ORIGINAL ARTICLE

Identification of the Students' Misconceptions about the Digestive System

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***Abstract**: The aim of this study is to determine the students' misconceptions about the digestive system. In this quantitative research, the study group comprised totally 259 sixth-, seventh-, and eighth-grade students. The data were collected through a three-tier diagnostic test and analyzed in terms of scientific knowledge, the lucky guess, lack of knowledge, and misconception levels of students on digestive system. According to the findings, 20.1% of the students' answers were in the scientific knowledge category and 9.1% were in the lucky guess category. On the other hand, 39.7% of the answers were in the lack of knowledge category and 26.0% were in the misconception category. The most prominent findings in the study were the students' misconceptions in a few questions, especially about physical and chemical digestion. In addition, some students did not fully understand the distinction between the excretory and digestive organs and the functions of some accessory. They also gave incorrect answers about the organs where the digestion of proteins, carbohydrates and fats begins and ends. At the end of the study, suggestions were made to eliminate the misconceptions.*

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Introduction

ONE OF THE most important problems of science education is the misconceptions and lack of knowledge that arise since science concepts are not learned in a meaningful and in-depth way in learning environments (Taban & Kiray, 2021). Research on the concept learning and teaching is one of the most important areas in science education (Al khawaldeh & Al Olaimat, 2010). Because some researchers have stated that students come to the classroom with different ideas about science and the natural world, especially in science lessons (Al khawaldeh, 2013). In order to reach a meaningful understanding, students should be associated with their current knowledge and new knowledge, and it should be ensured that they establish effective connections between them. If effective connections are not established between existing knowledge and new knowledge, the development of concepts in students' minds can be prevented (Novak, 2002). In other words, if the concepts are not grasped correctly and scientifically, they turn into information that has no scientific basis. This information, which is likely to cause learning difficulties, is named in different ways such as preconcepts, alternative concepts, misconceptions, and misunderstandings etc. (Dry, 1998; Gilbert, 1977; Novak, 2002; Tapia et al., 2019). In this study, the term "misconception" was preferred. Since misconceptions are resistant to change and negatively affect students' learning performance, it is very important to identify the misconceptions held by students in order to ensure effective learning (Bekkink et al., 2016). Since the last forty years, many researchers around the world have been conducting research to identify misconceptions held by students at different grade levels and in different topics of science. These studies show that misconceptions continue to be one of the main problems affecting science teaching today (Taban & Kiray, 2021). Therefore, in school science teaching, ideas need to be presented in ways that are both authentic representations of the scientific concepts, and yet simple enough to be meaningfully understood by the learners (Nahum et al., 2010). Yet, the broad scope of biology and the complexity of the topics increase the likelihood of students developing misconceptions (Al khawaldeh, & Al Olaimat, 2010; Andariana et al., 2020).

When the studies in the literature to identify or remove students' misconceptions about biology subjects are examined, it seems that there is an important literature that has a long history of study and reveals various concepts and misconceptions held by students at different education levels. In these studies, although it has been determined that students developed misconceptions about important biology subjects, it is noteworthy that less focus was placed on organ systems in the studies (Al khawaldeh, & Al Olaimat, 2010).

Most of the biology subjects in the curricula of almost every country focus on systems of the human body (Dry, 1998). Research into students' understanding of systems has shown that they have trouble understanding fundamental issues of biology, such as internal organs, organ systems, and their functioning (Reiss et al., 2002).

Every system in our body is interrelated. Therefore, learning the organ and functioning of each system can be effective in learning the other system (Ürey & Çalık, 2008). For example, since the subject of 'Digestive System' is closely related to subjects such as excretion and endocrine system, correctly teaching the subject of 'Digestive system' to students will make it easier to learn other subjects correctly (Çuçin et al., 2020). To give an example on this subject, it has been determined in the literature that some students define the intestine as an excretory organ. These false pre-knowledges detected in students may cause new misconceptions while learning the subjects and concepts related to the excretory system. Therefore, all systems in the body can be considered as a system, and the issues of each system can be evaluated analytically (Cerrah Özsevgeçet al., Ünal, 2012).

In the literature, there are studies to identify students' misconceptions about the 'Digestive System' (Ahi, 2017; Cakici, 2005; Carvalho et al., 2003). In some of the studies, students defined the 'Digestive System' as an open-ended tube, while others defined the stomach as a balloon with no mouth or mouth (Adriana & Andrea, 2017). Some students stated that the stomach is the most important organ of the 'Digestive System' (Carvalho et al., 2003; Çuçin et al., 2020). In the study by Çuçin et al. (2020), the students stated that fluids go to the small intestine and solids to the large intestine during digestion and, melting of sugar in the mouth is a digestive event. On the other hand, Dry (1998), Güngör and Özgür (2009) and Çuçin et al. (2020) revealed that students have established a wrong relationship between the 'Digestive System' and the 'Urinary System'. In another study, Cakici (2005) identified different misconceptions that students perceive the digestive process as the melting of foods instead of breaking them down. As different examples of the misconceptions determined (Cerrah Özsevgeç et al., 2012; Çuçin et al., 2020; Dry, 1998): "physical digestion takes place only in the mouth", "digestion is completed in the anus", "gallbladder holds liquid waste", "large intestine transmits wastes to kidneys" etc.

In the light of these studies, it can be said that the organs of the digestive system, their functions and the digestive mechanism are problematic issues for students at different education levels, and this problem continues today. This situation can be caused by different reasons such as drawings or confusing information in textbooks, teacher-centered teaching methods, cultural interactions of students, media and daily language (Cerrah Özsevgeçet al., 2012). Therefore, it can be said that the sources of misconceptions are quite high. In order to prevent students from holding misconceptions, it is of

central importance to understand the concepts correctly and to raise awareness against misconceptions (Taban & Kiray, 2021). This is especially important for students at lower levels of education. For example, in the context of our country, the digestive is taught in various courses from primary school to high school. The subject of 'digestion' as a system is first covered in the 6th grade science course. In high school, the digestive system is taught at the 11th grade level. Therefore, the misconceptions that arise in the lower levels of the teaching process may affect the students' mastery of the concept at the high school or university level in later years. This magnifies the problem and hinders adequate scientific literacy, which not only affects future citizens, but also the challenge of educating future scientists (Tapia et al., 2019). Therefore, it is important to determine the learning difficulties or misconceptions of the students from the lower stages of the teaching process. On the other hand, there are many diseases of our age. One of these is cancer. The top 3 most common cancer types in our country in 2020 are lung cancer, breast cancer and colorectal (large intestine) cancer. Colon cancer has a rate of 9.1% among all cancer cases. This rate should not be underestimated and among the reasons, the risk of colon cancer is increased in those who eat a diet rich in animal fat and low in calcium, folate and fiber. A diet low in fruits and vegetables also increases the risk (Global Cancer Observatory, 2023). At this point, teaching school children the importance of the digestive system and the health of the digestive system from an early age will prepare individuals for a healthier future. To achieve this, it is important to first determine students' awareness levels about the digestive system and identify misconceptions.

On the other hand, different techniques or measurement tools such as drawings (Adriana, & Andrea, 2017; Andersson et al., 2020; Carvalho et al., 2003; Çu çin et al., 2020; Reiss et al., 2002), open-ended questions (Cakici, 2005; Cerrah Özsevge ç et al., 2012), interviews (Adriana, & Andrea, 2017; Ahi, 2017; Cakici, 2005; Cerrah Özsevge ç et al., 2012; Teixeira, 2000), diagnostic tests (Andariana et al., 2020; Bozdağ, 2017; Özkan, 2017) are used to detect misconceptions held by students. In most of the studies, it is seen that drawings are used to identify students' misconceptions (Andersson et al., 2020). However, as stated by Taban and Kiray (2021), these methods have some deficiencies in revealing misconceptions. It is also important that this study is carried out by using the three-stage diagnostic test, which is one of the most recommended methods for the detection of misconceptions. It is claimed that a three-stage diagnostic test among these techniques is highly capable of detecting the misconceptions held by students in a more valid and reliable way compared to other techniques and even two-stage diagnostic tests (Karpudewan et al., 2015). Therefore, this study was determined the students' misconceptions by using a three-stage diagnostic test. In addition to misconceptions, determining the scientific knowledge and the lack of

knowledge ratios of students on digestive system is also important for understanding how deep this subject was learned by students. For this aim, the following questions were sought in this research:

- What are the students' scientific knowledge, lucky guess, lack of knowledge and misconception percentages about Digestive System?
- What are the students' common misconceptions about the Digestive System?

Method

In this study, a survey method based on a quantitative research paradigm was utilized. In survey studies, researchers determine a large sample group and collect data by using tests, surveys/scales or by conducting interviews. Survey studies are frequently used, especially in research conducted in the field of education (McMillan & Schumacher, 2010).

Participants

The study group comprised sixth, seventh and eighth grade students from a city located in the east of Turkey. The ethic board of the institute approved the study. A three-tier diagnostic test was applied to totally 259 volunteer students (48.6% female and 51.4% male) at the end of the second semester during the academic year 2021/2022 (**Table 1**). In determining the sample, the rule of Bryman and Cramer (2001) that "the sample should be at least five times the number of items in the scale" was considered.

Data Collection Tool

The three-stage diagnostic test was originally developed by Bozdağ (2017) and it was in accordance with the curriculum in force before 2018. But Turkish national science curriculum was updated in 2018. Therefore, test was examined by two field experts in terms of both knowledge of the misconceptions and the compatibility of the questions with the learning outcomes in the curriculum. In line with expert opinions, questions 6 (Q6) and 9 (Q9) in the original test were not included in this study. The reliability coefficient of the test (Cronbach Alpha = α) was 0.71 for the first stage of the test, 0.75 for the two stages, and 0.78 for the entire test, that is, for the three stages. As a result, the three-tier diagnostic test contained 10 three-tier items in this study. The first tier is the question part consisting of four multiple choice options with the correct answer together with the distracters containing possible misconceptions. The second tier is the multiple-choice part where the reasons for the answers given in the first stage are included. In the second stage, there is an open-ended option where students can write the reasons they want.

Table 1. Demographic Characteristics of the Sample Group.

Grade level	Gender	School 1	School 2	School 3	School 4	School 5
6th Grade	Female	12	11	7	13	5
	Male	19	10	14	9	10
7th Grade	Female	13	8	5	8	12
	Male	8	12	8	10	9
8th Grade	Female	11	9	8	-	4
	Male	-	11	7	-	6
Total		63	61	49	40	46

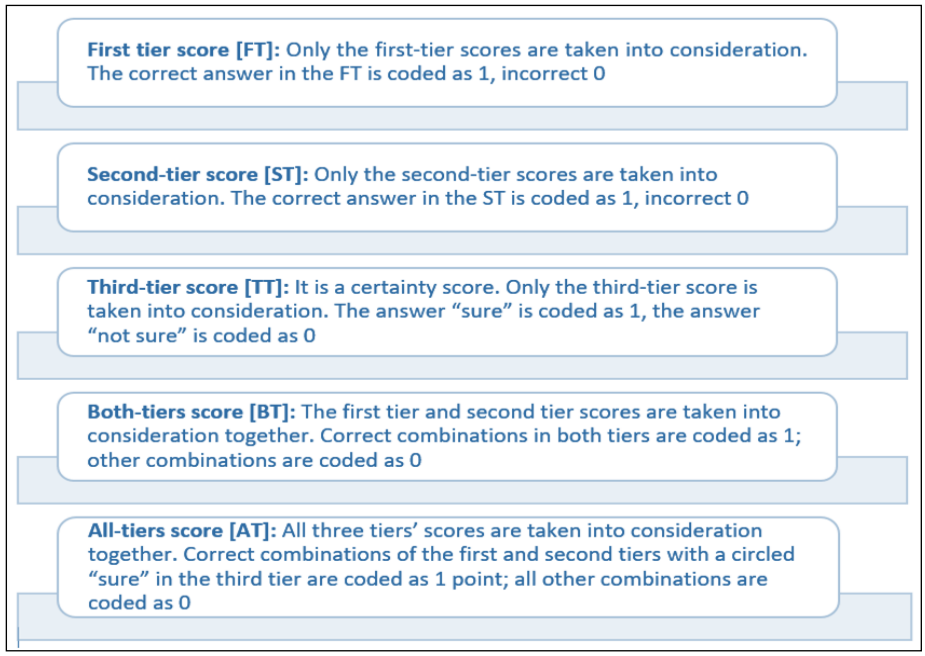

Figure 1. The Test's Definitions of the Contents by Tiers.

The third tier is the self-confidence stage, in which the degree of confidence in the answers given in the first and second stages is asked.

Data Analysis

All statistical analyses were performed in Microsoft Excel and IBM SPSS 20. The data were analyzed in two different ways in terms of both the test's definitions of the contents by tiers and the students' conceptual knowledge. The

test's definitions of the contents by tiers were scored like Milenković et al. (2016) in **Figure 1**.

In addition, very few students marked the open-ended questions (option E) in the second stage of the test, but their answers did not address any misconceptions and included statements such as "I don't know". Therefore, only the frequency value was calculated for open-ended questions and scored as "0".

As a result, according to the above criteria suggested by Milenković et al. (2012), the students' answers were defined as scientific knowledge, lucky guess, luck of knowledge, false positive, false negative and misconceptions (**Table 2**).

In subsequent analyses, it was calculated the percentage value of each response category in order to determine the students' conceptual knowledge. When calculating percentages, false positive and false negatives were categorized into misconceptions. And thus, the data obtained from the test were categorized according to the students' answers, and four different categories were created, similar to the study of Suwono et al. (2021). These were: scientific knowledge (SK), the lucky guess (LG), lack of knowledge (LK), and misconception (M).

Validity Analysis

False Positive (FP) and False Negative (FN) percentages were previously calculated for the content validity of the procedure applied in the analysis of the misconceptions held by the students about the digestive system. In relevant literature, it is recommended that the percentages of FP and FN do not exceed 10% for content validity of three-tier test evaluation (Milenković et al., 2016). According to the findings of present study, the FP percentage was 2.15%, and the FN was 2.23% (**Table 3**). Since the FP and FN percentages are within the recommended range, it can be said that the test is suitable for identifying students' misconceptions.

On the other hand, it was used a common method proposed by Cataloglu (2002) construct validity of the test. For this aim, the correlation between BT and TT scores was calculated for the method of providing evidence for the construct validity of the test. As a result, a positive correlation was found between BT and TT scores ($r = 0.367$; $n = 259$; $p = 0.00$). The correlation between BT and TT scores is shown graphically in **Figure 2**.

Figure 2 shows an increase in the number of correct answers in both stages with increasing confidence level. However, in addition to the few very high scores on the test, it is clear that many students are unsure of their answers. This important finding means a lack of trust, as stated by Milenković et al. (2016). On the other hand, when we look at the **Figure 2**, most of the students have low BT, but their confidence level is high. Therefore, low cor-

Table 2. All Possibilities of Responses.

All tier (AT)			
Both Tier (BT)			
First Tier (FT)	**Second Tier (ST)**	**Third Tier (TT)**	**Category**
Correct	Correct	Strongly sure or sure	Scientific knowledge
Correct	Correct	Not Sure or undecided	Lucky guess
Correct	Incorrect	Strongly sure or sure	Misconception false positive
Correct	Incorrect	Not Sure or undecided	Luck of knowledge
Incorrect	Correct	Strongly sure or sure	Misconception false negative
Incorrect	Correct	Not Sure or undecided	Luck of knowledge
Incorrect	Incorrect	Strongly sure or sure	Misconception
Incorrect	Incorrect	Not Sure or undecided	Luck of knowledge

Table 3. Percentages of FP and FN.

Variables	Questions										Mean (%)
	1	2	3	4	5	6	7	8	9	10	
FP	2.3	1.5	3.5	2.3	2.3	3.5	1.9	1.9	1.5	0.8	2.15
FN	3.5	0.8	1.9	2.3	5.4	2.3	1.5	1.2	1.5	1.9	2.23

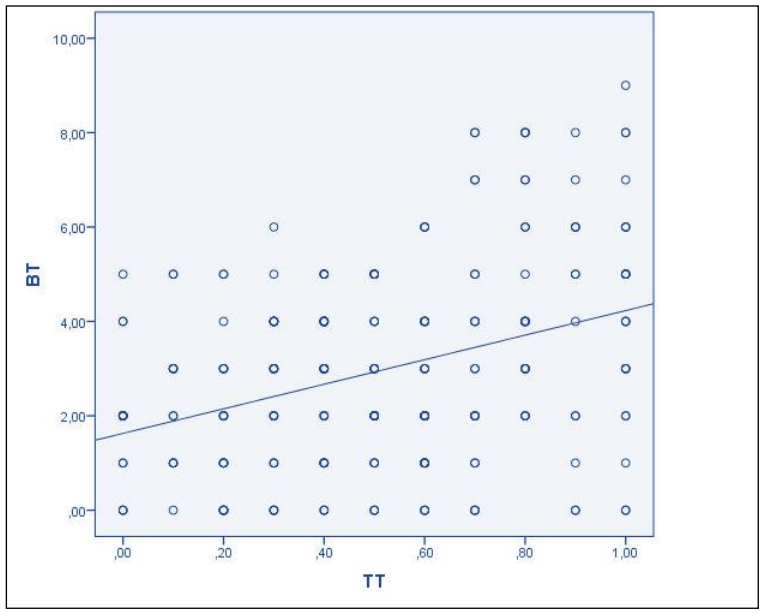

Figure 2. Scatterplot of BT versus TT.

relation was calculated between BT and TT. The reason for this may be the misconceptions of the students (Crocker & Algina, 2008).

Results

The Analysis on the Test's Definitions of the Contents by Tiers

The findings of the analysis on the test's definitions of the contents by tiers can be seen in **Table 4**.

The findings from **Table 4** indicated that the correct answer percentages gradually decreased from FT to AT. However, despite the gradual decrease in the response rate from BT to AT; TT rates continue to be higher. Accordingly, it was determined that the mean of correct answer percentage, which was 34.8% in the FT, was 29.5% in the BT and 20.1% in the AT. This difference of 5% between FT and BT scores can probably be attributed to the presence of false positives and false negatives. On the other hand, an average difference of about 9% was obtained between BT and AT. This difference may be due to lucky guessing or a lack of confidence. The approximately 14% difference between FT and AT scores can be attributed to lucky guess, lack of knowledge and misconceptions (Milenković et al., 2016). In summary, in the light of the findings, it can be said that the test successfully detected the misconceptions of the students about the digestive system.

The Prevalent Misconceptions Hold by Students

In this study, the student's percentage of SK, LG, LK and M are listed in **Table 5**. As seen in **Table 5**, 20.1% of students are in the category of SK, 9.1% are in the category of LG, 39.7% are in the category of LK, and 26.0% are in the category of M. According to the findings, LK has the highest percentage among the four categories. However, it is noteworthy that many students have misconceptions (26.0%).

In terms of SK, the highest percentage values belonged to Q2 (52.1%) and Q7 (49.4%) and the lowest values belonged to Q3 (9.3%) and Q6 (9.7%). When the findings were analyzed in terms of M, it was found that while the highest percentage value was in Q3 and Q4 (37.1%), the lowest value was in Q7 (14.7%).

In the study, misconceptions held by students were analyzed according to the tiers in order to see the misconceptions more clearly and they are presented in **Figure 3**. In **Figure 3**, it clearly can be seemed that the percentage of misconceptions decreases as the number of tier increases.

Table 4. Results of the Analysis of Correct Answers by Tiers.

Question	Score averages by test-tier, N = 259			
	FT	BT	AT	TT
Q1	30.5	25.5	18.5	49.4
Q2	67.2	61.4	52.1	72.2
Q3	23.2	17.4	9.3	51.7
Q4	22.8	19.3	12.0	54.1
Q5	30.9	24.7	13.1	47.9
Q6	24.3	17.8	9.7	40.2
Q7	64.9	60.6	49.4	67.6
Q8	27.4	21.6	11.6	41.3
Q9	28.2	22.4	11.6	40.9
Q10	28.6	23.9	13.5	41.3
Mean	34.8	29.5	20.1	50.7

Table 5. Analysis of Students' Conceptual Knowledge.

	Student test response categorizations, % (N = 259)			
Question	SK	LG	LK	M
Q1	18.5	6.2	43.6	23.6
Q2	52.1	7.7	18.5	17.4
Q3	9.3	8.1	38.2	37.1
Q4	12.0	7.3	38.6	37.1
Q5	13.1	11.6	40.5	27.0
Q6	9.7	7.7	51.7	24.7
Q7	49.4	11.2	21.2	14.7
Q8	11.6	10.0	48.6	26.6
Q9	11.6	10.8	48.3	26.3
Q10	13.5	10.4	48.3	25.1
Mean	20.1	9.1	39.7	26.0

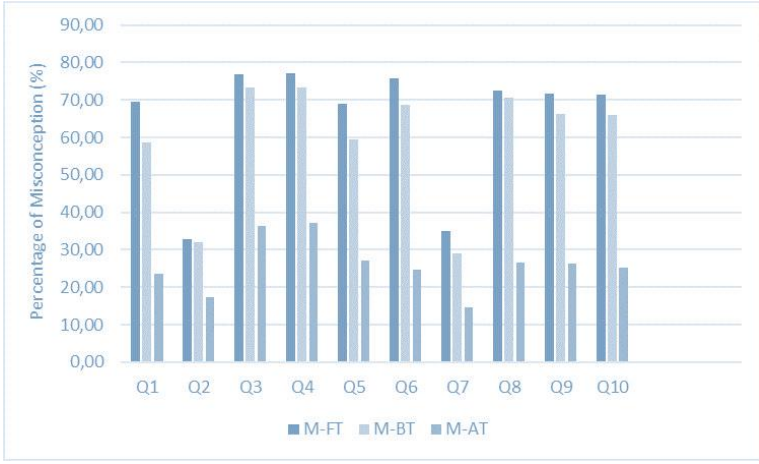

Figure 3. Analysis of Misconceptions by Tiers.

Many studies indicate that if the misconception rate (M-AT) is 10% or more, it should be considered significant (Bozdağ, 2017; Caleon & Subramaniam, 2010). When the findings in **Figure 2** are examined, it is understood that all the questions in the test showed the prevalence of misconceptions. It is understood from the findings in **Figure** 2 that all of the questions in the test show the prevalence of misconceptions. Especially Q3 and Q4 (37.1%) are the items that show the prevalence of misconception the most. The misconceptions related to these questions were summarized in **Figure 4-12**.

According to the findings in **Figure 4**, the percentages of correct answers were 30.5% for FT and 36.3% for ST. When the students' incorrect answers were examined, it was seen that they had the most misconception in option A.

According to the findings in **Figure 5**, the percentages of correct answers were 67.2% for FT and 62.2% for ST. When the students' incorrect answers were examined, it was seen that they had the most misconception in option C.

According to the findings in **Figure 6**, the percentages of correct answers were 23.2% for FT and 20.8% for ST. When the students' incorrect answers were examined, it was seen that they had the most misconception in option C.

According to the findings in **Figure 7**, the percentages of correct answers were 22.8% for FT and 23.2% for ST. When the students' incorrect answers were examined, it was seen that they had the most misconception in option D.

According to the findings in **Figure 8**, the percentages of correct answers were 30.9% for FT and 34.4% for ST. When the students' incorrect answers were examined, it was seen that they had the most misconception in option A.

According to the findings in **Figure 9**, the percentages of correct answers were 24.3% for FT and 24.7% for ST. When the students' incorrect answers were examined, it was seen that they had the most misconception in option B.

According to the findings in **Figure 10**, the percentages of correct answers were 64.9% for FT and 66.8% for ST. When the students' incorrect answers were examined, it was seen that they had the most misconception in option A.

According to the findings in **Figure 11**, the percentages of correct answers were 27.4% for FT and 23.6% for ST. When the students' incorrect answers were examined, it was seen that they had the most misconception in option C.

According to the findings in **Figure 12**, the percentages of correct answers were 28.2% for FT and 27.8% for ST. When the students' incorrect

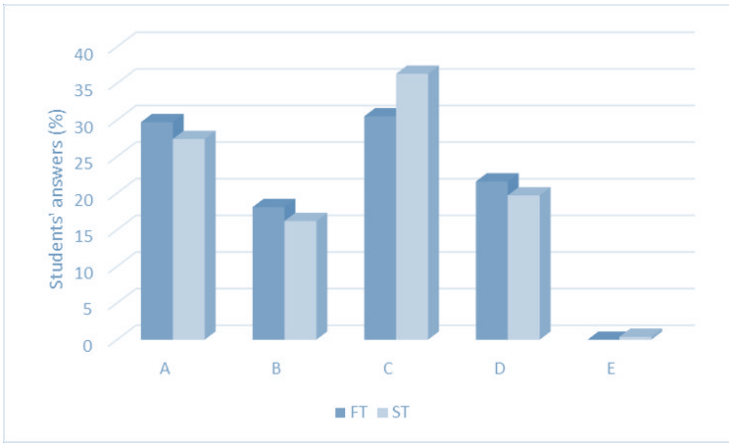

Figure 4. The Correct Answer for Q1 is C. *FT: First Tier, ST: Second Tier.*

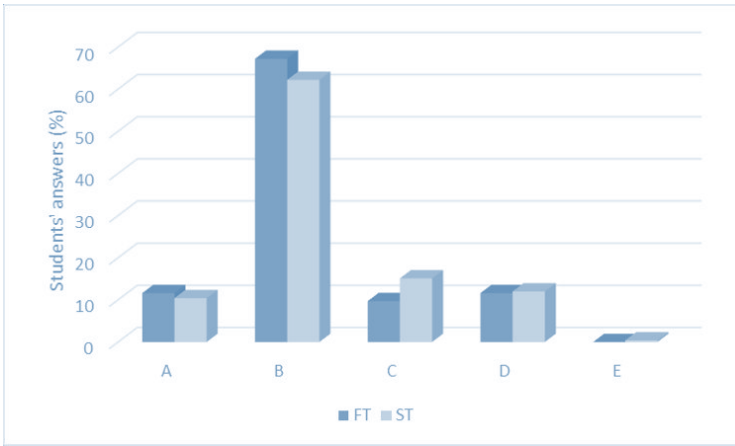

Figure 5. The Correct answer for Q2 is B.

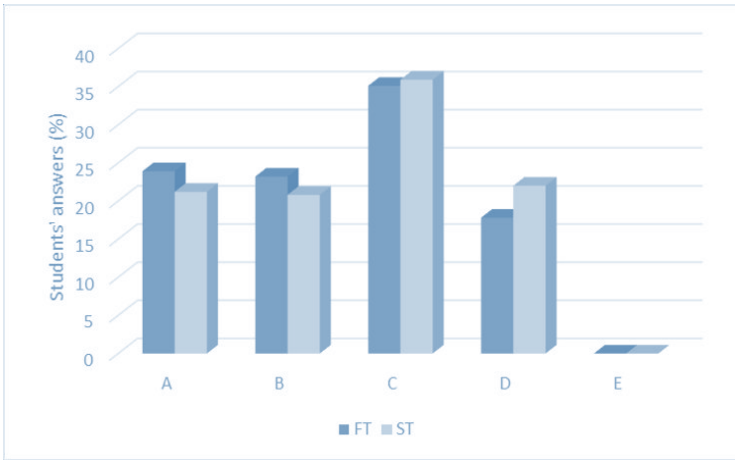

Figure 6. The Correct Answer for Q3 is B.

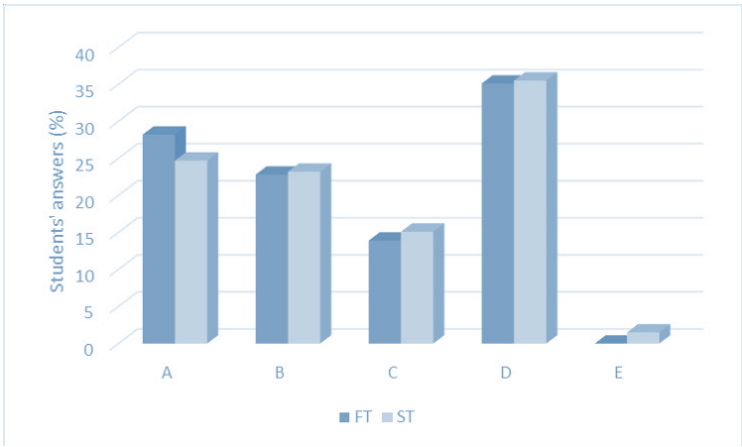

Figure 7. The Correct Answer for Q4 is B.

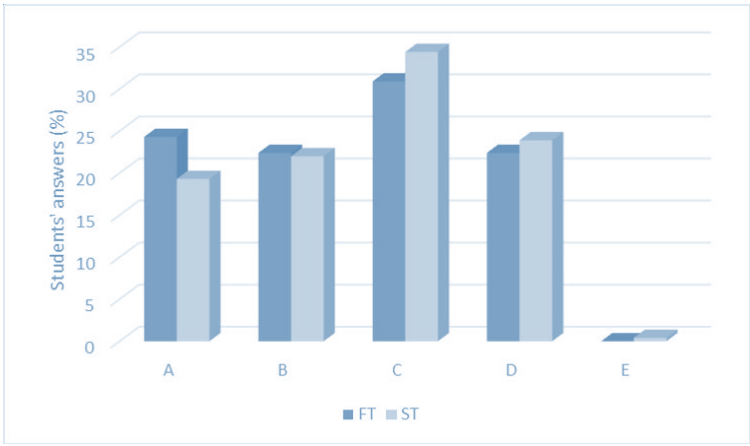

Figure 8. The Correct Answer for Q5 is C.

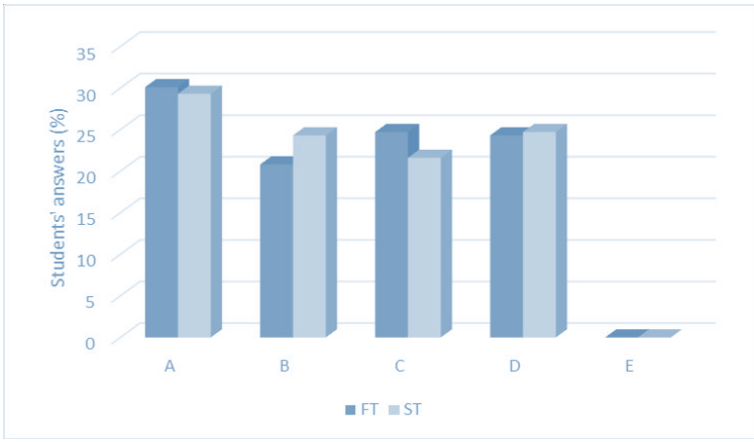

Figure 9. The Correct Answer for Q6 is D.

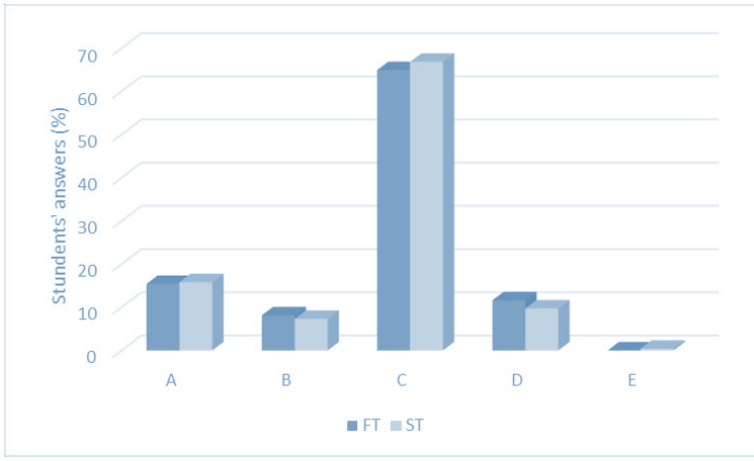

Figure 10. The Correct Answer for Q7 is C.

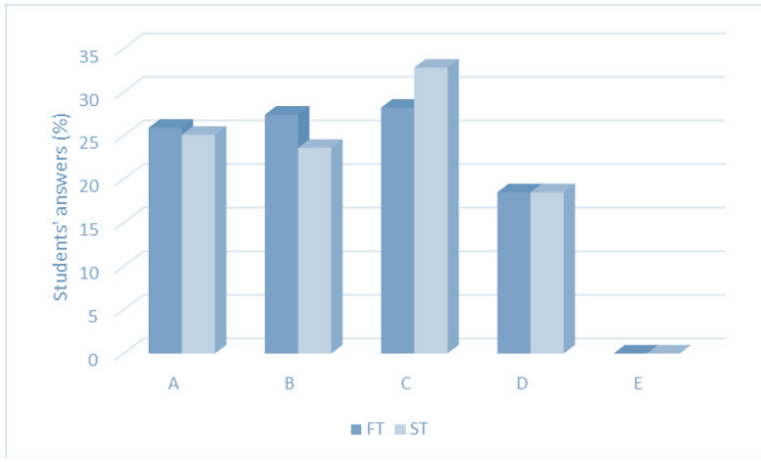

Figure 11. The Correct Answer for Q8 is B.

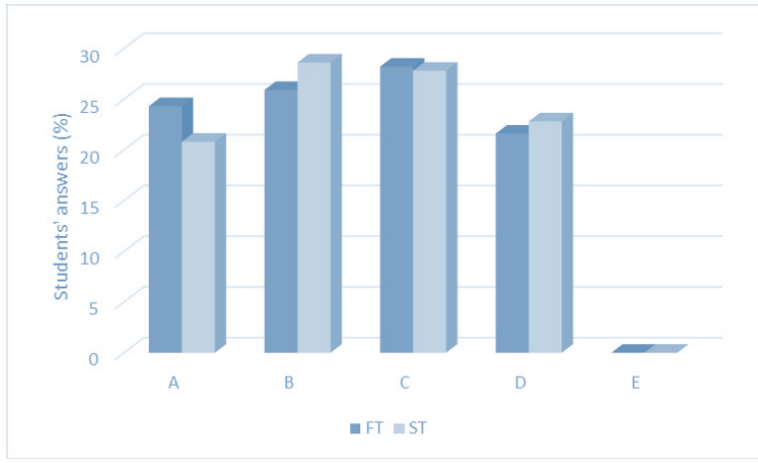

Figure 12. The Correct Answer for Q9 is C.

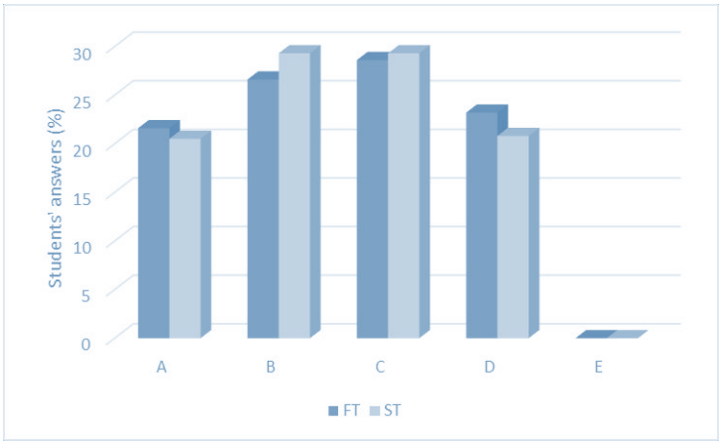

Figure 13. The Correct Answer for Q10 is C.

answers were examined, it was seen that they had the most misconception in option B.

According to the findings in **Figure 13**, the percentages of correct answers were 28.6% for FT and 29.3% for ST. When the students' incorrect answers were examined, it was seen that they had the most misconception in option B.

Discussion

The findings from **Table 4** indicated that the ratio of correct answer percentages gradually decreased from FT to AT. These findings are expected as they are in a full agreement with previous studies (Andariana et al., 2020; Bozdağ, 2017; Milenković et al., 2016; Suwono et al., 2021; Taban & Kiray, 2021). For example, in the study conducted by Andariana et al. (2020), the percentage of correct answers given by the students to the FT questions was higher than the ST, because the students could already distinguish the correct concept from the incorrect one. However, in some studies, most of the students could not give the correct answer to the question in the ST (Pascua & Chang, 2015). This situation shows that the students do not understand the concepts sufficiently. According to Pascua and Chang (2015), this is a partial understanding, that is, partial understanding is defined as the fact that students can answer the question in FT correctly, but fail to reason correctly for the ST answer. In other studies, this result was interpreted that students had difficulty in understanding the basic concepts related to the subject due to their tendency to memorize information (Johnston et al. 2015). Additionally, these results likely derived from the fact that answering first-tier multiple-

choice questions would be easier than fulfilling the explanations (reason tier) as stated by Suwono et al. (2021). However, despite the gradual decrease in the response rate from BT to AT; TT rates continue to be higher. In other words, students who answer the questions incorrectly are sure of their answers. As stated before, the reason for this may be the misconceptions held by the students or the difficulty of the test (Crocker & Algina, 2008). The reason for these differences observed in the first three tiers may also be due to lack of self-confidence, lack of knowledge or lucky guess (Bozdağ, 2017).

It is accepted that there is a satisfactory level of conceptual understanding if at least 75% of the students choose the correct answer in the evaluation of the conceptual understanding level. If the ratio is between 50-74%, it is considered to be adequate, if it is between 25-49%, low and if it is below 25%, it is considered to have a very low level of conceptual understanding (Bozdağ, 2017; Gilbert, 1977). The results obtained with the three-tier test indicated that 18.3% of the students answered the overall test correctly. Therefore, this result can be evaluated as the students' conceptual understanding is quite low. In the study, it was also determined that the percentage of misconceptions decreases as the number of tier increases. Accordingly, it can be concluded that the three-tier tests are more effective in distinguishing students' misconceptions and lacks of knowledge more accurately than other tests. These findings are in parallel with the studies in the literature (Andariana et al., 2020; Milenković et al., 2016; Suwono et al., 2021). For example, Cheung and Yang (2018) reached similar results in their study and suggested the use of three tier tests as more effective tools to diagnose misconceptions compared to two tier and traditional multiple-choice question tests.

When the findings of the study are examined in detail in terms of each question, it was seen that they had the most misconception in option A for Q1. Accordingly, students think that physical digestion takes place in the esophagus. In fact, the esophagus, which is a muscular tube, delivers food to the stomach through a series of contraction movements called peristalsis. Therefore, students may have developed a misconception by associating the contraction and relaxation of the muscles in the esophagus with the crushing of food and thus exposure to physical digestion. Similar findings that students develop a misconception that physical or chemical digestion takes place in the esophagus were obtained in some studies (Bozdağ, 2017; Cerrah Özsevgeç et al., 2012; Özkan, 2017). However, it should be underlined that studies in which the misconception that physical/chemical digestion takes place in the esophagus are generally conducted at the national level. This finding may also be due to the fact that the esophagus is generally described more superficially among the digestive system structures and organs in the context of our country. For this reason, the importance of not only the basic organs of the digestive system, but also all its structures and organs, and

even the accessory organs, should be emphasized and elaborated as a whole upon in the teaching process.

The findings from Q2 indicated that most of the students answered the question correctly. This question is related to the health of the digestive system and includes statements related to daily life. For this reason, it is thought that the correct answer was given by most of the students. On the other hand, it was seen that they had the most misconceptions in option C. Accordingly, students developed a misconception that it is beneficial to drink a lot of water during or just after a meal. Actually, drinking a normal level of water during or after a meal can aid digestion. However, excessive water consumption during or right after a meal tends to dilute the gastric juice. Our stomach is adept at absorbing water, but excess water intake after a meal dilutes the enzymes necessary for digestion. This is responded to by less secretion of digestive enzymes, which can lead to heartburn and acidity (Sengupta, 2019). The reason for the students' misconception about the need to drink plenty of water during or immediately after meals may be due to their association with the vital importance of water and helping digestion under normal conditions, as well as their lack of knowledge about the activity of enzymes. Therefore, while teaching any concept to students in the teaching process, its relationship with other concepts should be emphasized.

The findings from Q3 indicated that the students had the most misconceptions in option C. According to this, the students gave the kidney answer for the organ where water is absorbed the most. As it is known, the digestion of nutrients begins in the mouth and digestion is completed at the end of the small intestine. Digested nutrients and most of the water are absorbed in the small intestine and are prepared to be transported to the cells through the blood and lymph. Waste materials formed as a result of digestion and remaining water reach the large intestine. There is no absorption of nutrients here. The main task of the large intestine is to ensure the reabsorption of remaining water coming here. In the study, students' thinking that most of the water taken into the body is absorbed by the kidneys may be due to the kidneys' removal of some wastes such as urea through the urine and their role in reabsorption. Therefore, students may have developed the misconception that most of the water is absorbed by the kidneys. Similar misconceptions were found in a limited number of studies. For example, Cerrah et al (2012) determined that wastes are transmitted to the kidneys by the large intestine. And also, Dry (1998) revealed that students thought of the kidney as a digestive organ. In a study conducted by Güngör and Özgür (2009), it was determined that a wrong relationship was established between the digestive system and the urinary system by the students. It has been seen from the drawings of the students that the relationship between the digestive and urinary systems is not a relationship that takes place over the circulatory system, but a relationship in the form of direct connections between the digestive and

urinary organs. In this case, it is important to correctly comprehend the relationship and distinction between the urinary system and the digestive system in the teaching process. On the other hand, similar to the results of the studies in the literature, it was stated by some students in this study that water is absorbed the most in the stomach. Students developed a misconception by thinking that water should be absorbed by using it here in order to slurry and soften the food in the stomach. Additionally, some students considered the large intestine to be the place where most water was absorbed. In the study conducted by Bozdağ (2017), the students said that water is absorbed more in the large intestine because of its function of reabsorption of residual water. In fact, students may have associated water absorption with the large intestine, as the large intestine is the last place where water absorption occurs and digestive wastes are removed from the body. Here, it is clear that students are confused about the processes of digestion and absorption. Because the large intestine is the last organ of the digestive system, students may have thought that both absorption and digestion are completed in the large intestine. In different studies in the literature, there are findings that students give examples of different organs for the absorption of water. For example, in the study conducted by Özkan (2017), the students stated that water and minerals are absorbed in the accessory organs to digestive.

The findings from Q4 indicated that the students had the most misconceptions in option D. Accordingly, although some students correctly know that mechanical digestion is achieved with chewing in the mouth and churning in the stomach, it was determined that most of them had the common misconception. As stated by Teixeira (2000), people have empirical evidence of where the digestive processes begin as they put food in their mouths. Therefore, it is usual for students to know that digestion begins in the mouth. However, the end point of these processes is not so clear. For this reason, although the place where digestion begins is known by the students, it has been revealed that they have some misconceptions about the organ in which it is completed. As known, the last place of digestion is the small intestine. Since water, vitamins and minerals are not digested, absorption takes place in the large intestine, and the last absorption takes place in the large intestine (Bozdağ, 2017). However, the highest percentage of misconceptions in the study is that digestion begins in the mouth and is completed in the large intestine. The reason for this misconception may be that the students think of the large intestine as the last organ of the digestive system. As a matter of fact, similar results were obtained in many studies and students stated that digestion ends in the large intestine (Bozdağ, 2017; Çuçin et al., 2020; Özkan, 2017). This result shows that the findings that students have confusion about the tasks of the small intestine and large intestine continue today (Andersson et al., 2020). In this case, it is considered important to un-

derstand the distinction of the functions of these two organs more accurately and to focus more on these organs during teaching.

In addition to the above, in Q5, students were directly asked about the organs where digestion and absorption take place last. Approximately 30% of the students answered correctly that the last digestion takes place in the small intestine and the absorption takes place in the large intestine. However, when the general evaluation of the other answers is made, it is clear that the majority of the students have misconceptions about the organs where digestion and absorption are completed last. Accordingly, students have misconceptions about the function of small intestine and large intestine as in Q4. This result shows that students experience confusion about the concepts of digestion and absorption, as stated before.

In Q6, the physical and chemical digestion processes of fats are shown on the figure, thus questioning students' knowledge of the function of bile and pancreatic juice. Most of the students thought that both processes were chemical digestion and took place with pancreatic juice. As known, bile is produced by the liver and stored in the gallbladder. During the digestive process, this fluid is released into the first part of the small intestine called the duodenum and aids in the digestion of lipids. Bile salts, the main component of bile, break up large oil droplets into smaller droplets (stage 1 in Q6). Thus, the surface area of lipids increases and the work of enzymes become more accessible. In the following processes, it undergoes chemical digestion with pancreatic and small intestine enzymes. In the study, the students thought that breaking the fat into small pieces (stage 1) and breaking it into its building blocks (stage 2) was a chemical process that took place with pancreatic enzymes. In addition, according to the 6th grade science curriculum, the digestion of fats begins and is completed in the small intestine. However, it has been determined that some students think that the digestion of fats occurs only with bile, and some of them think that saliva is responsible for the physical digestion of fats. According to these results, students have various misconceptions about the role of bile and saliva in digestion, the role of accessory organs such as the pancreas, in addition to mechanical and chemical digestion, which are also detected in the above findings. In the literature, it is seen that similar or different results with the findings of this study were reached. For example, Çucin et al. (2020) identified misconceptions such as "biliary fluid is an enzyme", "bile is produced in the gallbladder", "fats taken with food come to the small intestine without digestion in the mouth and stomach". Additionally, Cerrah Özsevgeç et al. (2012) identified misconceptions such as "fats are digested mechanically in small intestine", "liver turns toxic substance into bile", "liver digests fats mechanically", "pancreas secretes bile". In the study of Güngör and Özgür (2019), students stated that bile is an excretory waste that is thrown out after being used in a vital activity in the body. In study by Uğur (2010) and Bozdağ (2010), the

misconception was also determined that bile does not have a role in the digestion of fats. As a result, according to the findings of this study, one of the misconceptions detected in Q6 is that the physical and chemical digestion phenomenon as in the previous questions of the test was not fully comprehended by the students. Similarly, Ahi (2017) stated that the participants could not determine the physical and chemical processes related to the digestive system. As a result, it is thought that one of the main reasons for this result stems from our national curriculum. Because one of the learning outcomes of the digestive system in the 6th grade science curriculum is "Only the definitions of chemical and physical digestion are given without mentioning the chemical digestion equations." is in the form. Therefore, students may have learned physical and chemical digestion by memorizing. As a result, they consider the activity of other organs on digestion as physical or chemical only. In addition, it should be considered that digestive organs as well as the accessory organs are an important part of this system. Because, as in this study, many studies show that students develop more misconceptions about the structure and function of the accessory organs (especially glandular organs such as salivary glands, liver, gallbladder, and pancreas). Therefore, in the teaching process, all the structures and organs of the digestive system should be considered as a whole, and teaching should be done by establishing relationships between concepts.

In Q7, the students were asked about the effect of swallowing the food taken by mouth without chewing it on digestion. As known, chewing increases the surface area of foods, allowing the enzymes to break down food more effectively. Accordingly, most of the students are aware that the contact surface of enzymes increases with chewing. However, when the incorrect answers of the students are examined, it is seen that some students think that the food was not digested in the stomach without chewing. Students associated these views with the thought that there would be no chemical digestion in the stomach without physical digestion. Some students thought that the food would be digested more quickly because it would go to the stomach without being swallowed. Therefore, it can be said that there are a few misconceptions here. For example, the students could not fully grasp the concept of physical and chemical digestion as determined in the previous questions. They also think that there is only chemical digestion in the stomach. On the other hand, they ignored the effect of chewing on enzyme activity. Few findings have been found in the literature regarding the effect of chewing on digestion. For example, in the study conducted by Uğur (2010), it was found that the absence of chewing does not affect digestion in the stomach. Özkan (2017) determined that the students thought that physical digestion takes place only in the mouth.

In addition to the above, in Q8, Q9 and Q10, students were asked questions about the digestion of carbohydrates and proteins. Although some

of the students gave correct answers, many misconceptions were also detected. Some students do not know which organic substances (protein, fat, carbohydrate) are rich in the food types given in the questions. This result shows the importance of putting a little more emphasis on healthy nutrition in the curriculum and presenting more examples from daily life. In addition, most of students gave incorrect answers, especially about where protein and carbohydrates are digested. Various misconceptions were identified in the literature on the digestive system. However, majority of these studies is on structure of digestive organs (Ahi, 2017; Cerrah Özsevgec et al., 2012; Çuçin et al., 2020; Harahap et al., 2019; Özkan, 2017; Teixeira, 2000). A limited number of studies on misconceptions about organs where each of the nutrients (carbohydrate, protein, etc.) is digested and separated into building blocks have been reached (Özkan, 2017). As a result, according to the findings of this study, it is clear that students have confusion about the organs in which different foods are digested. This shows that they do not fully understand the function of the digestive system organs. Therefore, as stated by Núñez and Banet (1997), in order to understand the digestive system clearly rather than individual organs, it is necessary to teach the system as a whole and to teach by establishing relationships between concepts.

Conclusion

As a result of the general evaluation of the findings of the study, it can be said that the students who answered the test had serious difficulties in understanding and explaining the concepts related to the digestive system and developed misconceptions. In the study, it was found that some students were not sure of their answers in the third stage questions despite their correct answers to the first and second stage questions. This finding is in line with the findings of some studies in the literature (Andariana et al., 2020; Milenkovic et al. 2016; Suwono et al., 2021). As Suwono et al. (2021) stated, students' lack of confidence in their answers indicates that their understanding of concepts is not strong enough and their confidence in the concept is low. Regarding this issue, Dry (1998) suggested creating a classroom environment in which students can exchange thoughts and ideas without fear of being mistaken in order to bring alternative concepts to the fore. The teacher can then address the misconceptions and cause students to be dissatisfied with the existing framework of knowledge. Students will begin to reconstruct their framework to incorporate the new knowledge they have just received.

The most obvious findings reached in the study were the students' misconceptions in a few questions, especially about physical and chemical digestion. In addition, some students did not fully understand the distinction between the excretory and digestive organs and the functions of some the accessory. They also gave incorrect answers about the organs where the di-

gestion of proteins, carbohydrates and fats begins and ends. It is suggested that students should be taught these concepts in a way that will enable them to learn in-depth and meaningfully, and that appropriate teaching methods and models should be used. It is recommended that the building blocks of organic compounds, the physical and chemical digestion process are given in more detail, and the information should be removed from the superficiality, and for this, the program should be updated. Ahi (2017) recommended reviewing the teaching of body functions, including the digestive system and other systems, in education programs.

Another finding is that most of students have misconceptions as well as lack of knowledge about the subject. As stated before, the subject of the digestive system is taught in the 6th grades in the secondary education curriculum. Therefore, the reason for the lack of knowledge identified in the study may be that the students in upper grades forgot some of the concepts due to the scientific disconnection they experienced in the following periods. Because, according to the forgetting curve put forward by Ebbinghaus as a result of his studies on the permanence of knowledge, people forget the information they have learned over time, and the rate of remembering what has been learned at the end of a one-month period can decrease to 20% (Ebbinghaus, 1885). Of course, in order to make a definite judgment on this issue, comparisons should be made at each grade level. In our study, 8th grade students could not be reached in some schools due to the LGS exam (High School Entrance System), and enough samples could not be reached because some students did not want to answer the questions. Therefore, the findings were not evaluated according to grade levels.

This study has some methodological limitations. The use of experimental methods in similar studies to be conducted in the future may provide clearer explanations for the reasons for similar findings. Andariana et al. (2020) recommended the active and meaningful learning model as one of the applicable learning models in this situation. According to Andariana et al (2020), an active and meaningful learning model can provide a high-quality learning experience that can facilitate students' understanding, reasoning, and realization of knowledge. On the other hand, this research was limited to a total of 259 middle school students. For further studies, similar studies can be conducted with high school or higher grade levels and a larger sample size. Finally, the results of this study are limited to the data collected by a three-tier diagnostic test about digestive system. In future studies, three-tier concept tests for different biology topics can be developed and applied to students.

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