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Investigation of secondary school students' learning about the fungi kingdom

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ABSTRACT Considering both the ecological niches of fungi and the different benefits they provide to humans, it is expected that students have a high level of scientific knowledge about living things in this kingdom. In the study, it was aimed to examine the learning of secondary school students about living things in the fungi kingdom. The research, which was carried out as a case study, was carried out with 52 secondary school students studying in the Central Anatolia Region of Türkiye in the 2022-2023 academic years. In the research, it was determined that the students had misconceptions and lack of knowledge about the classification of living things in the fungi kingdom, their diet, ecological functions and their effects on human life. The students stated that fungi take place in the world of plants, feed by photosynthesis and are used in making yogurt. According to these results, it is recommended to conduct studies on textbooks, teaching methods and teachers that cause students' misconceptions about living things in the fungi kingdom.

Keywords: *Fungi, Misconceptions, Secondary school students*

Ortaöğretim öğrencilerinin mantarlar âlemine yönelik öğrenmelerinin incelenmesi

ÖZ Mantarlar aleminde bulunan canlıların gerek ekolojik nişleri gerekse insanlara sağlamış olduğu farklı yararları düşünüldüğünde, öğrencilerin bu alemdeki canlılara yönelik bilimsel bilgi düzeylerinin yüksek olması beklenmektedir. Araştırmada, ortaöğretim öğrencilerinin mantarlar âlemine yönelik öğrenmelerinin incelenmesi amaçlanmıştır. Durum çalışması olarak gerçekleştirilen araştırma, 2022-2023 yılında Türkiye'nin İç Anadolu Bölgesinde öğrenim gören 52 ortaöğretim öğrencisi ile gerçekleştirilmiştir. Veri toplanmasında açık uçlu soru formu kullanılmıştır. Araştırma sonucunda, ortaöğretim öğrencilerinin mantarlar alemindeki canlıların sınıflandırılması, beslenme şekli, ekolojik işlevleri ve insan yaşamına etkilerine yönelik kavram yanılgılarının ve bilgi eksikliklerinin olduğu belirlenmiştir. Öğrenciler, mantarların bitkiler âleminde yer aldığını, fotosentez yaparak beslendiğini ve yoğurt yapımında kullanıldıklarını ifade etmişlerdir. Bu sonuçlara göre, öğrencilerin mantarlar âleminde yer alan canlılara yönelik kavram yanılgılarının oluşuma neden olan ders kitapları, öğretim yöntemi ve öğretmenlere çalışmaların yapılması önerilmektedir.

Anahtar Sözcükler: *Kavram yanılgıları, Mantarlar, Ortaöğretim öğrencileri*

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INTRODUCTION

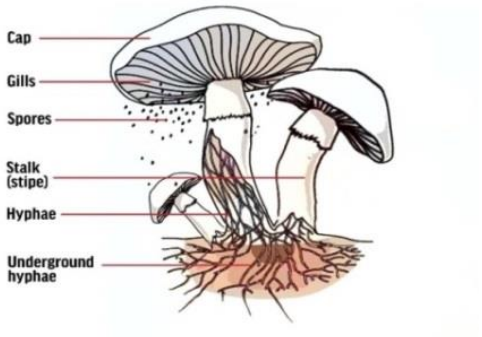
Fungi are extremely diverse in the world. The kingdom of fungi includes taxa ranging from microscopic unicellular yeasts, aquatic chytrids, macroscopic multicellular fungi to fungi in the structure of lichens. Estimates of worldwide species diversity are at least 2.2–3.8 million (Hawksworth & Lücking, 2017). However, the number of identified species is quite low (Baldrian et al., 2022). Fungi constitute the second most populous group of organisms on the earth's surface in terms of species, after the animal kingdom (Purvis & Hector, 2000). Living things in the fungal world transform the organic and inorganic materials that make up the ecosystem into forms that organisms can absorb. Apart from their ecological roles, people have been benefiting from living things in the fungi kingdom for centuries in different events. In addition, humans benefit from living things in the fungal kingdom in agriculture, forestry, health (antibiotic production), food production (bread making) and the production of different cheeses. Some fungi are also known to cause various diseases in plants and animals. Researches can identify the fungi (hat fungi, molds and yeasts) that people can observe more in their environment (Hawksworth & Lücking, 2017; Sadava et al., 2014; Simon et al., 2019; Taylor et al., 2018; Urry et al., 2021)

Theoretical Background

The fungi kingdom

Although fungi grow in abundance in forests and humid areas, they are very cosmopolitan creatures and can be found all over the world (Petersen, 2013). Most of the people see the living things in the kingdom of fungi as more related to the living things in the kingdom of plants. This is a misconception. The fact that studies on the fungi kingdom (mycology) were carried out by botanists was effective in the formation of this misconception (Karakaya et al., 2022). Scientists have stated that living things in the kingdom of fungi are like plants with their features such as being immobile and having cell walls, so they should be classified in the kingdom of plants. However, this classification is scientifically incorrect (Karakaya et al., 2022). Although living creatures in the kingdom of fungi have traits comparable to plants, they lack chlorophyll and hence cannot undergo photosynthesis. Since living things in the fungal kingdom do not contain chlorophyll, they do not show autotrophic properties. Therefore, they live as heterotrophs (Mader & Windelspecht, 2018; Simon et al., 2019). In addition, living things in the fungal kingdom are similar to animals in terms of chemoheterotrophic characteristics. However, they are not animals. The simplified structure of a mushroom is given in Figure 1.

Figure 1.
Simplified Structure of a Mushroom



Misconceptions in Biology Education

Biology is one of the important branches of science that is related to many disciplines in terms of content, subject and context. For this reason, it is very important to know the concepts related to biology correctly in terms of both the management of educational processes and the planning of scientific studies

(Karakaya & Yılmaz, 2021). However, biology is one of the disciplines in which students have a lot of misconceptions because it includes abstract and concrete concepts together (Galvin et al., 2015). Misconceptions are alternative concepts developed by individuals against concepts that have been explained and accepted by scientific sources (Çalgıcı & Duru, 2023). Misconceptions are defined as cognitive structures that affect students' understanding of scientific concepts and show resistance to change (Assimi et al., 2022). In other words, misconception is the misunderstanding of a concept agreed upon by scientists and experts and the creation of an alternative concept (Jung, 2020). Misconceptions affect the teaching process negatively. It prevents students from understanding the concepts (Jamaluddin et al., 2023), negatively affects their success (Karakaya et al., 2022) and causes the concepts to be memorized. In order to ensure permanent learning, misconceptions need to be understood, defined and analyzed together with their reasons using different methods (Simard, 2023; Thouin, 2020; Wind & Gale, 2015). Many studies have shown that misconceptions arise from students themselves, teachers, textbooks and teaching methods (Puspitasari et al., 2017; Yılmaz et al., 2017). In addition, it is stated that students can carry their misconceptions to the upper classes and transfer them to their professional life at a later level (Peker & Taş, 2020).

When the studies on misconceptions in biology education are examined, it has been shown that students have misconceptions about biological events and concepts such as classification of living things, cell structure, cell divisions, photosynthesis, sexual and asexual reproduction (Gul, 2021; Jung, 2020; Karakaya & Yılmaz, 2021; Machová & Ehler, 2023; Peker & Taş, 2020; Yen et al., 2007; Yılmaz et al., 2021). In the studies conducted by Yen et al. (2007), students' misconceptions about the fact that frogs are in the reptile class were identified. Özdemir and Çalışkan (2018), it was determined that students defined butterflies and bats as birds because they can fly. Peker and Taş (2020) discovered that 5th grade students have misconceptions about the taxonomy of living things. Studies have shown that students' misconceptions about biology concepts stem from textbooks containing scientifically erroneous information, teacher and student experiences, and teaching methods used (Adıgüzel & Yılmaz, 2020; Yates & Marek, 2014).

Figure 2.
The Product Aisle where Mushrooms are Sold

In Türkiye, fungi are known by people as a living group in the plant kingdom. As a matter of fact, on various platforms where people shop, mushrooms are located in the same aisles as plants (Figure 2). It has become critical for individuals to have scientific knowledge about living things, especially microorganisms, especially during and after the Covid-19 epidemic process (Simard, 2023). Yen et al., (2007) underlined that classification is one of the most important subjects of biology and stated that it is related to many disciplines such as evolution, ecology, anatomy and physiology. Considering both the ecological niches of living things in the fungi kingdom and the different benefits they provide to humans, students are expected to have a high awareness of these creatures. Until graduating from secondary education institutions in Türkiye, a student encounters academic knowledge about fungi during their education in the 5th grade of primary school and 9th grade of secondary education. In the Ministry of National Education Biology Curriculum (2018), there is the achievement of "Explains the

realms used in the classification of living things and the general characteristics of these realms" in the 9th grade. The description of this achievement is given below:

> *"The general characteristics of bacteria, archaea, protists, plants, fungi and animal kingdoms are explained and examples are given. It is not included in the classification of other realms other than the animal realm."*

Many concepts in science are complex for students to understand and cause misconceptions (Soeharto & Csapó, 2021). In order to eliminate misconceptions, it is necessary to know their nature and origin (Machová & Ehler, 2023). Identifying difficulties in understanding science concepts in science disciplines helps to improve students' learning outcomes (Park & Liu, 2021; Soeharto & Csapó, 2021). It is important to reveal the reasons for the misconceptions in order to understand how students pass from misconceptions to scientific knowledge and to help students overcome these misconceptions through conceptual change (Ferguson & Jensen, 2023). It is necessary to reveal their learning and misconceptions in order to achieve the achievements in the curriculum successfully and to raise the scientific awareness of the students about the creatures in the fungi kingdom. In addition, it is important for a sustainable environment for students to correctly interpret examples of the fungi kingdom (Karakaya et al., 2022). In the study, it was aimed to examine the learning of secondary school students about living things in the fungi kingdom. Classification of fungi, diet, ecological functions and effects on human life are focused on.

METHOD

Research Design

Case study, one of the qualitative research methods (Creswell, 2007), was used in the research. According to Aytaçlı (2012), case study provides a systematic examination of an event, analysis of data and in-depth interpretation of relevant results. The product resulting from the case study gives information about how/why the event originated and about the future processes (Gökçek, 2009). In this study, a case study was preferred in order to reveal in detail the secondary school students' learning (correct learning, misconception, lack of knowledge and lack of confidence/guessing based on luck) about living things in the fungi kingdom.

Participants

The research was conducted in the spring semester of the 2022-2023 academic year. The relevant period was chosen by taking into account the students' learning processes for this unit. The research was conducted with 52 secondary school students (27 female, 25 male) studying in the Central Anatolia Region of Türkiye. The students were included in the research on voluntary basis and convenience sampling method.

Data Collection Tool

Open-ended Question Form prepared by the researchers was used as a data collection tool. In the data collection tool, there are four different questions suitable for the purpose of the study. The prepared questions are in the form of three-stage misconception detection tests. For each question, the participant first expresses his/her answer and justification, and then expresses his/her certainty. Each question in the data collection tool was prepared in a three-stage (answer, justification and certainty) manner to examine the concepts of secondary school students about the organisms in the fungi kingdom from different perspectives (correct knowledge, misconception, lack of knowledge, lack of confidence or lucky guess). The validity of the form was ensured by taking the opinions of one faculty member working in biology education, two biology teachers and one science teacher.

Data Analysis

During the analysis of the data, an answer key was created by the researchers by referring to international scientific sources (Mader & Windelspecht 2018; Petersen, 2013; Sadava et al., 2014; Simon et al., 2019; Taylor et al., 2018; Urry et al., 2021). In the evaluation of the prepared answers, the coding procedure for three-stage scores developed by Arslan et al., (2012) and adapted for use in different studies by Sen and Yılmaz (2015) was used. The coding procedure is given in Table 1 and the explanations required for the three-stage scores are given in Apendix-1.

Table 1.
The Coding Procedure for Scores (Şen & Yılmaz, 2015)

Score Type	First Stage Question	Second Stage Question	Third Stage Question	Point Value
Score-1	True	-	-	1
Score-2	True	True	-	1
Score-3	True	True	Sure	1
Score-4	True	False	Not sure	1
	False	True	Not sure	1
	False	False	Not sure	1
Score-5	True	True	Not sure	1
Score-6	False	False	Sure	1
Score-7	True	False	Sure	1
Score-8	False	True	Sure	1
Score-9	-	-	Sure	1

*1: Correct point value

Two different researchers independently from each other made descriptive analysis according to the relevant procedure and determined frequency, percentage and sample views. In the reliability analysis of the research findings, Miles and Huberman's (2015) Reliability=Consensus/All opinions formula was applied. In this context, reliability was determined as 94%. In addition, some forms randomly selected from the data were evaluated by the field expert (biology education). It is aimed to prevent the bias of the findings obtained with this analysis. Later, differences of opinion were re-examined in the presence of field experts (biology education) and a common consensus was achieved.

Ethics

Participants of this study were selected on a voluntary basis. In addition, they were informed both verbally and in written form that their data would only be used for scientific purposes. Anonymity was ensured by giving pseudonyms to the participants. In addition, the ethics committee approval was obtained before starting the study, and as a result of the audit, approval was obtained for the study with the report from Yozgat Bozok University Social and Human Sciences Ethics Committee's dated 25.01.2023 and numbered 01/37.

RESULTS

The findings of the study were based on the analyses of the 3-stage misconception tests. A student's answer can be included in different score types (according to score type and stage). In the research, students' learning about the classification of the fungal kingdom was analysed. Table 2 displays the findings.

Table 2.
Findings for the Classification of the Fungi Kingdom

Score Type	f	Sample Opinion
Score-1	15	*S-2: The kingdom of fungi is a separate classification. These organisms have very different characteristics from the plant kingdom.* *S-12: He/she is in the realm of mushrooms. They are similar to animals in their glycogen storage. They resemble plants in that they are incapable of displacement and have a cell wall.* *S-36: Mushrooms are a separate realm in themselves.*
Score-2	3	*S-7: They are classified as the realm of fungi. Because mushrooms have their own characteristics.* *S-42: They are classified in the realm of fungi. There is a separate classification unit formed according to the characteristic features of fungi.*
Score-3	2	*S-42: They are classified in the realm of fungi. There is a separate classification unit formed according to the characteristic features of fungi (I'm sure).*
Score-4	15	*S-5: They take place in the realm of plants. Because it has roots (I'm not sure).* *S-9: He/she is in the realm of plants. It is a plant because we can collect it and eat it (I'm not sure).* *S-20: It is in the plant realm. They can live in soil like plants (I'm not sure).* *S-30: He/she is in the realm of plants. It is because it can be consumed as food (I'm not sure).* *S-33: He/she is in the realm of plants. It is because it grows in the soil and resembles plants in appearance (I'm not sure).*
Score-5	1	*S-7: They are classified as the kingdom of fungi. Because mushrooms have their own characteristics (I'm not sure).*
Score-6	25	*S-1: They are in the plant realm. Because it has chlorophyll and performs photosynthesis (I'm sure).* *S-4: They are in the realm of plants. Because they can photosynthesize (I'm sure).* *S-10: They are plants. Because they photosynthesize, they cannot move, and they have chloroplasts (I'm sure).*
Score-7	9	*S-21: Mushrooms are a different category. I got information as a result of research (I'm sure).* *S-36: Mushrooms are a separate realm in themselves. However, they are closely related to plants (I'm sure).*
Score-8	0	-
Score-9	36	*S-9: They are in the realm of plants. They get inorganic nutrients from their roots (I'm sure).*

When the findings in Table 2 were examined, it was determined that secondary school students had misconceptions regarding the classification of living things in the fungal kingdom (score-6 and score-7). Additionally, knowledge deficiencies of the participants (f=15) were also identified (score-4). Students stated that living things in the fungal kingdom are classified in the plant kingdom because they have chloroplasts/chlorophyll, can perform photosynthesis, and do not move.

In the research, students' learning about the nutrition of living organisms in the fungal kingdom was analysed. Table 3 displays the findings.

Table 3.
Findings on the Nutrition Patterns of Living Things in the Fungi Kingdom

Score Type	f	Sample Opinion
Score-1	6	*S-2: Living things in the fungi kingdom are consumers. They synthesize inorganic matter from organic matter.* *S-7: Mushrooms are consumers. It is fed by breaking down organic foods with its powerful enzymes.* *S-12: Living things in the fungi kingdom feed as heterotrophs (consumers). Thanks to its hyphae and mycelium structures, it meets the nutritional need from the soil.*
Score-2	4	*S-12: Living things in the fungi kingdom feed as heterotrophs (consumers). Thanks to its hyphae and mycelium structures, it meets the nutritional need from the soil.* *S-43: Mushrooms are decomposers. They can feed on dead, rotten fruit and plant debris.*

Table 3. (Continued)
Findings on the Nutrition Patterns of Living Things in the Fungi Kingdom

Score Type	f	Sample Opinion
Score-3	3	*S-7: Mushrooms are consumers. It is fed by breaking down organic foods with its powerful enzymes (I'm sure).* *S-12: Living things in the fungi kingdom feed as heterotrophs (consumers). Thanks to its hyphae and mycelium structures, it meets the nutritional need from the soil (I'm sure).* *S-43: Mushrooms are decomposers. They can feed on dead, rotten fruit and plant debris (I'm sure).*
Score-4	22	*S-5: They feed on the soil with their roots. It has roots (I'm not sure).* *S-24: They feed on soil or trees (I'm not sure).* *S-33: They feed on the sun and water. Because they look like plants, they are fed that way (I'm not sure).*
Score-5	1	*S-2: Living things in the fungi kingdom are consumers. They synthesize inorganic matter from organic matter (I'm not sure).*
Score-6	24	*S-1: They produce their own food. They feed on water and sunlight (I'm sure).* *S-8: They perform photosynthesis. Because they are plants (I'm sure).* *S-11: They feed by photosynthesis. Because they have chlorophyll, they use light energy to produce food (I'm sure).* *S-35: They produce their own food. Because they are plants (I'm sure).* *S-52: Mushrooms are producers. They produce their own food by photosynthesis (I'm sure).*
Score-7	1	*S-16: Mushrooms feed on heterotrophs. They store the food they produce as glycogen (I'm sure).*
Score-8	0	-
Score-9	28	*S-8: They perform photosynthesis. Because they are plants (I'm sure).* *S-12: Living things in the fungi kingdom feed as heterotrophs (consumers). Thanks to its hyphae and mycelium structures, it meets the nutritional need from the soil (I'm sure).* *S-43: Mushrooms are decomposers. They can feed on dead, rotten fruit and plant debris (I'm sure).*

When the findings in Table 3 were examined, it was determined that secondary school students had misconceptions about the nutrition patterns of creatures in the fungi kingdom (score-6 and score-7). Additionally, knowledge deficiencies of the participants (f=22) were also identified (score-4). Students stated that living things in the fungi kingdom can perform photosynthesis and benefit from sunlight (autotrophs).

In the research, students' learning about the ecological functions of living organisms in the fungal kingdom was analysed. Table 4 displays the findings.

Table 4.
Findings on the Ecological Functions of Living Things in the Fungi Kingdom

Score Type	f	Sample Opinion
Score-1	13	*S-2: Mushrooms help in the substance cycle. It breaks down dead waste and organisms.* *S-5: It is ensured that the dough is fermented by yeast fungi.* *S-12: enriches the soil in terms of minerals. Thanks to its saprophytic properties, it decomposes dead organisms. In this way, the soil is enriched in minerals.* *S-18: They are decomposers. They clean nature.*
Score-2	4	*S-2: Mushrooms help in the substance cycle. It breaks down dead waste and organisms.* *S-7: They are divisive. They function in the substance cycle.* *S-12: enriches the soil in terms of minerals. Thanks to its saprophytic properties, it decomposes dead organisms. In this way, the soil is enriched in minerals.*
Score-3	2	*S-7: They are divisive. They function in the substance cycle (I'm sure).* *S-12: enriches the soil in terms of minerals. Thanks to its saprophytic properties, it decomposes dead organisms. In this way, the soil is enriched in minerals (I'm sure).*
Score-4	25	*S-13: They produce oxygen. They photosynthesize like plants (I'm not sure).* *S-32: Renewing nature, taking carbon dioxide and turning it into oxygen. Every living thing has a task (I'm not sure).*

Table 4. (Continued)
Findings on the Ecological Functions of Living Things in the Fungi Kingdom

Score Type	f	Sample Opinion
Score-5	2	*S-2: Mushrooms help in the substance cycle. It breaks down dead waste and organisms (I'm not sure).* *S-20: They are decomposers. They enable the conversion of organic molecules in the natural cycle into inorganic ones (I'm not sure).*
Score-6	17	*S-3: They produce yogurt. Because they have the same properties as bacteria (I'm sure).* *S-10: Mushrooms provide the CO2-O2 cycle. Because it contributes to the atmosphere by doing photosynthesis (I'm sure).* *S-25: Mushrooms have chlorophyll. Therefore, it cleans the air of the atmosphere (I'm sure).* *S-51: Mushrooms are producers. It provides nutrients (I'm sure).*
Score-7	6	*S-19: They provide ecological balance. They have chlorophyll (I'm sure).*
Score-8	0	-
Score-9	25	*S-1: They are used in meals. Because they're vegetables (I'm sure).* *S-7: They are divisive. They function in the substance cycle (I'm sure).* *S-51: Mushrooms are producers. It provides nutrients (I'm sure).*

When the findings in Table 4 were examined, it was determined that secondary school students had misconceptions about the ecological functions of organisms in the fungal kingdom (score-6 and score-7). In addition, knowledge deficiencies of the participants (f=25) were also identified (score-4). Students stated (confidently) that organisms in the fungal kingdom have ecological functions such as photosynthesis, participation in yoghurt production and participation in carbon-oxygen cycles (photosynthesis).

In the research, students' learning about the effects of fungi on human life of living organisms in the kingdom of fungi was analysed. Table 5 displays the findings.

Table 5.
Findings on the Effects of Living Things in the Fungi Kingdom on Human Life

Score Type	f	Sample Opinion
Score-1	8	*S-6: Mushrooms are used by humans as a source of health and nutrition. There are also poisonous types.* *S-12: Mushrooms are an important food source for humans. Mushrooms also have positive effects on human health. Mold fungi produce an antibiotic effect thanks to penicillin.*
Score-2	3	*S-12: Mushrooms are an important food source for humans. Mushrooms also have positive effects on human health. Mold fungi produce an antibiotic effect thanks to penicillin.* *S-16: People use mold fungi for antibiotics. Yeast mushrooms make bread. Penicillin is obtained from mold fungus.*
Score-3	2	*S-12: Mushrooms are an important food source for humans. Mushrooms also have positive effects on human health. Mold fungi produce an antibiotic effect thanks to penicillin (I'm sure).* *S-16: People use mold fungi for antibiotics. Yeast mushrooms make bread. Penicillin is obtained from mold fungus (I'm sure).*
Score-4	10	*S-36: They are consumed as food. The downside is that it can be poisonous. Thanks to the poison, they kill and feed on people (I'm not sure).*
Score-5	0	-
Score-6	33	*S-4: Fungi give ATP energy. Because mushrooms contain different inorganic substances (I'm sure).* *S-7: They reproduce in the respiratory system with the spores they produce. Thus, they feed on the human body (I'm sure).* *S-21: Fungi are prokaryotic creatures. These creatures are used in making yoghurt (I'm sure).* *S-49: Fungi produce food because of their chlorophyll. People get the energy they have when they feed on them (I'm sure).*

Table 5. (Continued)
Findings on the Effects of Living Things in the Fungi Kingdom on Human Life

Score Type	f	Sample Opinion
Score-7	5	*S-6: Mushrooms are used as a source of health and nutrition for living things. Because they store energy (I'm sure).* *S-33: People consume mushrooms as food. Because they are inanimate beings that grow in the soil (I'm sure).*
Score-8	1	*S-47: Fungi are producers. Therefore, people use them as a food source (I'm sure).*
Score-9	41	*S-7: They reproduce in the respiratory system with the spores they produce. So they feed off the human body (I'm sure).* *S-16: People use mold fungi for antibiotics. Yeast mushrooms make bread. Penicillin is obtained from mold fungus (I'm sure).* *S-47: Fungi are producers. That's why people use them as a food source (I'm sure).*

When the findings in Table 5 were analysed, it was determined that secondary school students had misconceptions about the functions of organisms in the fungi kingdom in human life (score-6, score-7 and score-8). In addition, the participants (f=10) also had knowledge deficiencies (score-4). Students stated that living organisms in the fungal kingdom have functions in human life due to their functions such as providing ATP energy, being used in yoghurt making, being producers (autotroph).

DISCUSSION AND CONCLUSION

In the research, it was aimed to examine the learning of secondary school students about living things in the fungi kingdom. In this research, the classification, nutrition, ecological functions and effects on human life of living organisms in the fungal kingdom were emphasised. It was determined that the students had misconceptions about the classification of fungi in the plant kingdom. These students presented their assumptions that they have chlorophyll and chloroplast, that they can photosynthesize (*score-6*), that they are attached to a ground and cannot move, as a reason for classifying fungi in the plant kingdom (*score-6, score-7*). Additionally, the study found that students possessed inadequate and inaccurate understanding of the classification of living organisms within the kingdom Fungi (score-4). Students cited fungi as inhabiting the soil, having roots, and serving as a source of food as reasons for the confusion. It is supposed that scientific inaccuracies in science and biology texts, deficiency in learning objectives pertaining to organism classification, and teacher misconceptions contribute to this issue. Studies have found that both educators and pupils possess incorrect perceptions about the categorisation of life forms (Chen & Ku, 1999; Gul, 2021; Gülen, 2020; Hüseyinbaş et al., 2021; Lampman, 2007; Namdar & Demir, 2016). For instance, Gul (2021) has previously demonstrated that primary school pupils classify fungi as living organisms within the plant kingdom. Similarly, Hüseyinbaş et al. (2021) found that, while secondary school students can identify living things they encounter in their surroundings in the plant and animal kingdoms, their recognition of living things in the fungal kingdom is limited. In contrast, Gülen's (2020) research shows that students do not consider mushrooms to be alive. Insufficient botanical education of biology teachers (Brownlee et al., 2023) and scientific errors in textbooks (Gündüz et al., 2018) are considered the main causes of this situation. Literature indicates numerous scientific errors in the classification of living things in biology textbooks (Istanda et al., 2012) and inadequate learning outcomes (Sıcak & Arsal, 2013).

The study examined the understanding of secondary school students regarding the nutritional process of organisms in the fungal kingdom. It was found that the students held misconceptions regarding the photosynthesis (photoautotroph) of these organisms. Specifically, the students believed that living things in the fungal kingdom are capable of performing photosynthesis. The students stated that living organisms of the fungal kingdom produce their own food through the use of water and solar energy, similar to plants. This is attributed to the presence of chlorophyll. It is worth noting that the perception that fungi obtain nutrients from the soil raises the question of whether organisms within the fungal kingdom are autotrophic or heterotrophic, which is ultimately meaningless (score-6). It is thought that

the students' matching of the vital forms of the plants and fungi they observed in their close environment was effective in the formation of this situation. Students observe the most common capped mushrooms in their environment and identify these soil-bound creatures with plants. In addition, it can be said that students' misconceptions about photosynthesis mechanisms are also effective. Misunderstanding photosynthesis is a risk to society. Because people who have misconceptions about photosynthesis mechanisms do not understand environmental problems and mismanage them (Jančaříková & Jančařík, 2022). In this context, knowing the function of every living thing in nature, such as fungi, will lead to an increase in people's respect for the right to life of living things and to give importance to efforts to protect biological diversity. Studies have shown that students, pre-service teachers and teachers have misconceptions about photosynthesis mechanisms and that organisms in the fungal kingdom can photosynthesise during the feeding process (Gul, 2021; Gülen, 2020; Svandova, 2014; Urey, 2018). For example, Urey (2018) mentioned that pre-service science teachers have high misconceptions about chemical mechanisms rather than biological mechanisms in photosynthesis. According to Svandova (2014), secondary school pupils have misconceptions about plant cellular respiration and photosynthetic mechanisms.

The study analysed the comprehension of secondary school pupils regarding the ecological roles of living organisms in the fungi realm. It was found that students held misconceptions about photosynthesis in fungi. Specifically, they believed that fungi shared characteristics with plants, contained chlorophyll for photosynthesis and contributed to air purification. Furthermore, it was revealed that students possessed incomplete and inaccurate knowledge regarding the processes of nature's rejuvenation by fungi. This predicament is believed to stem from the students' inadequate and/or flawed comprehension of the cellular architecture and functions of fungi. Notably, extant research indicates that insufficiencies and misunderstandings concerning the cell's structure and operations exist among both students and pre-service educators (Duda, 2020; Gul, 2021; Kalaycı, 2017; Karakaya & Yılmaz, 2021). For instance, Gul (2021) found that students hold misconceptions about the structure and morphology of fungi. Similarly, Karakaya and Yılmaz (2021) discovered that preservice science teachers have misconceptions regarding cellular structures and organelles, which can be attributed to teachers and textbooks.

The research investigated the impact of living organisms within the fungi kingdom on human life and their effects on secondary school students' learning. The research found that students held misconceptions regarding the usage of fungal kingdom organisms for yoghurt production, ATP energy generation (one student's view was that mushrooms contain distinct inorganic substances), and nutrient production (autotrophic organisms). Regarding this issue, the students provided reasons that fungi can absorb inorganic molecules from the soil through their roots, possess productive properties due to the presence of chlorophyll, and are employed in the production of yogurt because of the structure of prokaryotic cells (6 points). Furthermore, it was revealed that the students have an incomplete understanding of the mechanisms by which fungi contribute to human mortality (4 points). One of the most noteworthy discoveries of the study is that students accept yeast as the agent responsible for converting milk to yogurt. This phenomenon is attributed to the use of the Turkish equivalent of "fermentation" in curricula, textbooks, and everyday life. Because the Turkish term "mayalanma" used for the process of transformation of milk into yoghurt is "fermentation" in English and "fermentum" in Latin. The term “yeast” in Turkish refers to the type of fungus that makes the dough rise (“yeast” in English). Gul (2021) stated that students have misconceptions about the use of living things in the realm of fungi in making yogurt. Yılmaz et al. (2021) stated that incorrect and/or incomplete use of the Turkish equivalents of biological concepts and terms causes misconceptions. It is beneficial in boosting students' personal development, social skills, environmental awareness, and academic performance through environment and life-oriented trainings (Villarroel et al., 2018; Wojciehowski & Ernst, 2018). Therefore, in order for students to learn about living things and their vital activities, it is thought that teaching processes that progress from near to far (Karakaya et al., 2022) and are carried out in the light of scientific knowledge are necessary.

SUGGESTIONS

The research has revealed that students possess erroneous beliefs concerning the categorisation and crucial influences of organisms within the fungi realm. The research has revealed that students possess erroneous beliefs concerning the categorisation and crucial influences of organisms within the fungi realm. Based on these findings, the subsequent recommendations are proposed:

In addition to Turkish scientific terminology incorporated within curricula, textbooks, auxiliary materials, and educational videos, Latin counterparts should also be provided. Moreover, during the educational process in institutions, these materials should be utilised to promote effective learning.

Teachers should thoroughly explain any concepts that may potentially confuse their students during their lessons, and also ensure that they monitor how the students perceive the material throughout the learning process.

It is believed that obtaining scientific expertise from scholars and educators during the program planning stage concerning living beings in the national media will significantly enhance accuracy in learning and eradicate any misunderstandings among students and viewers.

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APPENDICES

Appendix 1: Explanatory information for the three-stage score scores

Score Type	Description
Score-1	*It is the type of score calculated from the answers given by the students to the first stage.*
Score-2	*It is the type of score calculated from the answers given by the students to the first and second stages. According to this; those who answer correctly in the first and second stages receive one point.*
Score-3 (Scientific Correct)	*In this score type, the answers given by the students to all three stages were taken into consideration.*
Score-4 (Lack of Information)	*This score; it was calculated by taking into account the answers given by the students to each of the three stages. The scores students get for each question reveal the students' lack of knowledge in terms of related concepts. In this way, it is prevented that every wrong answer is classified as a misconception.*
Score-5 (Lack of Confidence or Lucky Guess)	*This enabled the test of the effect of the lucky guess factor when the students were asked to indicate whether they were sure of their answers even if they answered correctly.*
Score-6 (Misconception)	*If students mark the wrong option as the correct answer, mark the option to explain the reason for their answer, and indicate that they are sure of their answer in the third step, they are considered to have a misconception.*
Score-7 (Misconception-False in the positive direction)	*If students mark the wrong option as the correct answer, mark the option to explain the reason for their answer, and indicate that they are sure of their answer in the third step, they are considered to have a misconception.*
Score-8 (Misconception-Wrong in Negative)	*It is the type of score that is calculated if the students give a wrong answer in the first stage and a correct answer in the second stage and state that they are sure in the third stage.*
Score-9 (Trust Score)	*In this score type, only the answers given by the students to the third stage are essential.*

TÜRKÇE GENİŞLETİLMİŞ ÖZET

Ekolojik rollerinin yanı sıra, mantarlar yüzyıllardır insanlar tarafından çeşitli şekillerde kullanılmışlardır. İnsanlar genellikle mantarlar âlemindeki bazı canlıları besin olarak tüketirler. Ayrıca mantarlar âleminde yer alan canlılardan; tarım, ormancılık, sağlık (antibiyotik üretimi), besin üretimi (ekmek yapımı) ve farklı peynirlerin üretimi gibi alanlarda yararlanılmaktadır. Bazı mantarların bitki ve hayvanlarda çeşitli hastalıklara neden olduğu da bilinmektedir. Yapılan araştırmalar, insanların daha çok çevrelerinde gözlemleyebildikleri mantarları (şapkalı mantarlar, küfler ve mayalar) tanımlayabilmektedirler (Hawksworth ve Lücking, 2017; Simon ve diğerleri, 2019; Urry ve diğerleri, 2021). Mantarlar her ne kadar sadece ormanlarda ve nemli alanlarda bol miktarda yetişse de oldukça kozmopolit canlılar olup, dünyanın her yerinde rastlamak mümkündür (Petersen, 2013). İnsanların çoğu mantarlar âlemindeki canlıları daha çok bitkiler âlemindeki canlılarla akraba olarak görmektedir. Bu durum bir kavram yanılgısıdır. Bu yanılgının oluşmasında mantarlar âlemine yönelik çalışmaların (mikoloji) botanikçiler tarafından yapılması etkili olmuştur. Bilim insanları mantarlar âlemindeki canlıların hareketsiz olmaları, hücre duvarlarına sahip olmaları gibi özellikleriyle bitkilere benzedikleri bu nedenle bitkiler âleminde sınıflandırılması gerektiğini ifade etmişlerdir. Ancak bu sınıflandırma bilimsel olarak yanlıştır (Karakaya ve diğerleri, 2022). Çünkü mantarlar âlemindeki canlılar kloroplast bulundurmaz ve fotosentez yapamazlar. Mantarlar âlemindeki canlılar klorofil içermedikleri için ototrof özellik göstermezler (bağımsız olarak şeker, yağ ve nişasta gibi organik maddeler oluşturamazlar). Bu nedenle heterotrof olarak yaşarlar (Mader ve Windelspecht, 2018; Simon ve diğerleri, 2019). Ayrıca mantarlar âlemindeki canlılar hayvanlara kemoheterotrof özellik bakımından benzerdir. Ancak hayvan değildirler.

Biyoloji içerdiği konu ve çalışma alanları açısından insanı ilgilendiren önemli bir disiplindir. Bu nedenle biyoloji disiplinin kapsamında yer alan kavramlara yönelik bilgilerin bilimsel doğruluk taşıması bireylerin eğitim-öğretim süreçleri açısından oldukça önemlidir (Karakaya ve Yılmaz, 2021). Ancak biyoloji, soyut ve somut kavramları bir arada içermesi nedeniyle öğrencilerde kavram yanılgılarının çok olduğu disiplinlerden biridir (Galvin ve diğerleri, 2015). Yapılan çalışmalar, canlıların sınıflandırılması, hücre yapısı, hücre bölünmeleri, fotosentez, eşeyli ve eşeysiz üreme gibi biyolojik olay ve kavramlara yönelik öğrencilerin yanılgıları olduğu göstermiştir (Gul, 2021; Jung, 2020; Peker ve Taş, 2020; Yen ve diğerleri, 2007; Yılmaz ve diğerleri, 2021).

Özellikle Covid-19 salgın süreci ve sonrasında bireylerin başta mikroorganizmalar olmak üzere canlılara karşı bilimsel bilgiye sahip olmaları kritik hale gelmiştir (Simard, 2023). Yen ve diğerleri (2007), canlıların sınıflandırılmasının gerek eğitim gerekse alan eğitimi araştırmaları (örneğin; ekoloji, evrim ve çevre eğitimi) için önemli olduğunu ifade etmişlerdir. Mantarların gerek ekolojik nişleri gerekse insanlara sağlamış olduğu farklı yararları düşünüldüğünde, öğrencilerin bu alemdeki canlılara yönelik bilimsel bilgi düzeylerinin yüksek olması beklenmektedir. Türkiye'de ortaöğretim kurumlarından mezun oluncaya kadar bir öğrenci mantarlarla ilgili akademik bilgiyle ilköğretim 5. sınıf ve ortaöğretim 9. sınıflardaki öğrenimleri sırasında karşılaşmaktadır. Bu kapsamda mantarlara yönelik öğretim programlarında kazanımlar yer almaktadır. Öğretim programlarındaki kazanımlara başarıyla ulaşılması ve öğrencilerinin özellikle mantarlar âlemindeki canlılara yönelik bilimsel farkındalıklarının oluşabilmesi için öğrenmelerinin belirlenmesi ve kavram yanılgılarının ortaya çıkarılması gerekmektedir. Ayrıca öğrencilerin mantarlar âlemine yönelik örnekleri doğru anlamlandırmaları, yaşam alanları ve ekosistemlerin sürdürülebilirliğindeki işlevleri hakkında doğru bilgileri edinmeleri ortak geleceğimiz için önemlidir (Karakaya ve Yılmaz, 2022). Araştırmada, ortaöğretim öğrencilerinin mantarlar âlemine yönelik öğrenmelerinin ve bilgi düzeylerinin incelenmesi amaçlanmıştır. Mantarların sınıflandırılması, beslenme şekli, ekolojik işlevleri ve insan yaşamına etkileri konularına odaklanılmıştır.

Nitel araştırma yöntemlerinden durum çalışmasının kullanıldığı araştırma, Türkiye'nin İç Anadolu Bölgesinde öğrenim gören 52 ortaöğretim öğrencisi ile gerçekleştirilmiştir. Katılımcıların %52'si (N=27) kadın ve %48'i (N=25) erkek öğrencidir. Veriler "Açık Uçlu Soru Formu" kullanılarak

toplanmıştır. Veri toplama aracında araştırmanın amacına uygun 4 farklı soru yer almaktadır. Veri toplama aracında yer alan her soru; ortaöğretim öğrencilerinin mantarlar âleminde yer alan canlılara yönelik sahip oldukları kavramların farklı açılardan (doğru bilgi, kavram yanılgısı, bilgi eksikliği, güven eksikliği veya şanslı tahmin) incelenmesi sağlayacak şekilde üç aşamalı (cevap, gerekçe ve emin olma) durumunu içerecek şekilde hazırlanmıştır. Formun geçerliği, biyoloji eğitiminde görev yapan bir öğretim üyesi, iki biyoloji öğretmeni ve bir fen bilgisi öğretmeninin görüşleri alınarak sağlanmıştır. Verilerin analiz sürecinde, araştırmacılar tarafından uluslararası bilimsel kaynaklar (örneğin; Mader ve Windelspecht 2018; Petersen 2013; Simon ve diğerleri, 2019; Urry ve diğerleri, 2021) referans alınarak cevap anahtarı oluşturulmuştur. Hazırlanan cevapların değerlendirilmesinde ise Arslan ve diğerleri (2012) tarafından geliştirilen, Şen ve Yılmaz (2015) tarafından farklı çalışmalarda kullanılmak üzere uyarlanan "üç aşamalı skorlar için kodlama prosedürü" kullanılmıştır. İki farklı araştırmacı, birbirinden bağımsız olarak ilgili prosedüre göre betimsel analiz yaparak frekans, yüzde ve örnek görüşleri belirlemişlerdir. Elde edilen bulguların güvenirliği %94 olarak belirlenmiştir. Ayrıca veriler içinden rastgele seçilen bazı formlar; alan uzmanı (biyoloji eğitimi) tarafından değerlendirilmiştir. Bu analiz ile elde edilen bulguların yanlılığının önlenmesi amaçlanmıştır. Daha sonra, görüş farklılıkları alan uzmanları (biyoloji eğitimi) eşliğinde yeniden incelenmiş ve ortak görüş birliği sağlanmıştır.

Araştırma sonucunda, ortaöğretim öğrencilerinin mantarları bitkiler âleminde sınıflandırdıklarına yönelik kavram yanılgılarının olduğu belirlenmiştir. Bu öğrenciler; klorofile ve kloroplasta sahip oldukları, fotosentez yapabildikleri, bir zemine bağlı olup hareket edemedikleri şeklindeki kabullenmeleri ileri sürerek mantarları bitkiler âleminde sınıflandırmalarına gerekçe olarak sunmuşlardır. Ayrıca, araştırmada mantarlar âleminde yer alan canlıların fotosentez yaptığı (fotootrof), insanların mantarlar âleminde yer alan canlılardan yoğurt yapımında, ATP enerjisi üretmede ve besin üretmede (ototrof canlı) faydalanıldığına yönelik öğrencilerinin kavram yanılgılarının olduğu belirlenmiştir. Bu durumun oluşmasında, ders kitaplarında yer alan hatalı bilgilerin öğretmenlerdeki kavram yanılgılarının ve biyolojik kavramların Türkçe karşılığının yanlış kullanılmasının etkili olduğu düşünülmektedir.

Sonuç olarak; öğretim programlarında, ders kitaplarında, yardımcı kaynaklarda ve dersleri destekleyen videolarda bilimsel kavramların Türkçe karşılıklarının yanında parantez içinde Latince karşılıklarının verilmesi gerekli olduğu düşünülmektedir. Ayrıca, öğretmenlerin derslerinde öğrencilerin algılamalarında karmaşaya sebep olacak kavramları çok dikkatle anlatmaları ve bunları öğrencilerin ne şekilde algılandığını süreç içerisinde kontrol etmeleri yerinde olacaktır.