An Analysis of Pre-Service Teachers' Drawings about the Digestive System in terms of Their Gender, Grade Levels, and Opinions about the Method and Subject

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Abstract

The present study aims to examine the drawings of pre-service science and technology teachers about the digestive system in terms of certain variables, which are gender, grade levels, and levels of knowledge about the drawing method and the digestive system. With this object in mind, the pre-service teachers' drawings were analyzed in terms of three main groups of criteria, including the variables of gender and grade level, opinions about the drawing method, and opinions toward the knowledge levels about the digestive system. The research was conducted with 95 pre-service science and technology teachers studying in the Faculty of Education at Celal Bayar University during the academic year 2010-2011. The data collection instrument used in the study was Draw-A-Digestive System Test (DADST) with two sections. The drawings were analyzed by using the Draw-A-Digestive System Test-Rubric (DADST-R) developed by the researchers. SPSS 17 software was employed to analyze the data obtained from the rubric. As revealed by an examination of the study results, the scores obtained by the pre-service teachers on their drawings about the digestive system did not significantly differ according to the gender variable, while there was a significant difference according to the grade level variable in favor of the fourth-grade pre-service teachers. Furthermore, the total scores obtained by the participants in the drawing test about the digestive system did not reveal any significant difference with regard to how they described their achievement status, while a significant difference was found with regard to their levels of knowledge about the digestive system. Nevertheless, 80% of the pre-service science and technology teachers stated that they would like to employ the drawing method during their in-service career. In the light of these results, certain suggestions are made for further studies on the digestive system and the drawing method.

Keywords: digestive system, drawing, pre-service teacher.

Introduction

Science and technology curricula mainly aims to improve students' scientific process skills such as observation, classification, measurement, hypothesizing, and experimenting and also to educate science-literate individuals with positive attitudes toward science. Moreover, science curricula also aims to help students acquire related knowledge and skills (Demir, Sipahi, Kahraman, & Yalcin, 2007) and to train science/technology-literate individuals (Tasdemir & Demirbas, 2010). In this context, through science and technology courses, students are expected to become productive and self-confident individuals who can solve the problems they are faced with, think critically, use scientific process skills, and learn about and adapt to their environments using the knowledge they have acquired. For an individual to understand him/herself and his/her environment, notes Gunes and Gunes (2005), s/he needs to learn well about the biological topics that examine all living things and their environment. The unit called "the systems in our body" is one of the key biology topics that help individuals learn about themselves. Similarly, in a study examining the views of pre-service elementary teachers, Demirci-Guler (2008) notes that the most important part of the science and technology course that elementary students should learn is the biology topics and particularly the unit called 'let us solve the puzzle of our body'. In this context, it should be important that pre-service teachers and students have knowledge about the systems in our body as a unit in the science and technology curriculum, which may help students, be familiar with themselves and their surroundings and recognize and solve the problems they are encountered with. To this end, it is believed that conducting research about the systems in our body as a unit in the science and technology curriculum is important for and will contribute to the literature. Carried out with this purpose in mind, this study focused on the digestive system as a topic dealt with in the unit on the systems in our body and aimed to examine the levels of knowledge about the topic among pre-service teachers.

As is well known, all the organs that function in breaking down, digesting an absorbing food as well as in eliminating unabsorbed food from the body are collectively called the digestive system (Ozden, 2003, p.154). The organs in the digestive system include the mouth, pharynx, oesophagus, stomach, small and large intestines, and anus (Smith, 1995, p.152). Oral cavity is the first part of the digestive system in humans (Tumer, 2004, p.779) and it includes the teeth, salivary glands and the tongue which serve to catch, control, break down, chew and transform the food into round and smooth morsels (Basaran, 1999, p.324). The food digested in the mouth then passes on to the oesophagus through the pharynx. The oesophagus extends down along the larynx and the chest, joining to the stomach above the abdominal cavity (Tumer, 2004, p.781). The stomach is an organ usually with 'J' shape which stores, mechanically digests the food and secretes hydrolysis enzymes to digest the proteins (Demirsoy, 1992, p.88). The food digested in the stomach then passes into the small intestines, where digestion and absorption mostly take place, as noted by Basaran (1999, p.332). After leaving the small intestines, the digested food then travels into the large intestines and removed through the anus. Along with these organs, the liver, pancreas, and gallbladder also assist the digestion process through secretion (Smith, 1995, p.152). Ozden (2003, p.171) classifies accessory digestive glands as the salivary glands, the liver, and the pancreas. Pancreas is an important digestive gland that secretes enzymes which are operative on carbohydrates, fats and nucleic acids, which in turn flow through a canal into the general bile duct and later into the intestines (Demirsoy, 1992, p.92). The liver also secretes bile (Basaran, 1999, p.335), thus helping digestion. Salivary glands help salivary secretion – which plays a crucial role in tasting and oral digestion – flow into the oral cavity, and there are three kinds of salivary glands in the mouth, which are called 'parotid', 'submandibular' and 'sublingual' glands (Ozden, 2003, p.171). In parallel to this information about the

digestive system, we attempted in the present study to examine the levels of knowledge among pre-service teachers about the digestive system by the help of the drawing method.

As shown by a literature review, certain studies have been carried out to identify students' achievement and knowledge levels along with their misconceptions through different approaches, methods, techniques used to teach the subject of the digestive system. As for the effects of different approaches on teaching the digestive system, Pektas, Turkmen and Solak (2006) investigated the effects of computer-assisted learning; Cetin and Gunay (2007) investigated the impact of group work based on the constructivist theory; Kurtcuoglu (2007) examined the effects of the theory of multiple intelligences; Gumus, Demir, Kocak, Kaya and Kirici (2008) studied the impact of teaching with models; and Guven and Aydogdu (2009) attempted to find out the impact of portfolios and they usually used multiple choice tests as their data collection instrument. Mathai and Ramadas (2009) conducted a study with middle-school students, in which they investigated the impact of texts and diagrams on the visualization and comprehension of human body systems. On the other hand, the participants' misconceptions about the digestive system were identified using drawings and open-ended questions by Gungor and Ozgur (2009) and by a two-stage multiple choice test by Ugur (2010). In their study, Carvalho and Clement (2007) examined the relationships between digestive, circulatory, and urinary systems in Portuguese primary textbooks. Apart from all these, Cerrah, Ozsevgec and Ayas (2005) aimed in their study to identify through a questionnaire the possibly difficult parts for pre-service biology teachers when teaching the unit on the systems in our body, as well as their knowledge levels about these subjects. In a study examining the effectiveness of the constructivist approach with elementary students, Gultepe, Yildirim and Sinan (2008) asked the participants to draw diagrams of the respiratory and digestive systems on a human image; to state what they had in mind while drawing their diagrams; and to explain the concepts relating to the systems. Furthermore, Rowlands (2004) identified in a study how the students perceived the digestion of foods through writing-drawing and semi-structured interviews. Obviously, studies about the digestive system occupy a significant place in the literature and many of them employed the drawing method as their data collection instrument, along with other methods and techniques. Yet, there is a lack of research that effectively used the drawing method to determine the participants' levels of knowledge about the digestive system. Thus, in parallel to available research in the literature, the present study aimed to make an in-depth examination of the drawings of pre-service science and technology teachers about the digestive system.

Drawings are a way to find out learners' previous experiences or what they have learnt about a subject (Korkmaz, 2004). Thus, drawings may be effective in providing students with opportunities to improve their observational skills and allowing them to understand the natural world (Dempsey & Betz, 2001). Moreover, drawings assist students in revealing their knowledge and beliefs that remain concealed in other operations or methods without any verbal constraints (Karamustafaoglu, Karamustafaoglu, & Yaman, 2005: 49). Clearly, when trying to solve a problem or in cases that require decision making, not only can individuals express their ideas orally or in writing, but they can also use drawings to do that (Atasoy, Kadayifci, & Akkus, 2007). Still, although individual interviews, open-ended questions, and two-stage diagnostic tests may be effective in revealing students' deep beliefs about science topics, they could be subjective and hard to assess in certain cases (Kose, 2008). But researchers can more clearly diagnose the quality of a student's knowledge using the drawing method (Kara, Erduran-Avci, & Cekbas, 2008). Obviously, the drawing method allows identifying students' previous knowledge and misconceptions without placing any constraints upon them and offers them the opportunity to present their knowledge in a freer environment when compared to other methods used for the same purpose.

The drawing method has long been employed to reveal people's opinions, knowledge, understanding or ideas about a subject. As noted by Moseley, Desjean-Perrotta and Utley (2010), drawings as a way of research have been used in science education for almost half a century. Goodenough (1926) first developed the Draw-a-Man Test to survey the intellectual status of young children (cited in Moseley et al., 2010). Following the Draw-a-Man Test, many other studies in the literature made use of drawings and they were employed for various units and topics in science education. Open-ended questions and drawings have been used by the following authors to determine the understanding of students at various grade levels about different science concepts: university students' understanding of basic physics concepts by Popov, Zackrisson and Olofsson (2001); primary and secondary school students' understanding about the dissolution concept by Calik, Ayas and Unal (2006); high school students' understanding about the concept of cells by Yörek (2007); pre-service teachers' understanding of the light concept by Kara et al. (2008); and elementary students' understanding of the concept of force by Joung and Gunstone (2010). On the other hand, interviews and drawings were used to identify the participants' understanding/misconceptions about the concept of microbes by Saka and Ayas (2002); about photosynthesis and respiration in plants by Kose (2008); and about the phases of the moon by Bell and Trundle (2008) and Trundle, Atwood, Christopher and Sackes (2010). Furthermore, Chin and Teou (2010) employed concept cartoons, drawings, and group discussions to determine students' ideas about biological inheritance. In their computer-based study, Trundle and Bell (2010) used intensive interviews, drawings, and a lunar shapes card sort to determine the effectiveness of the following teaching methods: 'The planetarium software program', 'Starry Night™, nature observations' and 'Starry Night™ or nature observations alone'.

As noted by Dove, Everett and Preece (1999), drawings are used in various ways to investigate understanding in science. As shown by the literature, some studies have employed drawings to determine students' understanding and knowledge levels and to identify their misconceptions as well as their ideas/images regarding conceptions/subjects (Ayas & Ozmen, 2002; Canbulat & Sasmaz-Oren, 2009; Ilkorucu-Gocmencelebi & Tapan, 2010; Kendrick & Mckay, 2004; Kaya, Dogan, & Ocal, 2008; Moseley et al., 2010; Weber & Mitchell, 1996). On the other hand, Tunnicliffe and Reiss (1999) used drawings to understand the skeletal structure of animals, while Prokop, Prokop, Tunnicliffe and Diran (2007) used them to determine students' ideas about the internal structure of animals. Furthermore, in two studies, Uzunkavak (2009a) and Uzunkavak (2009b) attempted to reveal university students basic knowledge about Newtonian laws and the concept of work by the help of written expressions and the drawing method, comparing their levels of misconception. Obviously, the literature includes research on the use of drawings about different subjects in science education and with different purposes.

There has been a recent increase in the number of studies conducted to determine students' understanding about basic concepts (Alkis & Gulec, 2006), in which drawings are frequently used. As could be seen by an examination of the available literature, particularly the research on the human body as part of science education often makes use of drawings. Reiss and Tunnicliffe (2001), Reiss et al. (2002), Prokop and Fancovicová (2006), Cerrah-Ozsevgec (2007), Bartoszeck, Machado and Amann-Gainotti (2008) and Patrick and Tunnicliffe (2010) asked in their studies their participants to draw diagrams of the internal structure/systems/organs of the human body. Teixeira (2000), on the other hand, employed the interviewing method to identify student conceptions about the structure and functions of the digestive system; and during the interviews, they asked the students to draw diagrams of the digestive organs, how they function and what happens to the food. Furthermore, in some of the research in the literature, the researchers asked the participants to draw diagrams showing

the internal structure of the body of the digestive system, which were examined in terms of variables such as gender and age. In their study, Reiss and Tunnicliffe (2001) aimed to determine how the students in the 4-16 age group understand human internal structure. To this end, they asked 158 students of six different age groups to draw diagrams of the human body. The drawings obtained from the study were analyzed through a rubric of seven points, and the data were examined on the basis of variables such as gender and age. The authors' research demonstrates that the students' drawing scores increase with an increase in their age levels. As for gender, no statistically significant difference was found between the females and males. On the other hand, in a comparative study, Reiss et al. (2002) asked 586 students in 11 countries to draw diagrams of human internal structure. The study assessed the drawings of the seven or fifteen year-old participants using a rubric of seven points, and presented country-based results. The study's results suggest a significance level between the groups of seven and fifteen year-old students on the basis of all countries with regard to age, although there is no statistically significant difference in favor of the students in the fifteen year-old group. As for gender, the authors also performed independent comparisons for the students in the seven and fifteen year-old groups. In terms of the gender variable, the study's results for seven year-old students revealed a significant difference in favor of male students in two countries (Brazil and Taiwan), and in favor of female students in two countries (Portugal and Venezuela), while no significant difference was found between females and males in the remaining seven. Gender comparison for the fifteen year-old students showed a significant difference in favor of females only in one country (Australia), while a significant difference was found in favor of males in six countries (Ghana, Iceland, N. Ireland, Russia, Uganda and Venezuela). Nevertheless, in the remaining four countries there was no significant difference between female and male students. In another study, Cerrah-Ozsevgec (2007) aimed to determine students' understanding about their own body organs. To this end, elementary sixth- and eighth-grade students participated in the study and they were asked to draw diagrams of the organs in human body. The data obtained from the study were analyzed and examined in terms of the sixth and eighth grade levels. The author's findings revealed mostly higher percentages in grade 6 students than in the older ones. Patrick and Tunnicliffe (2010) aimed in their study conducted with science teachers to find out the participants' understanding about human internal structure. The teachers participated in dissection workshops with certain animals. Prior to the workshop, the participants filled in some information (gender; subjects taught and subject most often taught; why they attended the workshop; the number of years they had taught; and if they employed dissection in their classroom), and drew diagrams showing their ideas about what there is inside the human body. Their drawings were evaluated through a rubric, and examined according to variables. The study's results with regard to gender showed no significant difference in the drawings between males and females. Nevertheless, another result of the same study regarding gender is that fourteen females and three males drew the female reproductive organs and two females and one male drew the male reproductive organs.

As is clear from these studies in the national and international literature, the relevant literature contains research on the use of the drawing method for human internal structure and the systems in our body. Yet, there is arguably insufficient research examining the identification of the digestive system organs using the drawing method in terms of different variables. Therefore, this study aimed to examine the drawings about the digestive system made by pre-service science and technology teachers, who are going to teach the subject in their future professional life. Since the objects of interest in the study were whether the gender variable had an effect as a result of the drawing method used and whether there was any difference in the knowledge levels of the pre-service teachers at different grade levels who had been taught about the digestive system, we selected the variables of gender and grade

level as demographic characteristics. Furthermore, we assumed that the pre-service teachers' perceptions as to whether they know and can teach the drawing method and the digestive system might be effective in their levels of knowledge about the subject; so the participants' drawings were also examined in terms of their opinions about the drawing method and their levels of knowledge about the digestive system. For this purpose, we analyzed the pre-service teachers' drawings about the digestive system with regard to the variables of gender and grade level, their opinions about the drawing method, and levels of knowledge about the digestive system.

Method

Sample population

Carried out with pre-service science and technology teachers, this study employed the survey model, which is a quantitative research method. The study was conducted with 95 pre-service teachers studying in the Faculty of Education at Celal Bayar University in the Aegean Region in Turkey. Of all participants, 57 are female (60%) and 38 are male (40%); also, 48 of them (50.5%) studied in the third grade while 47 (49.5%) were in the fourth grade when the study was conducted. The mean age of the junior pre-service teachers was 20, while the senior pre-service teachers had a mean age of 21. Purposeful sampling strategy was employed when selecting the sample group for the study. As is well-known, in purposeful sampling, the researcher uses his/her judgment to select who will be involved and includes in his/her sample the subjects who are most eligible for the study purpose (Balci, 2007, p.90). In parallel, the selection criterion for the sample group in the present study was to include the students who had been taught about the digestive system before. Thus, the participants were those who had taken the 'human anatomy and physiology' course offered during the 5th semester of the science and technology teaching curriculum. In the study, the junior pre-service teachers had taken the course during the previous semester, while the senior pre-service teachers had taken the course three semesters ago. Obviously, the study's sample group was purposefully selected and 95 eligible pre-service teachers participated in the study. It is known that questionnaires are administered or interviews are held in descriptive research and if there are two sub-problems, data should be collected from at least 100 participants (Bozkurt, 2007: 85). Nevertheless, there were 95 individuals in the study sample obtained when all eligible pre-service teachers participated (excluding the number of pre-service teachers participating in the pilot study), so the number of participants could be identified as a limitation of the study.

Data collection

In the study, the Draw-A-Digestive System Test (DADST) developed by the researchers was used as the data collection instrument. DADST consists of two sections, the first of which involves the questions about the pre-service teachers' gender and grade levels; opinion questions about the drawing method; and open and close-ended questions through which the participants could reveal their perceptions toward their knowledge levels about the digestive system. The second section is the part where the pre-service teachers were asked to draw the digestive system. In developing the drawing test, the researchers reviewed the literature, on the basis of which they developed the DADST. For the first section of the DADST, they examined the variables about the demographics in the literature concerning the digestive system and the drawing method, and they formulated the open and close-ended question which they deemed suitable to include in this section. For the second section of the test, they similarly examined drawing tests developed about various subjects in the literature, and the section was formulated with necessary explanations for participants on how to draw the

organs in the digestive system by leaving enough space for their drawings. The test was revised and approved by two experts, meaning that the questions fully provided the required information and did not contain any clues. Furthermore, necessary corrections were made in line with the experts' feedback. Subsequently, the final version of the test was revised and rated by two pre-service teachers not induced in the sample group. The DADST was finalized in accordance with the feedback from these pre-service teachers. During the applications, it took about 15-20 minutes for the pre-service teachers to fill in the DADST, and the applications were completed with all the pre-service teachers in the study approximately within a week.

Data analysis

For data analysis, the drawing question in the second section of the test was first analyzed. In the study, the pre-service teachers' drawings were analyzed by the Draw-A-Digestive System Test-Rubric (DADST-R) developed by the researchers. The DADST-R was developed upon a review of the resources in the literature regarding the digestive system as well as the works by Demirsoy (1992) and Smith (1995). In parallel with the information obtained from the literature, the researchers decided that the DADST-R should include five subscales, which are 'digestive system organs', 'placing of organs', 'structure-organs conducive to digestion', 'connection among organs' and 'the shape of organs'. In the DADST-R, the participants were expected to draw the diagrams of seven digestive organs – the mouth, pharynx, oesophagus, stomach, small intestines, large intestines and anus – and of three structure-organs conducive to digestion – the liver, pancreas and the salivary glands. As for the subscales of the placing of organs, shapes and connection among organs, the participants were expected to draw diagrams for a total of ten structures/organs, including the seven digestive system organs and three structure-organs conducive to digestion. The aim was to inquire into their knowledge about the location of these organs in our body under the subscale of placing of organs; how the organs are connected to each other under the subscale of connection among organs; and about the shapes and sizes of the organs under the subscale of the shape of organs. Although each section in the rubric was assigned different scores, the highest score went to the digestive system organs, and the lowest score to the shape of organs. The scores obtained by the pre-service science and technology teachers on each section were rated at four different levels which are 'perfect performance (4 points)', 'sufficient performance (3 points)', 'limited performance (2 points)' and 'insufficient performance (1 point)'. As a result of the analyses, the participants could obtain 100 points at the maximum, and 25 points at the minimum in the DADST-R. Appendix A includes examples from the DADST-R, and the Appendix B presents examples of the pre-service teacher drawings.

The process of developing the DADST-R employed in the study primarily aimed to define the conceptual construct; therefore, the relevant research on the digestive system was reviewed, the construct was identified from the main references, and a framework was formed for the subject's dimensions. The type of the rubric (analytical in this study) was identified in view of these dimensions. Next, achievement levels were identified for all sub-dimensions (e.g. limited performance or perfect performance) and scale scores were determined for each performance component (e.g. 2 points for limited performance). Performance definitions were made for each measure, and were administered to a sample of five pre-service teachers not included in the sample group. This pilot study was carried out with pre-service teachers who were familiar with the drawing method and at the same grade levels as the students in the sample. Some corrections were made to the rubric by examining the results of the pilot study. Furthermore, the measures in the rubric and their content definitions were reviewed by three educators in the field, and some improvements were made in line with their opinions. Moreover, 30 pre-service teachers selected from the sample group were administered a test,

which consisted of three open-ended questions about the digestive system and was regarded as an external measure. Then a comparison was made between their scores in this test and the scores they obtained from the rubric. Correlation analysis was used in this comparison, the results of which demonstrated a significant, positive and high ($r = 0.77$, $p < 0.01$) correlation between the pre-service teachers' scores in the digestive system test and their scores in the DADST-R. The drawings made by the pre-service science and technology teachers about the digestive system were analyzed by two raters on the basis of the DADST-R. Inter-rater reliability was computed, the ratings were compared, and they were finalized through discussions where there were any differing opinions. Both Kappa statistics and Pearson's product-moment correlation were computed in the study. For total scores, the results of the inter-rater analysis are Kappa = 0.717 with $p < 0.01$. The correlation results demonstrate that there is a total inter-rater agreement of 0.911. Therefore, the DADST-R is arguably a valid and reliable instrument for use in the analysis of drawings about the digestive system.

In the study, the scores obtained from the DADST-R were analyzed through the SPSS 17 software. First, in order to examine whether the scores obtained by the participants in the DADST-R were normal according to the variables under study, the researchers examined the Kolmogorov-Simirnov and Shapiro-Wilk results, which showed that the scores did not have a normal distribution. In an attempt to resolve the issue, Mann-Whitney U-Test and Kruskal-Wallis Test were used as non-parametric analysis techniques. Furthermore, the participants' scores on the rubric were analyzed according to the rubric's subscales using descriptive statistical techniques and their frequency values were calculated. Moreover, descriptive analyses were performed on the participants' performances and their opinions concerning the extent to which they know about the drawing method and digestive system.

Results

The study results could be summarized in three categories: 'examination of the pre-service teachers' scores in the DADST-R according to the variables of gender and grade level'; 'opinions of the pre-service teachers about the drawing method and an examination of these opinions according to their scores in the DADST-R'; and 'opinions of the pre-service teachers toward their knowledge levels about the digestive system and an examination of these opinions according to their scores in the DADST-R'.

Examination of the pre-service teachers' scores in the DADST-R according to the variables of gender and grade level

In order to address the sub-problem of this study, the scores obtained by the participating pre-service science and technology teachers in the DADST-R were examined according to the variables of gender and grade level. Table 1 presents the frequency values for the scores of pre-service teachers on the rubric's subscales according to these variables.

Table 1. *Frequency Values for the Scores of Pre-Service Teachers in the DADST-R according to the Variables of Gender and Grade Level*

Subscales	Gender (*f*)								Grade Level (*f*)							
	Female (*n* = 58)				Male (*n* = 37)				Junior (*n* = 48)				Senior (*n* = 47)			
	1	*2*	*3*	*4*	*1*	*2*	*3*	*4*	*1*	*2*	*3*	*4*	*1*	*2*	*3*	*4*
Digestive System Organs	0	3	29	26	0	4	18	15	0	4	27	17	0	3	20	24
Placing of Organs	5	28	25	0	3	25	9	0	4	29	15	0	4	24	19	0
Structure- Organs Conducive to Digestion	14	22	20	2	10	7	19	1	19	13	16	0	5	16	23	3
Connections among Organs	29	28	1	0	23	14	0	0	32	16	0	0	20	26	1	0
Shape of organs	14	35	9	0	19	15	3	0	20	25	3	0	13	25	9	0

1= insufficient performance, 2=limited performance, 3= sufficient performance, 4= perfect performance

In the study, the frequency values for the scores of pre-service teachers in the subscales on the DADST-R were first examined according to the variables of gender and grade level. Thus, with regard to the subscale of the digestive system organs, no pre-service teachers were found with insufficient performance according to either gender or grade level. On the contrary, a great majority (females = 29, males = 18, junior = 27, senior = 20) exhibited sufficient performance. As for the gender variable, about half of the females ($f = 29$) performed insufficiently in the subscale of connections among organs, while more than half of the male pre-service teachers ($f = 23$) displayed this level of performance. The greatest difference with regard to the grade level variable was observed in the subscale of structure-organs conducive to digestion. In this dimension, 19 of the junior pre-service teachers exhibited insufficient performance and none of the juniors had perfect performance, whereas only 5 of the senior pre-service teachers had insufficient performance and 3 showed perfect performances. Table 2 shows the results of the Mann-Whitney U-Test performed on the total scores of pre-service teachers in the DADST-R according to the variables of gender and grade level.

Table 2. *The results of Mann-Whitney U-Test on the total scores according to the variables of gender and grade level*

Variables		*N*	*Sum of Ranks*	*Mean Ranks*	*U*	*Z*	*p*
Gender	Female	58	2946.00	50.79	911.00	-1.24	0.216
	Male	37	1614.00	43.62			
Grade Level	Junior	48	1924.50	40.09	748.50	-2.83	0.005
	Senior	47	2635.50	56.07			

The total scores of the pre-service teachers in the DADST-R were examined by Mann-Whitney U test with regard to the gender variable. The results of the Mann-Whitney U test indicate that the total scores obtained by the pre-service teachers on the drawing test about the digestive system did not show any significant difference according to the gender variable ($U = 911.00$, $p > 0.05$). Arguably, the female pre-service teachers (*mean* = 50.79) had a higher mean score when compared to the male pre-service teachers (*mean* = 43.62), a difference which, however, cannot be regarded as statistically significant. Similarly, the total scores of the pre-service science and technology teachers in the DADST-R were also examined by

Mann-Whitney U test according to the grade level variable. The results of this test revealed a significant difference between the pre-service teachers in favor of the seniors with regard to the total scores obtained on the digestive system test ($U = 748.50$, $p < 0.05$). The junior pre-service teachers had a mean score of 40.09, while the mean score of seniors was 56.07.

Opinions of the pre-service teachers about the drawing method and an examination of these opinions according to their scores in the DADST-R

In order to handle the problems addressed in the research, attempts were made to identify the opinions of pre-service teachers about the drawing method. In this context, they were asked close-ended and open-ended questions as to whether they know about the drawing method, whether they would like to use it during their teaching careers, and their descriptions of their performance. The opinions of pre-service teachers of their performance were inquired by a close-ended question with a five-point rating system (highly successful, successful, moderately successful, unsuccessful, highly unsuccessful), while close- and open-ended questions were used to examine whether they were willing to use the method during their teaching careers. Table 3 presents the percentage and frequency values for the results obtained from the participants with regard to these variables.

Table 3. *Percentage and frequency values for the performance of pre-service teachers and their opinions about the drawing method*

Performance						Knowledge of the drawing method				Use of the drawing method			
Successful		Moderately successful		Unsuccessful		Yes		No		Yes		No	
f	%	*F*	%	*F*	%	*f*	%	*f*	%	*f*	%	*f*	%
38	40.0	54	56.8	3	3.2	53	55.8	42	44.2	75	79.0	20	21.0

Even though a five-point rated question was used with regard to performance, the responses of the pre-service teachers are rather concentrated on three. Thus, most of the participants (56.8%) perceive themselves as moderately successful. The total scores obtained by the pre-service teachers in the DADST-R were examined by Kruskal-Wallis analysis in accordance with how they describe their departmental success, and the results of the analysis are given in Table 4.

Table 4. *The results of the Kruskal-Wallis Test on the total scores according to the performance variable*

Performance	*N*	*Mean Ranks*	*sd*	X^2	*P*	*Fark*
Successful	38	53.50				
Moderately successful	54	44.91	2	2.97	0.226	_
Unsuccessful	3	34.00				

As is clear from Table 4, the results of the analysis indicate that the total scores of pre-service teachers on the drawing test about the digestive system did not significantly differ

with their performance levels as they themselves described ($X^2_{(2)}$ = 2.974, p > 0.05). Their mean scores show that the highest scores were achieved by the pre-service teachers who define themselves as successful (*mean* = 53.50). The pre-service teachers who define themselves as moderately successful had a mean score of 44.91, while the mean score is 34.00 for the pre-service teachers defining themselves as unsuccessful. However, the total scores in the DADST-R make clear that these means do not imply a statistically significant difference.

One of the close-ended questions addressed to the participants concerned their knowledge of the drawing method. As seen in Table 3, more than half of the pre-service teachers (55.8%) stated that they knew about the method. Moreover, 75 of 95 pre-service teachers mentioned their willingness to use it during their professional careers. Mann-Whitney U analysis was used to examine the pre-service teachers' knowledge of the drawing method and whether they were willing to use it in their careers according to total scores, and the results are shown in Table 5.

Table 5. *The results of the Mann-Whitney U-Test on the total scores according to the variables of knowledge about and the willingness to use the drawing method*

Variables		*n*	*Sum of Ranks*	*Mean Ranks*	*U*	*Z*	*p*
Knowledge about the drawing method	Yes, I know about it	53	2740.50	51.71	916.50	-1.47	0.140
	No, I do not know about it	42	1819.50	43.32			
Use of the drawing method	Yes, I would use it	75	3616.00	48.21	734.00	-1.46	0.884
	No, I would not use it	20	944.00	47.20			

The analysis results revealed no statistically significant difference between the pre-service teachers' knowledge of the drawing method and their total scores (U = 916.50, p > 0.05). Given the mean ranks, the pre-service teachers stating that they knew about the drawing method (*mean* = 51.71) had higher scores in the drawing test about the digestive system than those who said they did not know about the method (*mean* = 43.32); however, the difference is not statistically significant. In a similar way, the total scores of the pre-service science and technology teachers were examined by a Mann-Whitney U test with regard to their willingness to use the drawing method when they become teachers. The results of the test revealed no significant difference between the total scores in the digestive system test and the willingness to use the drawing method (U = 734.00, p > 0.05). The pre-service teachers who would like to use the drawing method obtained a mean score of 48.21, while the mean score for those who were unwilling to use it was 47.20.

Opinions of the pre-service teachers toward their knowledge levels about the 'digestive system' and an examination of these opinions according to their scores in the DADST-R

In this part of the results, the first step was to identify the opinions of pre-service teachers concerning their knowledge about the digestive system. In this context, the pre-service teachers were asked to describe their knowledge levels about the digestive system, and to state their perceptions as to whether they can teach the subject and the adequacy of their knowledge levels. Their opinions concerning their knowledge levels about the digestive system were inquired through a five-point rated (fully adequate, adequate, moderately adequate, inadequate, totally inadequate) close-ended question, while a two-point rated (yes, no) close-ended question was used to examine their perceptions as to whether they can teach the

digestive system and their opinions concerning the adequacy of their knowledge levels. Table 6 presents the percentage and frequency values for the results obtained from the participants with regard to these variables under study.

Table 6. *Percentage and frequency values for the opinions of pre-service teachers concerning their knowledge levels about the digestive system*

Knowledge level about the digestive system								*Whether they can teach the digestive system*				*Whether their knowledge level is adequate*			
Totally adequate		Adequate		Moderately adequate		Inadequate		Yes		No		Yes		No	
f	%	*f*	%	*f*	%	*f*	%	*f*	%	*f*	%	*f*	%	*f*	%
7	7.4	46	48.4	36	37.9	6	6.3	74	77.9	21	22.1	64	67.4	31	32.6

Although a five-point rated question was used to identify the knowledge levels of pre-service teachers about the digestive system, the participant responses were rather concentrated on four of them. 48.4% of the participants stated that their knowledge levels about the digestive system were adequate, 37.9% believe that they have moderately adequate knowledge. The total scores of the pre-service science and technology teachers in the DADST-R were subjected to Kruskal-Wallis analysis with regard to their knowledge levels about the digestive system, and the results are shown in Table 7.

Table 7. *The results of the Kruskal-Wallis Test on the total scores according to the variable of knowledge level about the digestive system*

Knowledge level about the digestive system	*n*	*Mean Ranks*	*sd*	X^2	*P*	*Difference*
Totally adequate	7	78.79	3	13.83	0.003	(TA-A)
Adequate	46	51.23				(TA-MA)
Moderately adequate	36	38.42				(TA-I)
Inadequate	6	44.83				(A-MA)

(TA: Totally Adequate, A: Adequate, MA: Moderately Adequate, I: Inadequate)

As is seen in Table 7, there is a significant difference in the total scores of pre-service teachers in the drawing test about the digestive system in accordance with their descriptions of how well they know the subject ($X^2_{(3)} = 13.83$, $p < 0.05$). Clearly, the difference is between the pre-service teachers who perceive themselves as totally adequate-adequate, totally adequate-moderately adequate, totally adequate-inadequate and adequate-moderately adequate with regard to the digestive system. Their mean scores reveal that the highest values were achieved by the pre-service teachers who defined themselves as totally adequate (*mean* = 78.79) and adequate (*mean* = 51.23).

The last two close-ended questions addressed to the pre-service teachers in the study aimed to determine their perceptions as to whether they can easily teach the digestive system when they become teachers, and whether their knowledge levels about the digestive system is adequate. A great majority of the participants (77.9%) stated that they could easily teach the subject as teachers, while 67.4% perceive their knowledge levels about the subject as

adequate. Mann-Whitney U analysis was performed to examine the scores of pre-service teachers in the drawing test, and whether they can teach the digestive system and the adequacy of their knowledge levels, and the results are given in Table 8.

Table 8. *The results of the Mann-Whitney U-Test on total scores with regard to the variables of teaching the digestive system and the adequacy of knowledge levels about the digestive system*

Variables		*N*	*Sum of Ranks*	*Mean Ranks*	*U*	*Z*	*p*
Whether they can teach the digestive system	Yes, I can	74	3834.00	51.81	495.00	-2.53	0.011
	No, I cannot	21	726.00	34.57			
Whether their knowledge level about the digestive system is adequate	Yes, it is adequate	64	3392.50	53.01	671.50	-2.55	0.011
	No, it is inadequate	31	1167.50	37.66			

The total scores of the pre-service teachers in the DADST-R were analyzed by Mann-Whitney U test to investigate whether they can teach the digestive system. The results of the Mann-Whitney U test indicate a significant difference between the total scores of pre-service teachers in the drawing test with regard to whether they can teach the subject ($U = 495.00$, $p < 0.05$). The pre-service teachers who believe that they can easily teach the digestive system as teachers (*mean* = 51.81) have greater mean scores when compared to those who think they cannot (*mean* = 34.57). Similarly, Mann-Whitney U test was also performed on the total scores of the pre-service science and technology teachers with regard to the adequacy of their knowledge levels about the digestive system. The results of the test revealed a significant difference among the pre-service teachers in favor of those who perceive their knowledge levels as adequate with regard to the total scores in the digestive system test ($U = 671.50$, $p < 0.05$). The pre-service teachers perceiving themselves as adequately informed about the digestive system had a mean score of 53.01, while the mean score for those who perceive themselves as inadequate is 37.66.

Discussion

To assess drawings, which can be used to reveal the ideas of individuals for any event, situation, fact or concept; researchers developed and used different assessment keys related to their topic. In their study Dove, Everett and Precee (1999) analyzed the drawings of the participants regarding the relationship between river basins and the water cycle in three categories. The researchers used level of understanding (5 categories), orientation (8 categories) and content analysis in their drawing analyses. While Tunnicliffe and Reiss (1999) developed a 7 level grading key intended for animal skeleton drawing, Reiss and Tunnicliffe (2001) prepared a grading key that consists of 7 levels on the topic of the human body and organs. In addition, while Kara (2007) constituted an assessment table consisting of 6 levels in Newton's law of motion drawings, Kara, Erduran-Avcı and Çekbaş (2008) developed an assessment table/grading key that consists of 5 levels in the analysis of the topic of light. Also, in their study, Ormancı and Sasmaz-Oren (2010) developed an assessment key that consists of 0-1-2-3-4-5 grades in the evaluation of drawings. In some of the studies, however,

it is seen that drawing questions were analyzed by forming categories (Ayas & Ozmen, 2002; Calik, Ayas, & Unal, 2006). When all these available studies are analyzed, it is clear that the grading keys developed for the analysis of the drawings are usually prepared as a holistic rubric. In this study, however, the DADST-R was prepared as an analytical rubric. At the end of validity and reliability analyses performed for the rubric, it was concluded that this analytical grading tool, consisting of five sub-dimensions, can be used in a valid and reliable way to determine the ideas of the participants regarding the digestive system. In this respect, it is believed that DADST-R developed in this study can be used for further studies on other systems and human body.

In the study, the pre-service teachers' scores in the drawing test about the digestive system were examined according to the variables of gender and grade level. The examination revealed that the pre-service science and technology teachers had "sufficient performance" about the digestive system. Of the participants, the junior pre-service teachers were taught about the subject during the previous semester, while the senior pre-service teachers had learnt about it three semesters ago in the human anatomy and physiology course. Given that, their content knowledge about the subject must be adequate. Furthermore, the study also demonstrated that the pre-service teachers' total scores in the drawing test about the digestive system did not significantly differ according to the gender variable. In a similar study in the literature, Reiss and Tunnicliffe (2001) attempted to determine the students' understanding about human internal structure; compared the drawing scores in terms of gender; and found no significant difference. On the other hand, Ugur (2010) statistically evaluated students' misconceptions about the digestive system and whether such misconceptions differed with gender. In the study, the author found that gender did not have any significant impact on misconceptions. In this study conducted with pre-service science and technology teachers, a significant difference was found in favor of the senior pre-service teachers, with regard to the participants' total scores in the drawing question about the digestive system. Given that all the pre-service teachers participating in the study had been taught about the digestive system, the difference could be attributed to age. Since participants' experience and knowledge levels would increase with increasing age, the senior pre-service teachers' could have greater knowledge about the digestive system when compared to the junior pre-service teachers. Similarly, in Reiss et al.'s (2002) study on human internal structure, the seven-year-olds had some knowledge about human internal structure, but knew very little about inter-organ relationships, while 15-year-olds were found to have better knowledge of internal organs. Moreover, in a study on the digestive system, Teixeira (2000) notes that children between 4 and 10 years often preferred scientific terms to ordinary expressions in their statements with older age.

A great majority of the participants perceive themselves as moderately successful in their undergraduate education. Furthermore, the total scores of the pre-service teachers in the drawing test about the digestive system did not significantly differ according to their descriptions of their performance. However, the mean scores demonstrate that the highest value was achieved by the pre-service teachers who defined themselves as successful and the lowest value belongs to those who define themselves as unsuccessful. Arguably, there is a relationship, albeit insignificant, between the pre-service teachers' self-perceived success and their scores in the drawing test about the digestive system. On the other hand, more than half of the pre-service teachers in the study stated that they knew about the drawing method and no statistically significant difference was found between the knowledge of the drawing method and the total scores in the DADST-R. Moreover, 80% of the pre-service teachers expressed their willingness to use the drawing method in their teaching career. This is considered as an important result for the drawing method, which can be used to identify

previous knowledge and misconceptions, is employed as an alternative assessment instrument, and is effective in revealing individuals' knowledge in detail. The literature also includes certain studies on such characteristics of the drawing method. Uzunkavak (2009a) and Uzunkavak (2009b) concluded from their studies that drawings are crucial in revealing misconceptions. According to Kara et al. (2008) using the drawing method, researchers can get a clearer picture of the quality of a student's knowledge.

A majority of the pre-service teachers in the study stated that they had adequate or moderately adequate knowledge about the digestive system. This is attributed to the fact that they had learnt about the digestive system in the 'Human Anatomy and Physiology' course offered during the 5th semester of their undergraduate training. Furthermore, a significant difference was found between the scores obtained by the participants on their drawings about the digestive system in the study and their descriptions of their own knowledge levels about the subject. As might be expected, the higher the participants' knowledge levels about the digestive system, the more accurate and sophisticated their drawings about the subject would be, an expectation which was confirmed by the results of the study. Likewise, in research conducted in different fields and on different subjects, Dalgic, Hizel and Kose (1998) concluded that the frequency of correct responses increased with increasing level of education, while Bakirci, Subay, Midyatli and Unsan (2010) demonstrated that scientific expressions were more common with higher grade levels. In this study carried out with pre-service science and technology teachers, most of the participants stated their opinion that they could easily teach the subject as in-service teachers. Yet, the pre-service teachers' total scores in the DADST-R significantly differed according to their opinions as to whether they can teach the subject. As is well-known, an individual's success in a certain area is positively influenced by his/her adequacy of related knowledge and self-confidence. Similarly, Erden and Akman (1995) note that success in various tasks improves self-confidence, and increased self-confidence enhances the willingness to work and be successful. In parallel, it is an expected result that a positive relationship exists between the pre-service teachers' beliefs that they can teach about the digestive system during their professional careers and their drawings about the subject.

Educational Implications

The biology topics within the science and technology course are crucial for individuals both to know more about themselves and to live by adapting to their environments. The digestive system is one of these crucial biology topics which allow individuals to know more about their own bodies. In this context, we believe that it is important to take the opinions of pre-service science and technology teachers who are going to teach these topics in the future and to examine them in terms of different variables. An examination of the pre-service teachers' drawings about the digestive system shows that, although most of them attained a sufficient performance level, they displayed moderate or insufficient performance in some of the subscales. An important reason for this might be the systematical memorization of the names of organs, instead of performing applications on the models based on research while gaining knowledge related to the topic at different education levels. This conclusion is justified by various curriculum development studies and curricula. Even though some of the previous curricula (year 2000 science course curricula) underlined certain points in line with this notion, the education authorities in Turkey started to implement in 2005 a student-centered curricular understanding, which requires applications based on the constructivist philosophy and the literature. The digestive system is taught in the science and technology curriculum from the fourth grade to the eighth grade, under the education area of 'living and life', presented in an upward spiral with greater detail provided at each grade. However, since the pre-service teachers as the participants of the present study had learned about the digestive

system through a traditional, teacher-based approach instead of a constructivist-based one, their knowledge, perceptions and comprehension about the topic arguably involve a greater extent of memorized information. Thus, they have knowledge about the organs constitute the digestive system but lack sufficient information about their connections. From the perspective of teacher education, the only course in the curriculum which might involve the drawing method is the 'Special Teaching Methods-II', offered during the sixth semester to the pre-service teachers. In this context, further additions should be made into the curriculum in the form of drawings –both as an assessment instrument and a method used during the learning-teaching process, and also to identify previous knowledge and misconceptions – and also in the form of courses involving applications for similar methods to provide an in-depth insight. Moreover, pre-service science and technology teachers should at times be subjected to applications about such methods during their courses on physics, chemistry or biology. Additionally it could be suggested to organize in-service seminars or workshops about the digestive system and how to teach the subject for pre-service and in-service teachers.

Even though the literature presents some research attempting to reveal pre-service teachers' ideas/knowledge levels/opinions about human internal structure or the digestive system, the number of studies that examine drawings about this subject with regard to different variables is much limited. Thus, we believe that it is important to examine pre-service teachers' drawings about the digestive system according to variables such as age, gender, grade level, and knowledge level about the subject. Especially after the new curriculum reform realized in Turkey, certain studies have aimed at using drawings to identify what students at different education levels think about the digestive system and such studies may provide information about the output of the new science and technology curricula. With this purpose in mind, it could be suggested that students at different education levels, pre-service teachers, and even science and technology teachers should be asked to draw diagrams in order to identify their ideas about the digestive system and these drawings should be compared with regard to different variables.

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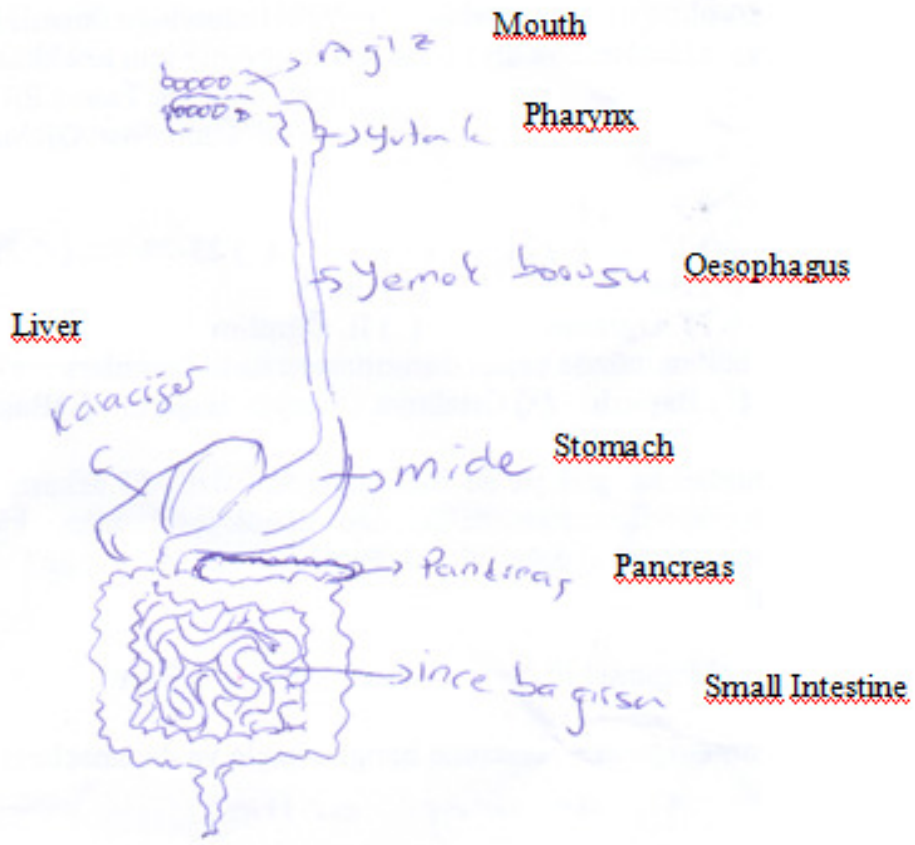
Appendix A

The Draw-A-Digestive System Test-Rubrics (DADST-R)

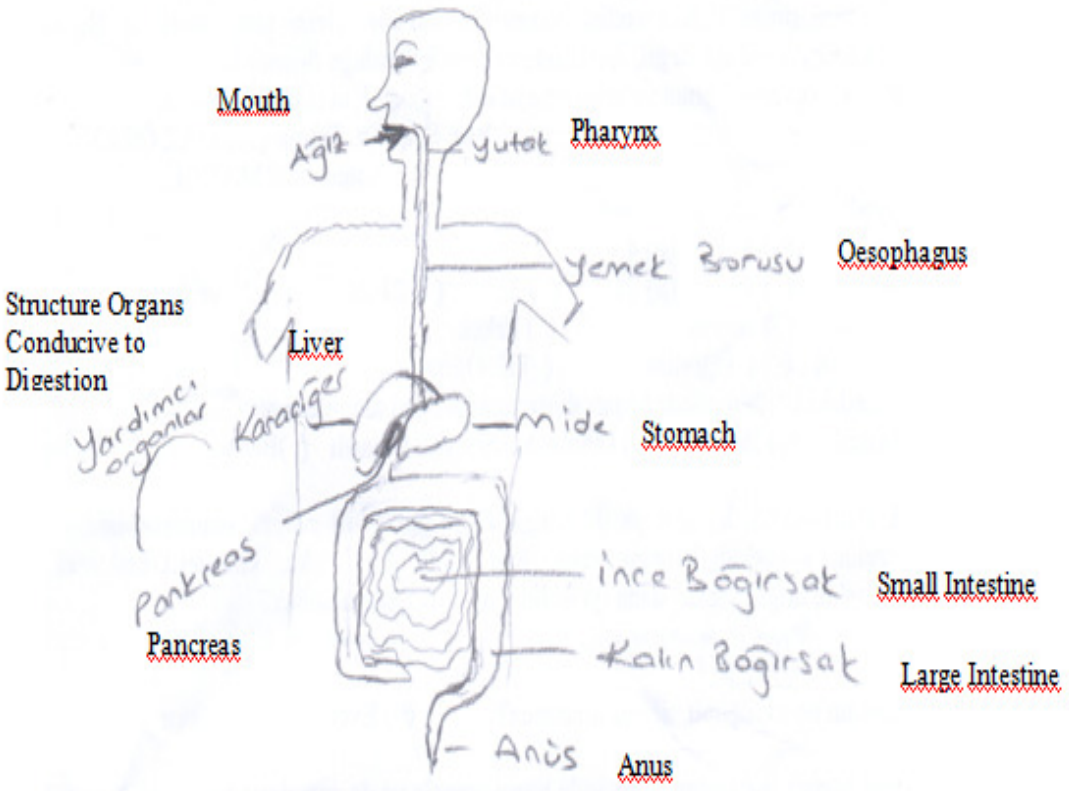
Level of Performance / Sub-dimensions	Insufficient Performance (1p)	Limited Performance (2p)	Sufficient Performance (3p)	Perfect Performance (4p)
Digestive System Organs (8 p)	*Named and drawn 0-2 organs*	*Named and drawn 3-4 organs*	*Named and drawn 5-6 organs*	*Named and drawn 7 or more organs*
Placing of Organs (6 p)	*7 or more missing*	*Indicated in correct places with 4-6 missing*	*Indicated in correct places with 1-3 missing*	*All indicated in correct places*
Structure-Organs Conducive to Digestion (4 p)	*None is present or there are unrelated structure-organs*	*2 of the structure-organs are missing*	*One of the structure-organs is missing*	*All structure-organs are indicated*
Connections among Organs (4 p)	*Deficiency in 7 or more connections*	*Deficiency in 4-6 connections*	*Deficiency in 1- 3 connections*	*All connections are shown clearly*
Shape of organs (3 p)	*Deficiency in drawing of 7 or more organs' shape*	*Deficiency in drawing of 4-6 organs' shape*	*Deficiency in drawing of 1-3 organs' shape*	*All organs are drawn and indicated correctly*

Appendix B

Examples from the Drawings



The drawing in the figure was analyzed on the basis of DADST-R and the participant obtained 71 points. The participant drew 6 of the 7 organs in the digestive system and had Sufficient Performance in the rubric's subscale of the organs. As for subscale of structure-organs conducive to the digestion, the participant drew 2 of the 3 organs and displayed Sufficient Performance in this subscale as well. Similarly, the pre-service teacher also had Sufficient Performance in the subscale of placing of organs and shapes. Nevertheless, with regard to the subscale of connections among organs, the participant's drawings had many shortcomings and she showed limited performance in this subscale.



As a result of an analysis on the drawing in the figure, the participant obtained 79 points. As for the pre-service teacher's drawing about the digestive system, he drew all of the organs in the digestive system and displayed perfect performance. However, in the subscale of structure-organs conducive to the digestion, the participant drew only 2 organs and exhibited sufficient performance. Similarly, the participant also had sufficient performance in the subscale of the placing of organs and shapes. On the other hand, with regard to the rubric's subscale of connections among organs, the participant showed limited performance with his drawing.