *"There are many animal and plant species"*.

The fifth category is the metaconcept of conservation/awareness, which can be directly related to biodiversity. The subconcepts of garbage (f=2) and global warming (f=2) appear here. When the concepts are examined, it is seen that both concepts can be associated with the metaconcept of "*Conservation/Awareness"*. Analyzing the examples given by the students, it is seen that S13 said, *"Biodiversity is being destroyed", S45 gave the example of "Biodiversity is decreasing"*, *S53* said, *"We live in a place with a lot of biodiversity"* and *S69* said, *"Our country is rich in biodiversity"*. Based on the students' sentences, it can be interpreted that they have a consciousness of this issue.

The last category was the concept of variation associated with genetic diversity. Considering the frequency value of this concept, it is seen that it is variation (f=2). *Genetic diversity* refers to the diversity of genes in a particular living group (Polat, 2017). On the other hand, *variation* can be characterized as the differences that arise with the possibility of various genes coming together (Karakaya, 2020). An examination of the concept showed that it can be associated with the metaconcept of genetic diversity. Analyzing the examples given by the students, it is seen that *S196* made the sentence *"We should increase intraspecies diversity"* while *S146 formed the sentence "Biodiversity includes many variations."* Based on these, it can be interpreted that the answers given by the students are related to the metaconcept.

3.1.2. Schematic Concept Networks Formed by Students with the Concept of Biodiversity in Their Minds

Figure 1 illustrates the concept network created for the concept of biodiversity for cut point 112 and above.

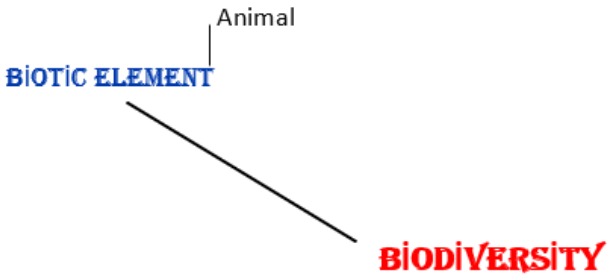

Figure 1: Concept Network Created for Cut Point 112 and Above

As can be seen in Figure 1, only the concept of animal (f=112), which is connected to the metaconcept of biotic element, emerged first. No other concept was formed at this stage.

Figure 2 illustrates the concept network formed for the concept of biodiversity for the cut point 52 and above.

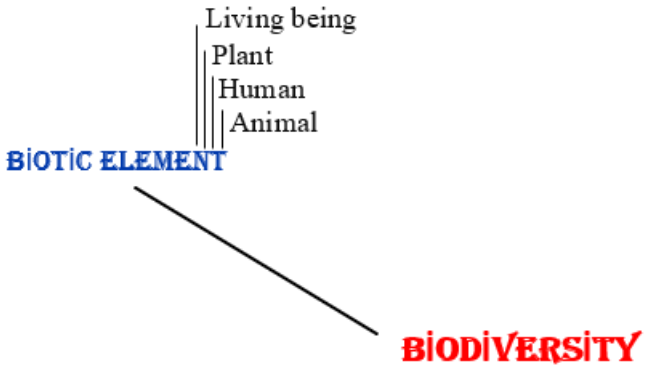

Figure 2: Concept Network Created for Cut Point 52 and Above

An examination of Figure 2 reveals that the concepts of human, living creature, and plant were formed under the metaconcept of biotic element. No other metaconcept or subconcept was formed at this stage.

Figure 3 presents the concept network formed for the concept of biodiversity for cut point 22 and above.

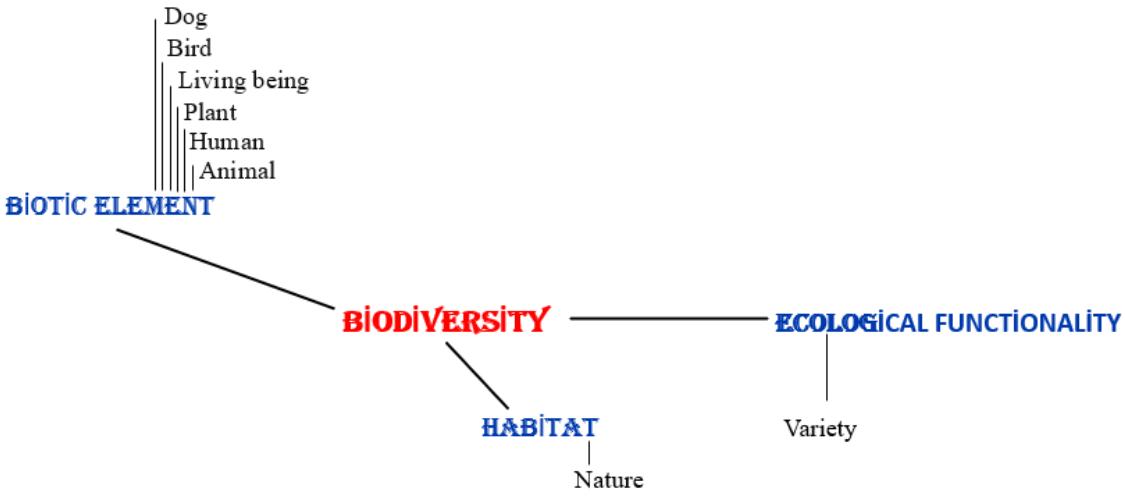

Figure 3: Concept Network Created for Cut Point 22 and Above

An examination of Figure 3 indicates that the metaconcepts of living environment and ecological functionality have emerged. Under these metaconcepts, nature and diversity subconcepts emerged. At the same time, it is seen that the subconcepts of bird and dog were formed under the metconcept of biotic element.

Figure 4 presents the concept network formed for the concept of biodiversity for the cut point 12 and above.

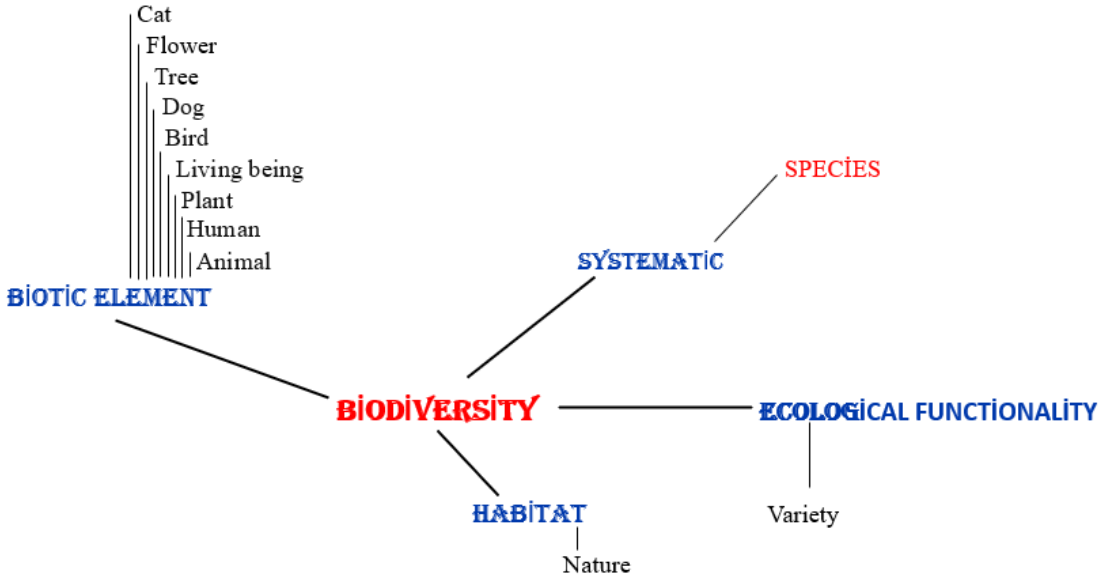

Figure 4: Concept Network Created for Cut Point 12 and Above

When Figure 4 is examined, it is seen that at this stage, the subconcepts of tree, flower and cat were formed under the metaconcept of the biotic element. In addition, the systematic metaconcept emerged, and the species key concept was formed as a subconcept. At this stage, it can be interpreted that students made a connection between the key concept of biodiversity and the key concept of species.

Figure 5 presents the concept network created for the concept of biodiversity for cut point 2 and above.

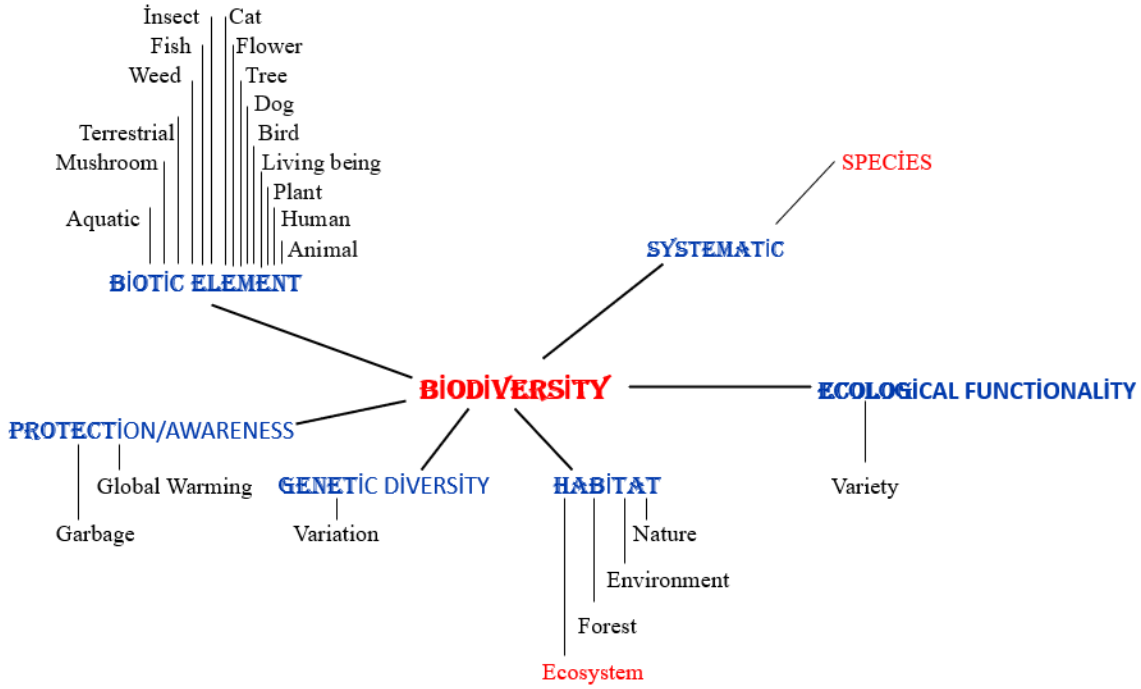

Figure 5: Concept Network Created for Cut Point 2 and Above

An examination of Figure 5 indicates that the key concept of ecosystem emerged as a subconcept under the metaconcept of living environment. At this stage, it can be interpreted that students established a connection between this key concept and other key concepts. The other metaconcepts that emerged were genetic diversity and conservation/awareness.

3.2. Concepts Associated with Species

3.2.1. Frequency and Percentage Distributions of Concepts Associated with Species

As a result of the data analysis, a total of ten metaconcept categories and thirty-one subconcept categories were formed for the concepts associated with species in the word association test. Table 2 presents the frequency and percentage distributions of the concepts in each category.

Table 2: Frequency and Percentage Distributions of Concepts Associated with the Concept of Species in the Word Association Test

Metaconcept	Concept	1st Word	2nd Word	3th Word	4th Word	5th Word	f	%	Total f	Total %
Biotic Element	Animal	65	23	22	12	3	125	8,74%	498	34,82%
	Plant	5	35	22	13	7	82	5,73%		
	Human	13	22	19	7	3	64	4,33%		
	Bird	16	15	8	6	5	50	3,49%		
	Living being	17	12	2	11	2	44	3,07%		
	Dog	8	7	6	6	1	28	1,95%		
	Cat	5	6	1	2	5	19	1,32%		
	Insect	3	2	2	3	3	13	0,89%		
	Tree	1	1	-	5	4	11	0,76%		
	Reptile	4	2	2	1	1	10	0,69%		
	Fish	3	2	5	-	-	10	0,69%		
	Lion	-	1	5	2	1	9	0,62%		
	Mammal	5	1	1	1	1	9	0,62%		
	Flower	4	4	1	-	-	9	0,62%		
	Wolf	-	1	5	-	-	6	0,62%		
	Fox	1	1	1	-	3	6	0,62%		
	Mushroom	-	-	2	-	1	3	0,20%		
Abiotic Element	Dead	1	-	1	-	1	3	0,20%	3	0,2%
Living Community	Generation	2	1	4	1	1	9	0,62%	12	0,82%
	Population	1	2	-	-	-	3	0,20%		
Systematic	Type	2	4	-	1	1	8	0,55%	8	0,55%
Life	Biodiversity	5	1	2	1	5	14	0,97%	16	1,1%
	Life	-	1	1	-	-	2	0,13%		
Ecological Functionality	Variety	40	9	4	5	4	62	4,33%	62	4,33%
Habitat	Environment	-	-	4	1	1	6	0,62%	9	0,82
	Nature	1	2	-	-	-	3	0,20%		
Genetic Diversity	Variation	-	3	-	-	-	3	0,20%	9	0,82
	Adaptation	-	-	1	1	-	2	0,13%		
	Crossbred	-	-	1	1	-	2	0,13%		
	Genotype	-	1	-	-	1	2	0,13%		
Protection/Awareness	Extinction	2	-	-	1	-	3	0,20%	3	0,20%
Number of Words Associated with Species							620	43,35%	620	43,35%
Number of Words Not Associated with Species							810	56,64%		
Total Number of Words Expected to be Associated with Species							1430	100%		

The students participating in the study associated 31 different concepts related to species. These associated concepts were categorized under nine metaconcepts. The metaconcept with the highest frequency among the associated concepts is the one related to the biotic element (f=498). In this category, participants emphasized the concepts of animal, plant, human, bird and living creature. The first three concepts most frequently repeated by the participants within the metaconcept of biotic element are animal (f=125), plant (f=82) and human (f=64). These results revealed that the students mostly made direct associations between species and animals, plants and humans. A *species* is a living thing that comes from a common lineage and produces fertile offspring when it mates (Demirayak, 2002). From this point of view, when the concepts in this category that students associated with species were examined, it was seen that all of them were living beings. In line with the answers given by the students, it was found appropriate to combine these concepts as the meta concept of "*Biotic element*". Analyzing the examples given by the students, it is seen that *S11 said, "There are many species of living things."*, *S63* said *"Living things have similar characteristics to each other."*, *S67* said *"There are more than a hundred animal species." S69 "Dogs have many species."*, *S81 "There are many species."*, *S102 "We are human species."* and *S202 "Woodpecker is a bird species."*

Analyzing the other most repeated category, it is seen that students associated species with the concept of ecological functionality (f=62). Students emphasized the concept of diversity (f=62) within the metaconcept of ecological functionality. These results indicated that students established a direct relationship between species and diversity. As ecological functionality can be associated with all living species when the concepts are examined, it can be considered appropriate to use it as the metaconcept of "*Ecological functionality*". Analyzing the examples given by the students, it is seen that *S4 "Intraspecies diversity has decreased a lot."*, *S10 "Animal species are very important for nature."*, *S85 "If intraspecies diversity decreases, life may become difficult." S99* gave the sentences *"Intraspecies diversity"* as examples.

An examination of the concept considered as the third category reveals that the metaconcept of life (f=16) emerged. When the concepts that emerged under this metaconcept are examined, it is seen that there are the concepts of biodiversity (f=14) and life (f=2). *Biodiversity* is the variety of living things that continue to exist in a place (Şahin, 2018). On the other hand, *life* can be expressed as the period between the birth of a living being and the loss of its vitality in the world (TDK, 2024). This metaconcept can be considered appropriate as biodiversity is included in life. Analyzing the examples given by the students, it is seen that S53 *"We live in a place with a lot of biodiversity."*, *S83 "There are many types of plants."*, S85 *"If intraspecies diversity decreases, life may become difficult."*, *S115* "*Anatolia is home to many species." S124 "There are many animal species in nature."*, *S159 "There are many species of animals in our country."* It is seen that the examples are related to biodiversity. In other words, the student made a connection between species, life and biodiversity.

The fourth category was associated with the living community (f=12) meta-category because it refers to living communities. In this category, students formed the

subconcepts of generation (f=9) and population (f=3). *Generation* refers to the human community that continues its existence in approximately the same periods (Karakaya, 2020). *Population* is the name given to the grouping of species that share a common habitat (Fıstıkeken, 2017). With the connections established by the students, it can be seen that it can be associated with the metaconcept of living community. Examining the examples given by the students, *S45 "He is a type of goat." S181 "A living community showing the same characteristics."*, *S185 "Humans are an omnivorous species."* On the basis of the examples, it can be interpreted that the students formed sentences about a community of living things.

An examination of the fifth category with the highest frequency shows that the living environment (f=9) metacategory was associated with the species. In this category, students emphasized the concepts of environment and nature. As there are two concepts that students repeated the most, these concepts are environment (f=6) and nature (f=3). *Environment* is the whole of systems that affect each other where there is life (Ateş, 2010). *Nature* is an area that emerges spontaneously and has a functioning within itself (TDK, 2024). This result indicates that students established a direct relationship between species and the concepts of environment and nature. When the concepts are examined, it is seen that these concepts can be associated with the metaconcept of "*Living Environment"* since they are related to the living environment. Analyzing the examples given by the students, it is seen that *S10 "Animal species are very important for nature."*, *S124 "There are many animal species in nature."*, S159 *"There are many species of living things around us."*, *S179* "*There is more than one species in our environment*." and *S197 "There are many species of living things in nature*." It is seen that the examples given can be associated with the ratio of life.

The sixth category is the metaconcept of genetic diversity, which is related to the genetic basis of living things. Here, the metaconcept of genetic diversity (f=9) was associated with the subconcepts of variation, adaptation, mutation, hybrid and genotype. The frequency values of the concepts were determined as variation (f=3), adaptation (f=2), hybrid (f=2) and genotype (f=2). While *genetic diversity* is expressed as intraspecies diversity, it can also be defined as the fact that the same living group contains different genes (Polat, 2017). *Variation* is the creation of new gene combinations by a living group for various reasons (Karakaya, 2020). *On the other hand*, adaptation is the potential of offspring from the same lineage to continue their generation by providing the best adaptation to living conditions (Ateş, 2009). *Mutation* is the hereditary change that occurs in the heredity material of the cell (Debeleç *et al.,* 2006). Genetic diversity was associated with the metaconcept of genetic diversity since the concepts that emerged when the concepts were examined were associated with the concept of genetic diversity. Analyzing the examples given by the students, it is seen that *S72 "Intraspecies diversity is variation."*, *S75 "Mutation is one of the events that increase intraspecies diversity."*, *S96 "Some mutations increase the diversity of living things."* can be associated with the concept of genetic diversity.

The seventh category is the metaconcept of systematic, which deals with the systematics of living things. Only the concept of genus (f=8) emerged here. A *genus* is a group of species that have common characteristics in terms of character (URL 3).

Analyzing the examples given by the students, it is seen that *S6 "There are different species of whales in the world"* and *S69 "There are many species of dogs"* are based on a genus.

In the eighth category, there is the concept of an abiotic element that can be associated with inanimate beings. Here, the metaconcept of the abiotic element (f=3) was associated only with the subconcept of inanimate (f=3). *Abiotic elements* include non-living elements in ecosystems (Özügül, 2018). From this point of view, it can be said that the metaconcept of abiotic element can be associated with the answers given by the students.

The ninth category is the metaconcept of conservation/awareness, which is related to the continuity of the extinction of living things. Here, it is seen that the concept of extinction (f=3) emerged under the concept of protection/awareness (f=3). *Extinction* is the disappearance of a creature that previously existed as a generation due to various reasons (URL 5). Analyzing the examples given by the students, it is seen that *S6 "Bald ibis are about to become extinct in our country."*, *S13 "Do not destroy different species of living things."*, *S96 "Living species are in danger."*, *S183 "We should protect species to protect the generation."*, *"Some animal species are disappearing."* It can be interpreted that the examples are related to extinction and that the students associate the concept of species with the continuity of generation.

3.2.2. Schematic Concept Networks Formed by Students with the Concept of Species in Their Minds

Figure 6 illustrates the concept network created for the concept of species for the cut-off point 122 and above.

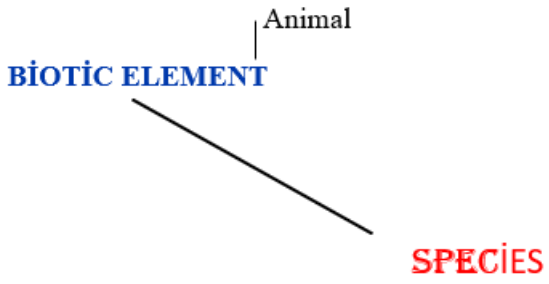

Figure 6: Concept Network Created for Breakpoint 122 and Above

When Figure 6. is examined, the concept network created for the concept of species started with the subconcept of animal (f=125), which has the highest frequency under the metaconcept of biotic element. No other concept emerged at this stage.

Figure 7 illustrates the concept network created for the concept of species at cut point 82 and above.

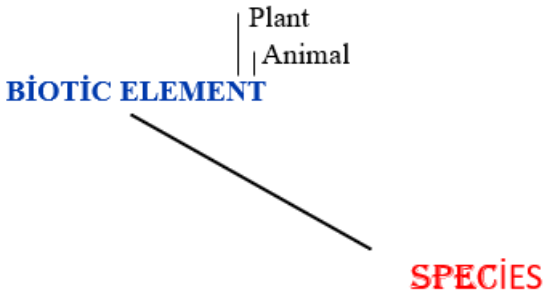

Figure 7: Concept Network Created for Cut Point 82 and Above

When Figure 7 is examined, no new metaconcept emerged, but the subconcept of plant (f=82) associated with the metaconcept of biotic element emerged.
Figure 8 illustrates the concept network created for the species concept for cut point 62 and above.

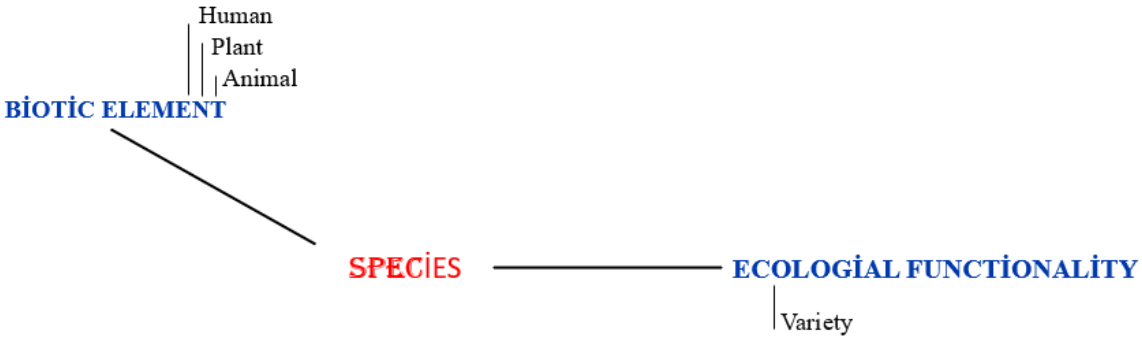

Figure 8: Concept Network Created for Cut Point 62 and Above

When Figure 8 is examined, it is seen that human (f=64) subconcepts emerged under the biotic element metaconcept of the species key concept. At the same time, the concept of diversity (f=62) emerged under the metaconcept of ecological functionality.
Figure 9. illustrates the concept network created for the species concept at cut-off point 42 and above.

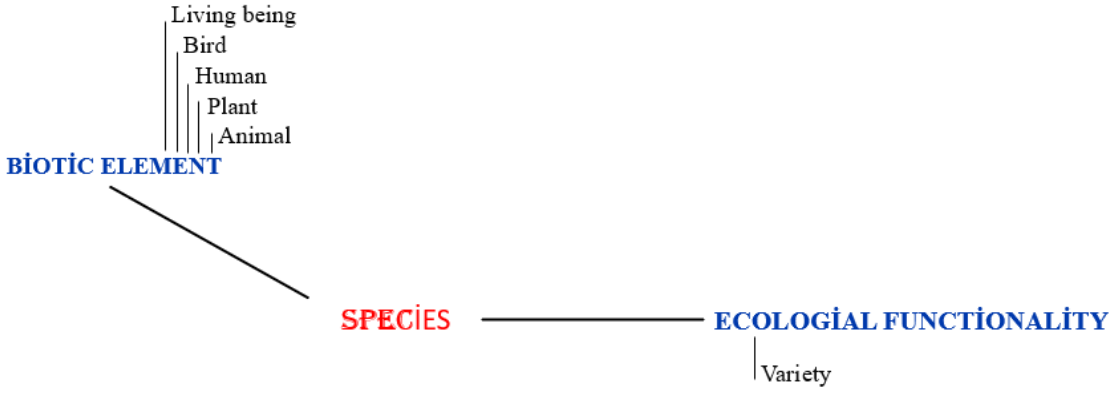

Figure 9: Concept Network Created for Cut Point 42 and Above

When Figure 9 is examined, it is seen that only the concepts of bird (f=50) and living thing (f=44) were formed under the metaconcept of the biotic element formed under the key concept of species.

Figure 10 illustrates the concept network formed for the species concept for the cut-off point 22 and above.

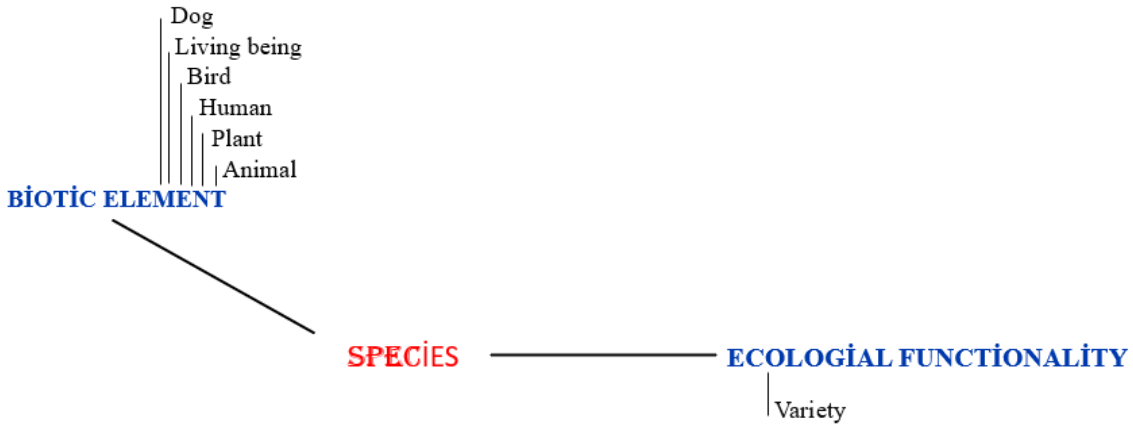

Figure 10: Concept Network Created for Cut Point 22 and Above

When Figure 10 is examined, it is seen that only the subconcept of dog (f=28) emerged under the metaconcept of biotic element at this stage.

Figure 11 illustrates the concept network created for the concept of biodiversity for cut point 12 and above.

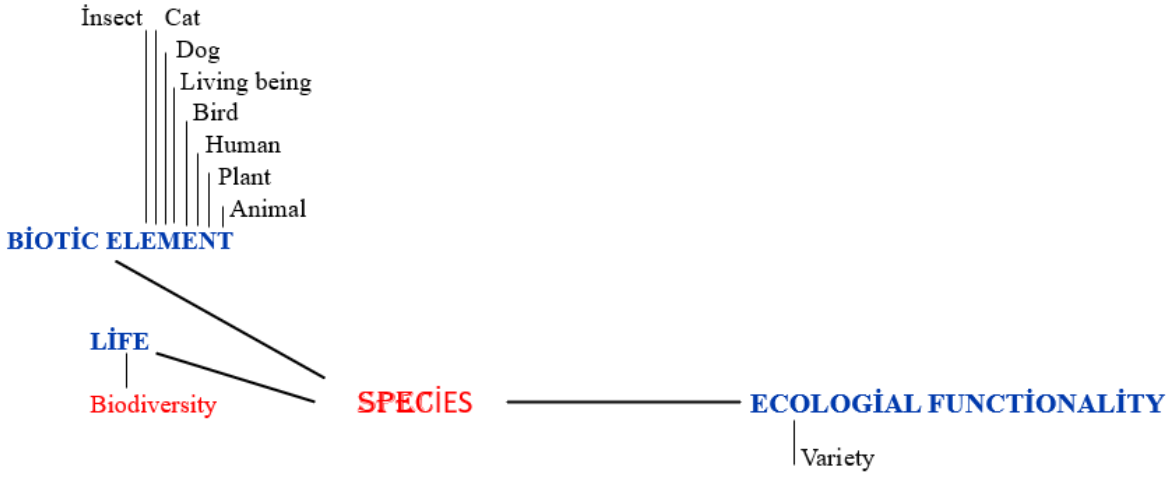

Figure 11: Concept Network Created for Cut Point 12 and Above

When Figure 11 is examined, the concepts of cat (f=19) and insect (f=13) emerged under the metaconcept of biotic element, while the key concept of biodiversity (f=14) emerged as a metaconcept.

Figure 12 illustrates the concept network created for the concept of species for breakpoint 2 and above.

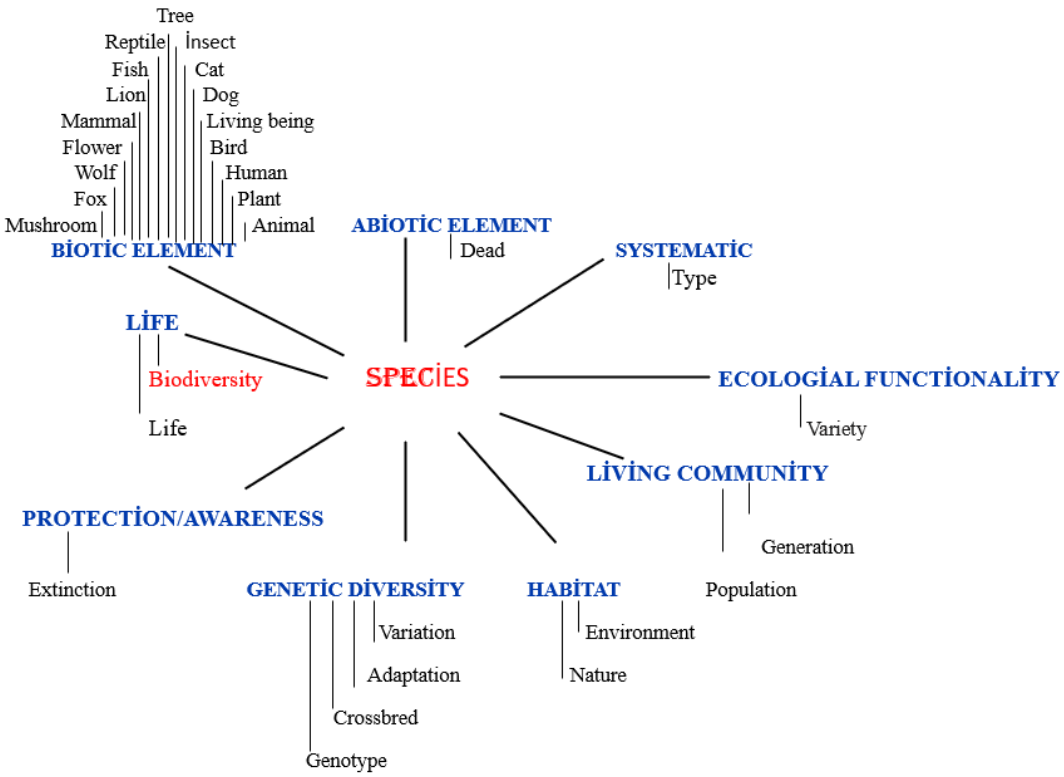

Figure 12: Concept Network Created for Cut Point 2 and Above

Figure 12 illustrates that nine metaconcepts emerged under the key concept of species. These metaconcepts are biotic element (f=498), ecological functionality (f=62), life (f=16), living community (f=12), habitat (f=9), genetic diversity (f=9), systematic (f=8), abiotic element (f=3). When the subconcepts under these concepts are analyzed, it can be interpreted that the students established a connection between the main concept and the key concepts.

3.3. Concepts Associated with Ecosystem

3.3.1. Frequency and Percentage Distributions of Concepts Associated with Ecosystem

As a result of the data analysis, a total of seven metaconcept categories and thirty subconcept categories were formed for the concepts associated with the ecosystem in the word association test. Table 3 illustrates the frequency and percentage distributions of the concepts in each category.

Table 3: Frequency and Percentage Distributions of Concepts Associated with the Concept of Ecosystem in the Word Association Test

Metaconcept	Concept	1st Word	2nd Word	3th Word	4th Word	5th Word	F	%	Total f	Total %
Biotic Element	Living being	23	4	12	5	1	45	3,14%	131	9,11%
	Animal	12	9	6	6	3	36	2,51%		
	Plant	3	6	4	3	4	20	1,39%		
	Human	4	5	3	3	1	16	1,11%		
	Bird	2	2	3	2	-	9	0,62%		
	Tree	2	-	-	2	1	5	0,34%		
Abiotic Element	Soil	12	2	3	2	2	21	1,46%	78	5,4%
	Dead	1	14	2	2	2	21	1,46%		
	Air	5	3	4	4	1	17	1,18%		
	Water	2	6	3	1	2	14	0,97%		
	Fossil	1	1	1	-	-	3	0,20%		
	Climate	-	-	2	-	-	2	0,13%		
Living Community	Population	-	1	-	-	1	2	0,13%	2	0,13%
Life	Life	-	1	2	2	-	5	0,34%	5	0,34%
Ecological Functionality	Process	3	1	1	-	1	6	0,41%	15	1,01%
	Interaction	1	-	2	1	-	4	0,27%		
	Balance	2	1	-	-	-	3	0,20%		
	Immigration	1	-	1	-	-	2	0,13%		
Habitat	Environment	10	6	8	3	-	27	1,88%	99	7,11%
	Nature	10	4	2	4	2	22	1,53%		
	Living area	6	5	1	2	6	18	1,25%		
	Forest	5	2	3	1	4	15	1,04%		
	Desert	3	2	-	1	-	6	0,41%		
	World	2	-	-	1	-	3	0,20%		
	Mountain	1	-	2	-	-	3	0,20%		
	Lake	-	-	1	2	-	3	0,20%		
	Sea	2	-	-	-	-	2	0,13%		
Protection/Awareness	Pollution	3	-	1	-	1	5	0,34%	5	0,35%
	Global Warming	-	-	-	-	2	2	0,13%	2	0,13%
	Sensitivity	-	-	-	2	-	2	0,13%	2	0,13%
Number of Words Associated with the Ecosystem							339	23,71%	339	23,71%
Number of Words Not Associated with the Ecosystem							1091	76,29%		
Total Number of Words Expected to be Associated with the Ecosystem							1430	100%		

The students participating in the study associated 30 different concepts related to ecosystem. The metaconcept with the highest frequency among the associated concepts is the one related to the biotic element (f=131). In this category, participants emphasized the concepts of living things, animals, plants and humans. The first three concepts most frequently repeated by the participants within the metaconcept of biotic element are living organism (f=45), animal (f=36) and plant (f=20). These results revealed that the students established a direct relationship between ecosystems and living organisms, animals, and plants the most. The elements that makeup ecosystems consist of living and non-living elements. *Biotic elements* may be regarded as humans, plants, animals and microorganisms. In other words, all living beings (Özügül, 2018). Accordingly, an examination of the concepts in this category that the students associated with the ecosystem showed that all of them can be associated. The responses of the students suggest that these concepts can be combined as the metaconcept of *biotic element*. *S6 "Living and non-living things in the universe are intertwined."*, *S77 "One of the living things suitable for the desert ecosystem is camels."*, *S85 "Producers are important in the ecosystem." S86 "The interaction of living and non-living things is called ecosystem." S181 "Everything in the ecosystem is intertwined."* An analysis of the students' examples shows that they associate with biotic elements.

Regarding the other most repeated category, it is seen that students associated ecosystem with the concept of living environment (f=99). Within the living environment metaconcept, students emphasized the concepts of nature, environment, habitat and forest. The first three concepts that the participants repeated the most were environment (f=27), nature (f=22) and habitat (f=18). These results indicated that students established a direct relationship between ecosystem and nature, environment and habitat. *Environment* can be expressed as the area in which living things continue their existence and affect each other (Karaca, 2007). Meanwhile, *nature* includes entities that constantly develop and change around their own rules (TLA, 2024). Analyzing the concepts, it can be considered appropriate to use habitat as a metaconcept since all concepts can be associated with habitat.

When the other most repeated category is analyzed, it is seen that students associate ecosystem with abiotic elements (f=78). Within the metaconcept of abiotic elements, students emphasized the concepts of soil, inanimate, air, water and climate. The first three concepts that the participants repeated the most were inanimate (f=21), soil (f=21) and air (f=17). These results suggest that students established a direct relationship between ecosystem and the concepts of soil, non-living and air. *Abiotic element* refers to non-living elements that are part of ecosystems, such as soil (geology, physical structure, etc.), climate (heat, light, humidity, air) (Özügül, 2018). Considering the concepts, it can be considered appropriate to use abiotic element as a metaconcept since all of them can be associated with the abiotic element part of the ecosystem. An analysis of the examples given by the students reveals that *S145* gave the example of *"Ecosystem is the place where living and non-living things are"*, and *S124* gave the example of *"Ecosystem covers everything"*.

The fourth category is the concepts emphasising the functionality of the ecosystem (f=15). Here, students emphasized the concepts of interaction, process, migration and balance. The most frequently repeated concepts under the name of ecological functionality are process (f=6), interaction (f=4), balance (f=3) and migration (f=2). *Ecological balance* can be explained as the way of preserving the existing organised state of species with the interaction of species with other species and their environment (URL 4). Considering the concepts, it can be said that since all of them can be associated with the functionality part, it can be used as a metaconcept of functionality. Analysing the examples given by the students, *S45 "The ecosystem is in a cycle.", S83 "Producer, herbivorous, carnivorous, omnivorous organisms are in balance in the ecosystem.", S86 "The interaction of living and non-living things is called ecosystem."*

The fifth category is associated with protection/awareness (f=9), which emphasizes the continuity of the ecosystem. Within the metaconcept of protection/awareness, students emphasized the concepts of pollution, global warming and sensitivity. Under the metaconcept of protection/awareness, the most repeated concepts are pollution (f=5), global warming (f=2) and sensitivity (f=2). *Pollution* is the release of solid, liquid and gas wastes into the environment with the consumption of resources (Yazgan, 2010). *Global warming,* on the other hand, is the increase in the temperature of the world as a result of the gases released into the atmosphere as a result of human activity (Hekimoğlu & Altındeğer, 2008). Considering the concepts, protection/awareness can be used as a metaconcept of protection/awareness since all of them can be associated with protection/awareness. An analysis of the sample sentences given by the students shows that *S13, "The ecosystem should not be destroyed.", S53 "Our ecosystem is deteriorating.", S63 'The ecosystem is important.", S77 "Ecosystems are deteriorating day by day.", S179 'Protect the ecosystem."* and *S198 "We should protect our ecosystem."*

The sixth category is the metaconcept of life (f=5), associated with the ecosystem and expressing the process of life. *Life* can be defined as the adventure of life that takes place between the emergence of a living being and the end of this life (URL 6). For this reason, the concept of life can be used as one of the ecosystem metaconcepts.

The last category is another concept related to the ecosystem, which refers to living groups. This metaconcept, which was handled as the living community (f=2) metaconcept, was associated with the subconcept of the population (f=2). *Population* can be expressed as the living organisms from the same lineage living in a region as a community (Doğan, Özçelik, Dolu, & Erman, 2010). Therefore, the resulting concepts can be associated with the metaconcept of a living community.

3.3.2. Schematic Concept Networks Formed by Students with the Concept of Ecosystem in Their Minds

Figure 13 illustrates the concept network created for the concept of ecosystem for cut point 42 and above.

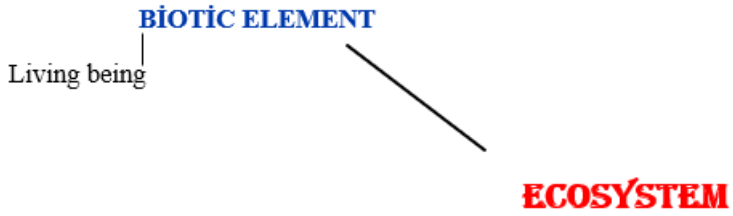

Figure 13: Concept Network Created for Cut Point 42 and Above

Figure 13, the first metaconcept formed under the key concept of the ecosystem was the metaconcept of biotic element, while the first concept produced from this concept was the subconcept of living organisms (f=45). No other concept was formed at this stage.

Figure 14 illustrates the concept network formed for the ecosystem concept for the cut-off point 32 and above.

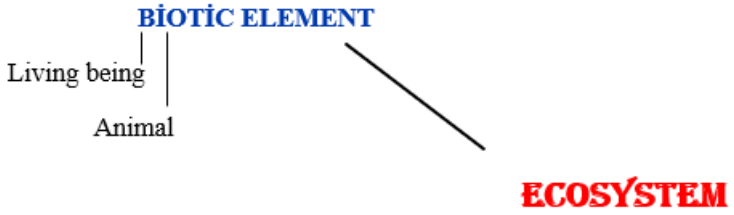

Figure 14: Concept Network Created for Cut Point 32 and Above

An analysis of Figure 14 shows that at this stage, only the concept of animal (f=36) emerged under the metaconcept of biotic element.

Figure 15 illustrates the concept network created for the concept of ecosystem for cut point 22 and above.

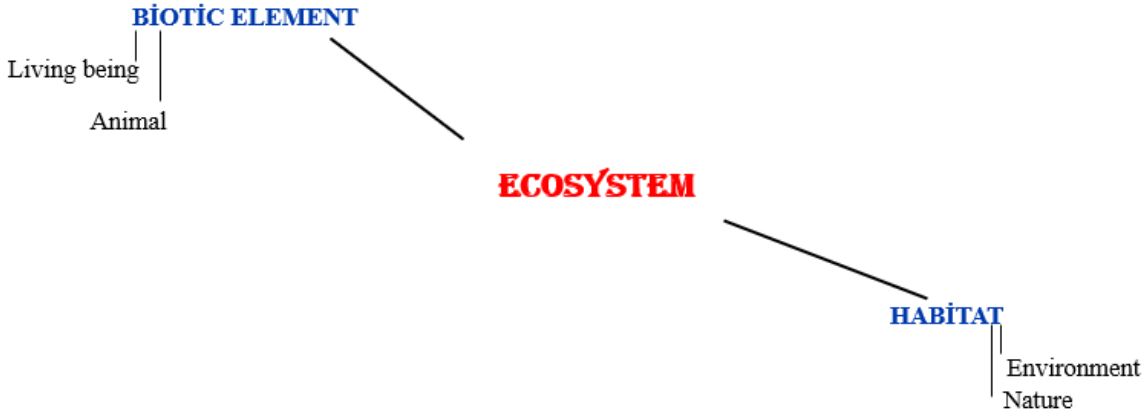

Figure 15: Concept Network Created for Cut Point 22 and Above

An analysis of Figure 15 shows that the metaconcept of living environment emerged. It is seen that the subconcepts of environment (f=27) and nature (f=22) related to this metaconcept were formed by the students.

Figure 16 illustrates the concept network created for the concept of ecosystem for cut point 12 and above.

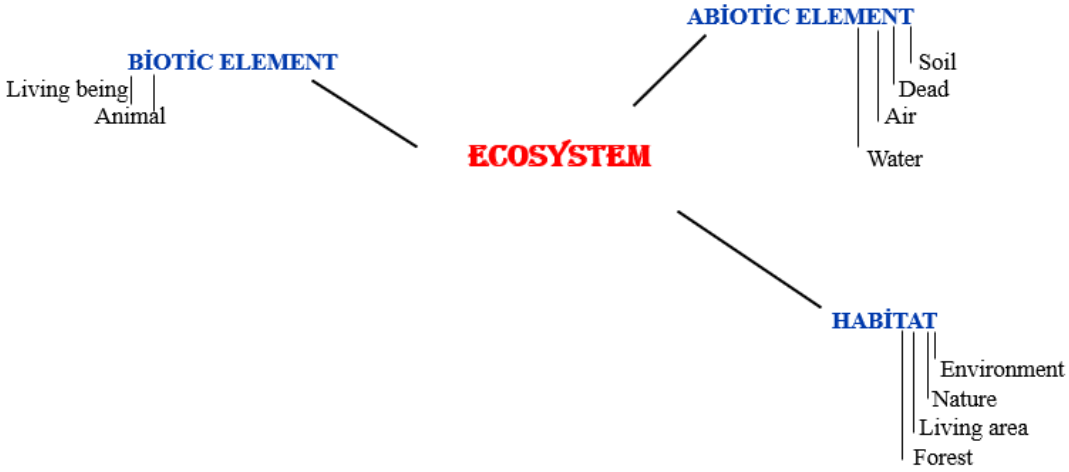

Figure 16: Concept Network Created for Cut Point 12 and Above

An analysis of Figure 16 shows that the subconcepts that emerged under the metaconcept of habitat are habitat (f=18) and forest (f=15). Besides these, the subconcepts of soil (f=21), inanimate (f=21), air (f=17) and water (f=14) that can be associated with the abiotic elements metaconcept emerged.

Figure 17 illustrates the concept network created for the concept of ecosystem for cut point 2 and above.

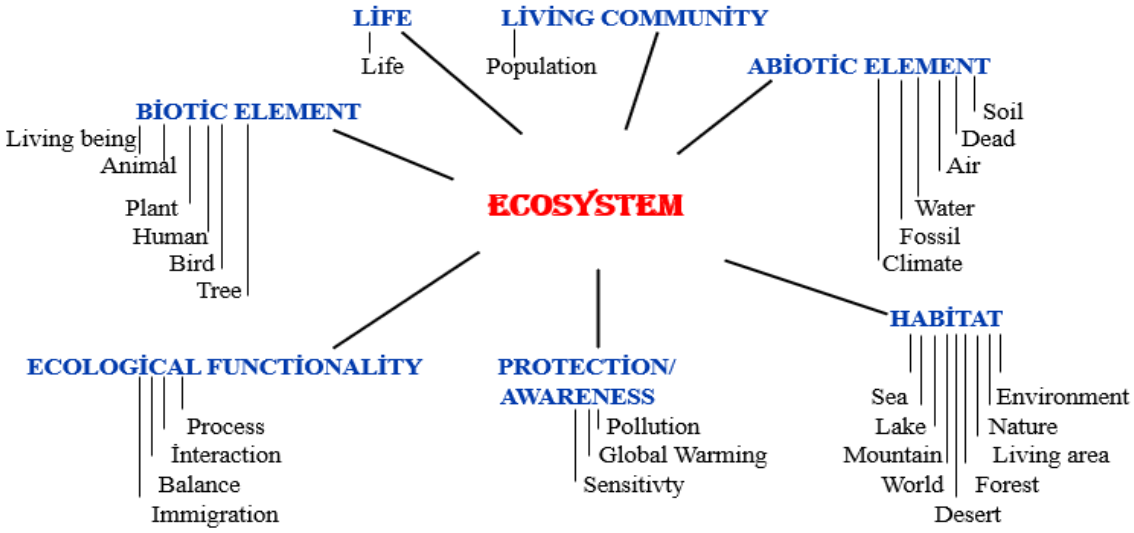

Figure 17: Concept Network Created for Cut Point 2 and Above

An analysis of Figure 17 reveals that seven metaconcepts belonging to the key concept of ecosystem emerged. These concepts consist of biotic element (f=131), living environment (f=99), abiotic element (f=78), ecological functionality (f=15), protection/awareness (f=9), life (f=5) and living community (f=2). From this point of view, it is seen that a meaningful connection was established between subconcepts and metaconcepts.

4. Results and Discussion

In this study, it was tried to reveal the conceptual schemas existing in the cognitive structures of 8th grade students in order to determine their conceptual knowledge levels about biodiversity, species, and ecosystem. For this purpose, a word association test was used, and the data obtained were analyzed.

The first key concept in the word association test is the concept of "biodiversity". Students formed 24 different subconcepts for the key concept of biodiversity. Biodiversity is the whole of genes formed by all ecosystems and living species in a place (Önel, 2022). The total number of subconcepts produced for this concept was (f=528), which corresponds to 37% proportionally. The responses of the students suggested that the concept of biodiversity was associated with the concept of biotic elements by 30% (f=428) and with the concept of living environment by 3% (f=43). The main concept of ecosystem was written by the students as a subconcept under the living environment metaconcept and took its place in this category. At the same time, the key concept of species was also one of the concepts formed under the systematic metaconcept. From this point of view, it is seen that students established a connection between the concept of biodiversity and the concepts of species and ecosystem. It can be interpreted that a connection was established from the sample sentences written by the students, such as *S67 "Our environment is important in biodiversity." S126 "Biodiversity means the variety of living things in the environment"*, S52 "There are many plant and animal species." In a similar study, it was interpreted that they associated biodiversity with concepts such as animal, tree, plant, flower, human, sun, cell, and some of them were correctly associated (Çam, 2022). Students created 31 different subconcepts for the key concept "species". It is seen that 498 (34.82%) of 620 (43.35%) concepts associated with the key concept of species are related to biotic elements, and 62 (4.33%) concepts emphasize the ecological functionality of the concept of species. Species refers to a living community that has common characteristics, descends from a common ancestor and can produce fertile offspring (Önel, 2022). At the same time, the key concept of biodiversity appears here as a metaconcept. When the examples given by the students are analyzed, it is seen that *S11 "There are many species of living things.", S63 "Living things have similar characteristics to each other.", S10 "Animal species are very important for nature.", S115 "Anatolia is home to many species."* From this point of view, it can be said that the schemes formed by the students about the concept of species are correctly associated. Çam (2022) commented that according to the answers given by the students in the word association test, the concepts of animal, film type,

human, vegetable, fruit, living creature, and plant were associated and that some of them had strong and some of them had weak relationships.

For another key concept, "Ecosystem", students created 30 subconcepts. The total number of subconcepts produced for this concept was (f=339), which corresponds to 23.71% proportionally. When the ratios of the metaconcepts were analyzed, 9.11% (f=131) were associated with biotic elements, 6.31% (f=91) with the living environment, and 5.4% (f=78) with abiotic elements. Ecosystem is defined as all living and non-living things in a place and all the processes involving their interaction (Önel, 2022). An analysis of the examples given by the students revealed that *S6 "Living and non-living things in the universe are intertwined.", S181 "Everything in the ecosystem is intertwined.", S145 "Ecosystem is the place where living and non-living things are.", S124 "Ecosystem covers everything."* In this respect, it can be said that the relationship established by the students is correct. In his study, Çam (2022) commented that the students associated with concepts such as system, animal, economy, air, air, living, water, plant, environment, saving, and numerical content course, and therefore some of them were correct.

In the word association test, students formed many metaconcepts and subconcepts for each key concept. Concept networks were created according to frequencies. When the subconcepts under each key concept were examined, it was seen that some of these concepts were also key concepts in the word association test. In other words, it can be said that students established meaningful connections between concepts. However, when we look at the rate at which the students participating in the study associate the concepts of biodiversity, species and ecosystem with other words, it is seen that these are insufficient. Students were able to associate the concepts of biodiversity with other words at a rate of 37%, species at a rate of 43.35% and ecosystem at a rate of 23.71%. This shows that students cannot yet adequately associate the concepts of biodiversity, species and ecosystem with other concepts in their mental structures and cannot create big schemas related to these concepts.

5. Suggestions

This study was conducted as an indicator of the ability of 8th grade students in Türkiye to cognitively structure the concepts of biodiversity, species and ecosystem and to associate them with different concepts, and to contribute to the literature. In order to contribute to the literature, these concepts and different concepts of ecology need to be examined in different universes and samples. Because we need to create and impart conceptual relationships on this subject at an early age for individuals who know the environment they live in and respect ecology. After realizing these two situations, we will enable the individual to develop the correct concept on this subject.

Conflict of Interest Statement
The authors declare that they have no conflict of interest related to the study or preparation of the manuscript.

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