



Fifth-Grade Elementary School Students' Conceptions and Misconceptions about the Fungus Kingdom*

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ABSTRACT

This study was conducted with four fifth-grade children from a public elementary school. The purpose was to investigate children's conceptions and misconceptions about the fungus kingdom both before and after a teaching intervention, using the interview and observation techniques of qualitative research. At both sets of interviews, the students were asked questions about molds, yeast, and mushrooms and about their feeding styles, reproduction, and living conditions. Interviews were tape recorded.

The students received six hours of instruction after the pre-interviews. Student misconceptions before and after instruction were identified by qualitative analysis of verbatim responses. Results indicated that before instruction students had many misconceptions like "mold and yeast are not living organisms", "fungi are plants", "fungi mean mushroom" etc. Although they changed most of their misconceptions after the instruction, they still had conceptions that were inconsistent with the scientific perspective. Children's persistent misconceptions, incomplete explanations, and over-generalizations are also discussed in this paper.

Keywords: Elementary Science Education; Conceptions; Misconceptions; Fungus Kingdom; Elementary School Students

INTRODUCTION

The construction of knowledge in the science class begins with what students know when they come to class. Studies indicate that children do not come to primary science lessons as a "Tabula Rasa" but come with rich knowledge about their physical world based on their everyday experience (Pine, Messer, & St. John, 2001). Posner, Strike, Hewson, and Hewson, (1982) defined this knowledge as *conceptual ecology*, a network of concepts interrelated in our head. According to them, students' conceptions are organized into interconnected sets of concepts or ideas and this pre-existing interconnectedness of students' conceptions helps explain why instruction so often fails to help students obtain scientifically correct ideas.

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Research in science education has indicated that students have many ideas that are called *misconceptions* that are different from scientific views. People develop these misconceptions from personal experience, other people, unscientific everyday language, media or textbooks (Driver, Guesne, & Tiberghien, 1985; Alparslan, Tekkaya, & Geban, 2003). Misconceptions are deep rooted and difficult to overcome with traditional instruction; many persist even after students complete and receive high grades in science courses taught by competent instructors (Mestre, 1991). Driver *et al.* (1985), assert that the integration and consistent use of new concepts is a much longer process. To integrate new concepts, children may have to modify the organization of their ideas. They also stated that children do not adopt new ideas or change their ideas radically in the period of time usually allocated to a lesson or even to a sequence of lessons.

Research has demonstrated that students also come to class with a series of misconceptions about biological principles (Nazario, Burrowes, & Rodriguez, 2002). The literature includes numerous studies related to students' ideas and misconceptions about plants. In these studies, sometimes researchers include examples from the fungus kingdom like mushrooms, shelf fungi or bread mold to elicit beliefs from students. However, hardly any research has been done so far specifically related to misconceptions about the fungus kingdom. There are research examples in which students have classified them as "fungi" not as "plants." For example, in Tunnicliffe and Reiss (2000), when 5-, 8-, 10-, and 14-years-old children were asked to classify six different types of plants, one 10-year-old boy categorized the mushroom as "vegetable and fungus". In the same study, one 14-year-old girl defined the mushroom as "fungi-different group."

On the other hand, there is also research in which the students misclassified fungi as plants. Chen and Ku (1999) found that most of the children from all the grades, especially lower grades, thought of mushrooms as plants. Because mushrooms and shelf fungi grow on wood, two-thirds of the children thought them as plants. The children in that study thought that all objects that grow in soil or on wood (e.g. mushrooms) were plants. In addition, Barman, Stein, Barman, and Mc Nair (2003), found that most students in their study knew that bread mold wasn't a plant; however, half of them misclassified the mushrooms as plants because their structures looked plant-like.

This research was conducted according to the science curriculum that was accepted in November 2000 by the Turkish Ministry of National Education (MEB, 2000). In that curriculum the topic of the fungus kingdom was taught in the unit of "Living organisms and their interactions with nature." Similar to other objectives in the 2000 curriculum, the objectives about the fungus kingdom are also more complex, and scientific process skills are not stated clearly (Pekmez & Taşkın Can, 2007). The six objectives related to this topic are presented in the following table.

Table 1. 2000 Science Curriculum Objectives Related To the Fungus Kingdom

GRADE	CONTEXT	OBJECTIVES
5	There are both useful and harmful fungi	<ul style="list-style-type: none"> • To become aware of the members of the fungus kingdom that causes molds and some infectious diseases. • To recognize some multi-cellular fungi species that might be poisonous and not edible. • To be able to explain how to protect our food from various types of molds and to learn molds' living environments. • To give examples of the diseases caused by various molds and ways of protection from these diseases. • To examine different members of the fungus kingdom by using microscope, magnifying glass or naked eye. • To explain physical characteristics of fungi and their reproduction.

In the case of the current (2004) science and technology curriculum, which was developed from a constructivist perspective, the topic “fungus kingdom” is still taught at fifth grade level (MEB, 2005). However, the name of the unit where this topic is taught was changed to “Learning about the Living World.” In addition to many other differences between the two curricula, in the 2004 curriculum each unit has different topics with various objectives. For example, one unit has eight different topics. The fungus kingdom has two topics: 1) classification of living organisms and 2) characteristics of members of the fungus kingdom and their roles in our lives. The objectives of the unit according to these two topics are listed in Table 2.

Table 2. 2004 Science and Technology Curriculum Objectives Related to the Fungus Kingdom

GRADE	CATEGORIES	OBJECTIVES
5	According to classification of living organisms	<ul style="list-style-type: none"> • To be able to classify living organisms according to their similarities and differences such as, plants, animals, fungus kingdom, and microscopic organisms.
	According to characteristics of members of the fungus kingdom and their roles in our lives	<ul style="list-style-type: none"> • To point out the differences between a mushroom and a flowering plant. • To give examples of the various types of fungi after their observation. • To test characteristics of the fungus kingdom by making controlled experiments and to relate the results of these experiments with daily life. • To investigate the importance of the fungus kingdom for people.

The 2000 curriculum did not have much emphasis on teaching and learning activities. By contrast, different teaching and learning activities that guide teachers in a positive way were presented for each objective in 2004 curriculum (Pekmez & Taşkın Can, 2007). The names of these teaching and learning activities about the fungus kingdom are: “Is a mushroom a plant?” “Let’s examine yeast!” “Let’s make dough!” “What happened to my bread?” and “Examining a mushroom and bread mold under magnifying glass.” The program reminds teachers that the most common misconception among children is that “mushrooms are plants.” Therefore, the classroom activities are designed to help students understand that mushrooms are not plants or that plants and fungi are quite different from each other in various aspects. In addition, examining different examples such as bread, orange, and cheese molds, budding yeast, and rising dough might be helpful for students to understand that not only mushrooms but also some unicellular organisms (molds and yeasts) are the members of this kingdom.

Most of the studies that were conducted before 2004 indicated that students in different cultures have classified mushrooms as “plants” rather than as “fungi” (Barman, et al., 2003; Chen & Ku, 1999; Nazario et al., 2002; Türkmen, Çardak, & Dikmenli, 2003). This is not surprising since fungi were classified as plants, because of their cell walls, until the early 1960’s. In 1950 Robert H. Whittaker became the first biologist who proposed adding a fifth kingdom, Kingdom Fungi, based on fungi’s unique method of obtaining food (Encarta, 2007). It was reported in this online encyclopedia that Whittaker argued that fungi do not make their own food, as plants do, and they do not ingest it, as animals do. Rather, fungi secrete digestive enzymes around their food, breaking it down before absorbing it into their cells. Since then, there is agreement within biology that the fungus kingdom is a separate kingdom in the classification system (Lewis, 1994; Victor & Kellough, 1997). It is now known that the cell walls are made of chitin in fungi and of

cellulose in plants. Therefore, recent molecular evidence strongly suggests that fungi are probably more closely related to animals than to either plants or protists (Volk, 2000).

Because of the long history of misclassification of fungi as plants, some of the classroom activities in the current curriculum specifically focus on changing this common student misconception and improving students' level of understanding. Also, classification activities can help students understand where the fungus kingdom actually is in the system of classification.

The purpose of this paper was to determine fifth-grade elementary school students' conceptions, and misconceptions about the fungus kingdom. Specifically, this paper examines the following questions: (a) What were the fifth-grade students' pre-instruction conceptions and misconceptions of the fungus kingdom? (b) Did fifth-grade students' misconceptions of the fungus kingdom change after instruction? and (c) If student misconceptions were not corrected, what were students' persistent misconceptions, incomplete explanations, and over-generalizations?

METHODOLOGY

a) Sample

This study was conducted in a fifth grade classroom at a public elementary school in the city of Bursa in the academic year 2002-2003. There were 18 boys and 14 girls, 11-12 years of age, in the class. The classroom teacher selected four (Harun, Betül, Esra, and Oğuzhan) of the 32 students who were representative of the class population based on their academic achievement (One-high, two-average, one-low). The students' willingness to talk with the lead researcher (first author) was another important point that the classroom teacher considered while selecting these students. Note that *Harun*, *Betül*, *Esra*, and *Oğuzhan* are all pseudonyms.

b) Role of the Teacher

The classroom teacher demonstrated his interest in this research project. He was willing to share his classroom for the investigation of students' conceptions of fungi. In this study, both the lead researcher and the classroom teacher were responsible for facilitating student learning of the concepts about the fungus kingdom. While the lead researcher was facilitating the instruction, the teacher's role was to manage the class and help the lead researcher during the instruction in the classroom. The students' misconceptions and details of the planned intervention were shared with the classroom teacher after the first interview by the lead researcher. After each class, the lead researcher and the teacher talked informally about student engagement and whether the students seemed to understand the lesson. When the teacher noticed problems in understanding, his concerns got incorporated into the next lesson. Additional informal conversations took place between the classroom teacher and researcher before and after the instructional lessons. These conversations allowed evaluation of the previous lesson and also adjusting the next lesson with him. The teacher and lead researcher benefited from these conversations to meet the needs of all students in the classroom.

c) Pre and Post Instructional Interviews

This study employed a qualitative methodology to investigate the nature of students' ideas about the fungus kingdom. One week before reaching the textbook chapter called "The living organisms and their interactions with their environment," the first author conducted the pre-instruction interviews. All interviews were taped in a small, quiet room, and lasted 20-30

minutes. During the individual interviews, all the students were open to the questions and seemed to share their ideas freely. As the four students were interviewed, the lead researcher listened, and interpreted the students' verbatim answers. The intervention instruction was planned according to the results of the pre-instructional interviews.

A semi-structured protocol was used to interview students about their conceptions regarding the fungus kingdom. The students answered 15 questions from broad to specific. In a general sense, the interview questions were determined according to the science curriculum that was accepted in November 2000 by the Ministry of National Education (MEB, 2000). Also, the interview questions were consistent with the research questions. The lead researcher first tried to get the general ideas of the students related to *molds*, *yeast*, and *mushrooms*. After the general questions, the students were asked specific questions about fungal *reproduction*, *feeding*, *living conditions*, and *classification* as poisonous or not poisonous. In addition, the students were asked to draw pictures of a *mold* and a *fungus*. The interviews took place prior to the first lesson and after the final lesson. Since the lead researcher conducted all the interviews, took notes on student responses, and coded the responses for misconceptions, internal consistency can be assumed. Therefore, no interrater reliability was calculated for the questions. The interview questions have face validity in that they are all questions about fungi and their reproduction, feeding, living conditions, and classification. For the interview questions see the Appendix.

In addition, pictures of fungi/non-fungi from sources such as science magazines, books, and Internet based sources were shown to the students. The lead researcher asked each student, while showing each picture, whether or not it represented a member of the fungus kingdom. The sources of data were interview audiotapes and drawings.

d) Instructional Context

The instruction on fungi was presented for three weeks (6 class hours), every Monday and Wednesday (one class time is forty minutes, ten minutes break) in the classroom. The hands-on activities and the contents for the 6 lessons are as follows:

i) Lesson one: The different types of molds, like orange mold, bread mold, and cheese mold, were examined by using magnifying lenses both individually and in small groups.

ii) Lesson two: Students studied the reproduction of yeast by budding. By using yeast, sugar, and warm water, the students prepared their own samples. They observed the budding activity of yeast under the compound microscope.

iii) Lesson three: Students examined the structure of the "cultivated mushroom" by using small plastic knives. They dissected the cultivated mushrooms and observed their structures with magnifying lenses.

iv) Lesson four: Fungus/non-fungus pictures from sources such as science magazines, books, and Internet based sources, were shown to the students. The lead researcher asked students, while showing each picture, whether or not it represented a member of the fungus kingdom.

v) Lesson five: The answer to the question "Why can we not classify the fungus as a plant?" was discussed with the entire class. The students tried to determine why plants and fungi are different from each other.

vi) Lesson six: The characteristics of fungi were reviewed via different pictures. The common differences between poisonous and nonpoisonous mushrooms were discussed in detail.

FINDINGS

Four students' pre and post instruction answers to the questions are presented in the following section.

a) Students' Conceptions, Misconceptions, Incomplete Explanations, and Over-Generalizations before Instruction

The verbal responses, drawings and observations indicated that the students had some misconceptions, incomplete explanations and over-generalizations about the fungus kingdom. They created consistent explanations that made sense according to their beliefs and observations. Before instruction, the most common misconception was: students were more likely to consider a *fungus to be a plant* if it possessed specific characteristics or parts and lived and grew in specific places. Their drawings showed that *mushroom* was the only fungus image in their minds. The following are the most common misconceptions (m), incomplete explanations (ie) and over-generalizations (og) before instruction:

- Mold and yeast is not alive (m)
- Bread is like a sponge because bacteria can cause it (m)
- Fungi are plants (m)
- Fungi have roots, stems, and flowers (m)
- Fungi reproduce by their seeds (m)
- Fungi take their food from the soil by their roots (m)
- Fungi are parasites (og)
- All fungi have caps (og)
- Fungi can grow only in dark and moist conditions (ie)

Although Harun was selected as the best student in terms of academic achievement, his verbal responses surprisingly indicated that he had a lot of misconceptions about this topic. He had no idea about the structures of *mold* and *yeast*. He thought that mold is not a living organism. On the other hand, he was not sure whether yeast is a living organism or not. In addition, he believed that bacteria produce yeast and cause dough formation. He also thought that fungus is a kind of plant and reproduces by seeds. He drew a mushroom picture for question 10; however, he did not answer question 3. (See appendix for questions.) His drawing represents his belief that fungi have caps and stems with spots on them. See Figure 1.

Betül asserted that yeast was the major factor for dough formation. She defined fungus as a kind of food and the reason for disease. All other three participants classified fungi as plants. Betül didn't know which kingdom fungi belong to. She also said that fungi reproduce asexually and sexually, and they also take their food from the soil by their roots. Unlike Harun, Betül drew bread mold with spore sacs on it. See Figure 2.

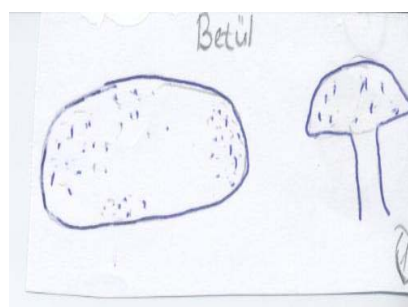


Figure 1. Harun's Drawing for Fungi

Figure 2. Betül's Drawings for Mold and Fungi

Esra stated that mold is a nonliving thing that forms in moist environments. She heard the name of yeast from her mother's experiences; however, she thought yeast was not a living organism. She could not define the term *fungus*. She asserted that mushrooms only have stems, but not roots or leaves. She thought that fungi reproduced sexually, live in sunny environments, and get food from the soil; however, she provided no clarification for the details of the type of feeding. She did not answer question 3. For question 9, she drew a mushroom with big spots. See Figure 3.



Figure 3. Esra's Drawing for Fungi

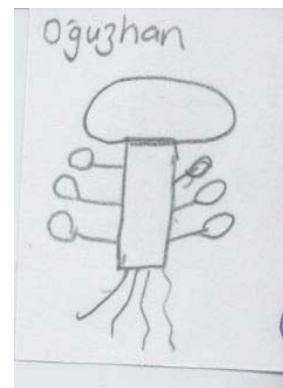


Figure 4. Oğuzhan's Drawing for Fungi

b) Students' Correct Conceptions, Misconceptions, Incomplete Explanations and Over-generalizations after the Instruction

The results of the post-instruction interview showed that the students had changed most of their misconception; however, they had still some incomplete explanations and over-generalizations. At the end of the second interview, the lead researcher and teacher determined that the children had acquired some correct ideas and gained important understandings related to this topic. For example, they understood that mold and yeast are living organisms and that fungi are not plants (they don't have chlorophyll, they can't make their own food, and they don't reproduce by their seeds etc.) On the other hand, they missed the whole picture for some of the concepts and gave partial conceptions for them. The most common incomplete explanation they had was that "mushrooms have roots and leaves." Representative examples of persistent incomplete explanations and over-generalizations were as follows:

- Molds are *green* in color (ie)
- Molds are *white* in color (ie)
- Fungi grow on *sunny* areas (ie)
- Because of the respiration of yeast, bread looks like a sponge (ie)
- Mushrooms have roots and leaves (ie)
- Fungi classified as *parasites* (og)
- Fungus means *mushroom* (og)

Harun's post instructional interview results indicated that, he changed most of his misconceptions. He provided detailed explanations, scientifically acceptable concepts and detailed drawings during his interview. Because of the fact that he examined the mold and dissected the cultivated mushroom during instruction, he could easily draw them. See figure 5. He was able to define "mold" and "yeast." He understood that fungi are not plants. On the other hand, he classified fungi as "parasites." Harun was the only student who mentioned "mycelium", production of CO₂ gas during yeast respiration, reproduction of fungi, and heterotrophic feeding in his answers as well as in his drawings. See Table 3 for Harun's pre and post instruction concepts.

Table 3. Harun's Pre and Post Instruction Concepts

QUESTIONS	PRE INSTRUCTION	POST INSTRUCTION
What is mold?	I don't know	One-celled organism that lives in moist, dark places. Smells bad, and green in color
Is mold living or not?	Nonliving	Living
What is yeast?	Produced by bacteria	One-celled fungus that causes the formation of "dough". It also produces CO ₂ gas while it is <i>respiring</i> .
Is yeast living or not?	I don't know	It is living
Why do you think bread is like a sponge?	Because, bacteria cause the formation of dough	Because CO ₂ gas is produced during respiration.
What is a fungus?	It is kind of plant	It can be either a <i>one-celled</i> or <i>multi-cellular</i> organism. It can be poisonous or nonpoisonous in nature.
Can you see all fungus with a naked eye?	No, I can't.	No, I can't see one-celled fungi with the naked eye.
What is the structure of mushroom?	It has root, and stem. Flower? I am not sure.	They don't have <i>real roots, stem and flowers</i> . They have " <i>mycelium</i> ", " <i>stalk</i> ", " <i>cap</i> " and " <i>lamella</i> " on their bodies.
How can you classify fungi? Plants? Animals? Or what else?	I don't know	Parasites
How do they reproduce?	With their seeds	They have <i>spore sacs</i> under <i>the lamella</i> of their <i>caps</i> . With the help of air and water, the spores are dispersed. When the spores land on soil, they form <i>hyphae, mycelium</i> and then <i>whole mushrooms</i> .
What kinds of environments are suitable for them to reproduce?	I don't know	They prefer <i>dark</i> and <i>moist</i> environments
How do they feed?	I don't know	They are <i>heterotrophic</i> organisms. They live as a " <i>parasites</i> ".
Can you eat each mushroom?	No, some mushrooms are poisonous.	No, some mushrooms are poisonous.
Do you know the differences between poisonous and nonpoisonous fungi?	I don't know	We need to eat <i>cultivated mushrooms</i> . Others might be really poisonous.

It was unexpected that Betül did not change her drawing for question 3 during the second interview. She drew exactly the same figure as during the first interview. She tried to differentiate the parts of the mushroom. See figure 6. She changed many of her misconceptions after instruction; however, she still had some incomplete explanations and over-generalizations even after instruction. For example, she said "fungus means mushroom" for question 7. Her answer indicates that her image of "fungus" is one that has

a cap on the top. She stated that bread is like a sponge because of the yeasts' respiration activity. After instruction, she also talked about the digestive enzymes for the feeding of fungi. For Betül's pre and post instruction concepts, see Table 4.

Table 4. *Betül's Pre and Post Instruction Concepts*

QUESTIONS	PRE INSTRUCTION	POST INSTRUCTION
What is mold?	I don't know	White structures on bread on which moisture is formed.
Is mold living or not?	Yes, it is living.	Yes, it is living.
What is yeast?	A kind of effect on making dough	It helps the formation of "dough".
Is yeast living or not?	Yes, it is living.	Yes, it is living.
Why do you think bread is like a sponge?	Because of yeast, it is pretty soft.	Because of the respiration of yeast, bread looks like a sponge.
What is a fungus?	A kind of food, the reason of disease.	Fungus means <i>mushroom</i>
Can you see all fungus with a naked eye?	Yes, I can.	No, I can't. Some fungi are one-celled, some are multi-celled.
What is the structure of mushroom?	It has only stem and root	They don't have real root, stems, or flowers.
How can you classify fungi? Plants? Animals? Or what else?	I don't know	"Parasites"
How do they reproduce?	Sexual and asexually	<i>Sexual and asexually</i>
What kinds of environments are suitable for them to reproduce?	They reproduce in moist environments	They reproduce in moist and dark environments. Some grow also in light.
How do they feed?	They take their food from the soil by their roots.	They digest food with the help of <i>digestion enzymes</i> .
Can you eat each mushroom?	No, I can only eat organic mushrooms.	No, <i>wild mushrooms</i> might be very poisonous. They can kill us.
Do you know the differences between poisonous and nonpoisonous fungi?	I don't know	We always need to ask the professionals before eating. The healthiest ones are cultivated mushroom.



Figure 5. *Harun's Drawings for Mold and Fungi* **Figure 6.** *Betül's Drawings for Mold and Fungi*

At the second interview, Esra provided very detailed verbal responses to the questions. She corrected her misconceptions about mold and yeast. She stated that a mushroom is not a plant and there are also unicellular fungi in nature. See Table 5. for Esra' pre and post instruction concepts. Esra drew bread mold and its parts for question 3. She also showed the detailed structures of a mushroom for question 9. See figure 7.

Table 5. *Esra's Pre and Post Instruction Concepts*

QUESTIONS	PRE INSTRUCTION	POST INSTRUCTION
What is mold?	They are things that form in the moist places.	The structures that form in dark and moist places. Bread mold for example.
Is mold living or not?	No it is not living.	Yes, it is living.
What is yeast?	I just heart from my mom.	One celled fungus that causes the formation of dough.
Is yeast living or not?	No, it is not living	Yes, it is living
Why do you think bread is like a sponge?	I don't know.	I don't know.
What is a fungus?	I don't know.	Some are poisonous, some are not. They can be either one- celled or multi cellular.
Can you see all fungus with a naked eye?	No.	Some fungus is unicellular. We may need microscope.
What is the structure of mushroom?	Mushroom only has a stem. No root, no leaf...	Mushroom has cap and stem.
How can you classify fungi? Plants? Animals? Or what else?	They are plants.	They are not plants. They are parasites.
How do they reproduce?	Sexually	Asexually and sexually.
What kinds of environments are suitable for them to reproduce?	They like sun. Sun is needed them to grow.	They prefer dark and moist conditions.
How do they feed?	They take food from the soil.	They have digestive enzymes. By using the enzymes, they take the food from the soil.
Can you eat each mushroom?	No, some of them can be poisonous.	Some mushrooms even kill us.
Do you know the differences between poisonous and nonpoisonous fungi?	We need to smell, and look at the structure.	We may examine under the microscope.

Oğuzhan drew the cap, gills, and the stem of mushroom; however, he didn't name them. In addition, he could draw bread mold but only showed the spore sacs on the top. In other words, his second drawings were not as informative as his first ones. See figure 8. He stated that mold grows on bread if the environment is dry. After instruction, he changed his mind and said that they also grow in warm and moist conditions. He defined "yeast" as "one cellular fungus, reproduce by budding." On the other hand, he still thought that fungi have roots and leaves. Finally, he was the only student who mentioned that fungi reproduce asexually, sexually and also by budding. In spite of the fact that all of the students observed the reproduction of yeast by budding under the microscope, the other three students didn't mention it. In Table 6 Oğuzhan's pre and post instruction concepts are presented.

Table 6. *Oğuzhan's Pre and Post Instruction Concepts*

QUESTIONS	PRE INSTRUCTION	POST INSTRUCTION
What is mold?	They form on the bread on dry environments.	If the room is dark, warm and wet, they can easily form. They are green in color.
Is mold living or not?	No, it is not living.	Yes, it is living.
What is yeast?	It helps mom to make dough.	They are one cellular fungus. They reproduce by budding.
Is yeast living or not?	No, it is not living.	Yes, it is living.

Table 6. Continued..

Why do you think bread is like a sponge?	Because, the dough itself is soft.	Because, yeast expand when we put it into the warm conditions.
What is a fungus?	They are saprophytes.	They can be poisonous, one celled, and different types of molds.
Can you see all fungus with a naked eye?	Some can be very small to see.	Some of them are one celled. Therefore, we may need microscope.
What is the structure of mushroom?	It has root, stem, and flower.	It only has root, and stem but no flower.
How can you classify fungi? Plants? Animals? Or what else?	They are plants.	They are kind of parasites.
How do they reproduce?	I don't know.	Asexually, sexually, and by budding.
What kinds of environments are suitable for them to reproduce?	Dark and moist environments.	They need sunny and open environments to reproduce.
How do they feed?	They take food from the soil by their roots.	They take food from the soil by their root-like structures.
Can you eat each mushroom?	No, some of them are poisonous.	No, some can kill us easily.
Do you know the differences between poisonous and nonpoisonous fungi?	I don't know but I know that cultivated mushrooms are safe.	The colored ones are poisonous. We need to be careful.

The students conceptualized spore sacs and stems of bread molds for question 3 in their drawings. On the other hand, cap, gills, and stem were seen as the most distinct elements for mushroom in their drawings for question 9. See figures 7 and 8.

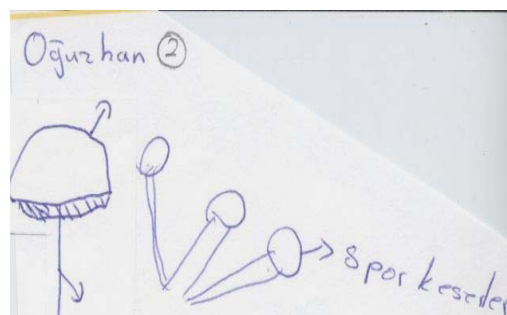


Figure 7. Esra's Drawings for Mold and Fungi **Figure 8.** Oğuzhan's Drawings for Mold and Fungi

The results of this study showed that fifth-grade students' understanding of the fungus kingdom was not complete even after instruction. They did not realize that molds could occur both *green* and *white*. Similarly, their answers did not give any idea that different members of the fungus kingdom can grow under different conditions. These conditions do not necessarily have to be *dark*, *moist*, or *sunny*. In spite of the fact that different examples of fungi, (molds, yeast, athlete foot etc.) were shown to the students during the instruction, they over-generalized and said "fungi means mushroom" rather than a mushroom is a kind of fungus. For example, they didn't give any information related to uni-celled fungi. Although, the students had seen the yeast example that is not a parasite, they classified the entire fungus kingdom as *parasites*.

DISCUSSION AND CONCLUSION

Misconceptions are stable and resistant barriers to acquiring scientific perspectives. Because of the fact that these misconceptions are strong predictors of student achievement in science, the research that identifies these misconceptions at the elementary school level can help teachers be aware of their students' prior knowledge. This study showed that Turkish elementary classes teaching biological concepts might not correct students' preconceptions. And, teachers may not be aware of children's misconceptions. All the students in this study with different levels of academic achievement had almost the same types of misconceptions. Even the most successful student in this study had many misconceptions before special instruction.

The results of this current research study showed that fifth-grade students' understanding of the fungus kingdom seems to be limited. All four participants incorrectly classified bread mold as a plant before instruction. Students were more likely to consider a fungus to be a plant if it possessed specific characteristics or parts, such as roots or stems. As for mistaking the members of the fungus kingdom, especially mushrooms, for plants, this was a very common misconception in this study. This finding is consistent with research in which investigators found half of the students misclassified mushrooms as plants because structures looked plant-like (Barman, et al., 2003). Consistency with previous studies suggests that fifth graders need more help in understanding the fungus kingdom. However, because the study was carried out with only four students, it is impossible to generalize the results for the all fifth-grade students in Turkey.

The pre-instructional students' verbal responses showed that the students thought of mold and yeast as nonliving. In the article cited in Annenberg/CPB (2004), researchers stated that because plants and fungi don't move, some children think they aren't alive. If it moves, it is alive. Or if it seems to move by itself, it is alive. Nonetheless, both plants and fungi demonstrate the characteristics of life. Children who consider movement as a requirement for life may hold this idea. In this case animals may be considered to be the only things that are alive.

The students had a difficulty linking anatomical features they observed to where fungi live and to the adaptations they show. This may show the effects of emphasis in much of biology teaching on naming and categorizing organisms in isolation from their habitats and from their species.

Although they have changed most of their misconceptions after the instruction, students still had incomplete explanations and over-generalizations. One of the limitations of this study was that the time for the research instruction was limited. With more than 6 hours of instruction, learning results might have been greater. Another limitation of the study was that as a conceptual change strategy only hands-on activities were used during the instruction. Other conceptual change strategies, such as concept mapping, conceptual change texts, analogies, and computer-based programs, might also have been used to change the students' incorrect understandings. For any further study, these additional strategies could be used to overcome misconceptions in this area.

SUGGESTIONS

The following are suggested based on the findings of this study:

a) Strengthen the Discrimination of Fungi from Plants

The results of the present study showed that there was considerable ambiguity between concepts regarding plants and fungi. In order to reduce the chance of

misconceptions, elementary school teachers need to make sure that children understand the scope and limits of concepts about fungi, and put more emphasis on life processes as well as fungal attributes, so that students will not over generalize and conclude that fungi (especially mushrooms) are also plants.

b) Enhance Teaching of the Critical Attributes of the “Fungus” Concept

The children had a lack of understanding that fungi cannot make food by themselves, unlike plants. Therefore, if teachers can emphasize the importance of autotrophic feeding, giving children the opportunity for comprehension and application, then not only can the misconception that fungi are plants be eliminated, but children’s future understanding of the producer/consumer concept about ecological systems will be improved.

c) Increase Learning of Recognizing Fungi

In order to strengthen the impact of school teaching, elementary school teachers should provide children more opportunities to recognize the fungus kingdom in school and community settings. They might help children observe more carefully and with greater precision. Many biological concepts are very abstract and therefore difficult for children to imagine and represent. Visualization can provide students with cognitive aids that make abstract biological ideas more comprehensible. For this purpose, demonstrations, pictures, preserved specimens, and Internet based sources might be useful to make students’ understandings of biological concepts meaningful. Field trips might be another way for them to recognize the organisms in their specific ecological niches. In addition, using a combination of several models and assessment techniques depending on the topics might be helpful for teachers to overcome the persistent misconceptions. Teachers should also be explicitly aware of their students’ prior knowledge and misconceptions and should examine why misconceptions occur.

Further, the students’ stable, incomplete explanations and generalizations showed that the concepts the lead researcher tried to teach might be too technical for fifth-graders. This might be the reason that the students had difficulty absorbing the whole terminology about the fungus kingdom. Perhaps this topic should be taught at a higher grade level. However, since the current 2004 science and technology curriculum is based on constructivist approaches and has more hands-on activities than the previous curriculum, perhaps students at the fifth grade level will develop better understanding of difficult concepts such as the nature of fungi. Additional research is needed to see what fifth grade students know since the 2004 science curriculum was accepted.

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APPENDIX

The interview questions:

- A) 1) What is mold?
 - 2) Is mold living or not?
 - 3) Can you visualize “mold” and draw a picture of it?
- B) 4) What is yeast? and
 - 5) Is yeast living or not?
 - 6) Why do you think bread is like a sponge?
- C) 7) What is a fungus?
 - 8) Can you see all fungi with a naked eye?
 - 9) What is the structure of a fungus?
 - 10) Can you visualize a “fungus” and draw a picture of it?
 - 11) How can you classify fungi? Plants? Animals? Or what else?
 - 12) How do they reproduce?
 - 13) What kind of environments is suitable for them to reproduce?
 - 14) How do they feed?
 - 15) Can you eat each mushroom?
 - 16) If the answer is “No” for the item 15, Do you know the differences between poisonous and nonpoisonous fungi?