# The effects of Swedish Knife Model on students' understanding of the digestive system

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## Contents

# Abstract

This study was designed to examine the effect of Swedish Knife Model on students' understanding of digestive system. A simple experimental design (pretest-treatment-posttest) was used in the study and internal comparison of the results of the one group was made. The sample consisted of 40 7th grade Turkish students whose ages range from 13 to 15. The Digestion Test, comprising 7 open-ended questions and a semi structured interview were used to collect the data. The pretest results showed that the students had misconceptions about the chemical and mechanical digestion and also the functions of the digestive organs. The total results of pre and post-test comparison also revealed that Swedish Knife Model consisting of discussion, puzzle, analogy development, grid, story completion and cut and stick activities helped the students to overcome their alternative conceptions about digestion, function and location of the digestive organs.

**Keywords**: Swedish Knife Model, digestive system, understanding, 7th grade students.

# Introduction

Students' understanding and misconceptions have been the major themes of science education researches over the past five decades. There is a long history of studies examining students' alternative conceptions within biology and there has been now a substantial body of literature documenting the various types of conceptions or misconceptions held by students at different educational levels. The most frequently researched subjects in biology are genetics, cells, diffusion and osmosis, photosynthesis, environment and respiration (e.g. Sanders, 1993; Hazel and Prosser, 1994; Özkan, Tekkaya and Geban, 2004; Saka et al, 2006; Dikmenli, 2010). Other problematic topics within biology are internal organs, organ systems and the

processes within our bodies (e.g. Bahar, Johnstone and Hansell, 1999; Cuthbert, 2000; Jaakkola and Slaughter, 2002; Dalkıran, Kesercioğlu and Boyacı, 2005). Toyoma (2000), examined young children's awareness of biological transformations associated with eating and breathing. He found that young children rarely refer to biological transformation. Furthermore, the results of an international study showed that the most well-known organs generally belong to the digestive system, the gaseous exchange system and the skeletal system. Students had a better knowledge of their internal organs, but a limited understanding of their organ system (Reiss et al., 2002). Teixeira (2000), researched how young children aged 4-10 conceptualized the structure and the function of the digestive system. The results indicated that the younger children explained the function of the organs based on their daily inferences. On the other hand elder children's knowledge of the digestive system had a biological basis. Garcia-Barros et al. (2011) also examined the younger children's (aged 4-7) knowledge of digestive and respiratory systems. They also found that the younger children know about their digestive organs before formal instruction at school. But their knowledge about their functions was not adequate.

Cakici (2005) investigated 4th and 5th level (ages 10–11) students' understanding of digestion. He found that some of the students considered digestion as 'melting of foods' rather than 'breaking foods down'. Some of them also described digestion as a filtering process. They believe that stomach filters food in order to separate the useful and waste parts of the food. These findings of the study revealed that social influences and everyday language had an important effect on children's learning of the digestive process. Carvalho, Silva and Clement (2007), analyzed the topic of digestion in 63 Portuguese textbooks (1920–2005). Their findings revealed that the explanation of the digestive process in the textbooks is clear, but images and pictures are confusing. And the visual problem of the textbooks is persistent throughout the period studied. Dictatorship had effective in 1926-1974 in Portuguese. To demonstrate the influence of this period, they compared their books with French textbooks (which developed during the same period with the aim of presenting clearer representations of the digestive tract). The findings of the study suggested that confusing and inadequate visuals in textbooks may be important reason of forming misconceptions and weak learning of the digestive function. Güngör and Özgür (2009), examined the effects of the didactic factors on development of 5th grade students' misconceptions about digestive system. The results of the study revealed that the curriculum, textbooks and teachers were not effective to overcome students' misconceptions. Students had learning problems about digestive and

excretory systems. It was suggested that determination of the students' misconceptions before instruction and reorganizing the teaching environment based on these misconceptions are necessary for construction of effective learning. Teachers should enrich teaching materials to prevent learning problems rooted from didactic. Curriculums and textbooks also should contain alternative teaching activities to guide teachers.

In the light of the aforementioned studies it can be said that the organs of digestive system, their functions and the mechanism of the digestion are problematic subjects for the students at different education level. Some important causes of these learning problems may be indicated such as drawings and the confusing knowledge in the textbooks, traditional, teacher centered teaching methods, cultural interactions of the students, media and everyday language. The sources of formation of misconceptions are very much and misconceptions are quite resistant to change. It is really difficult to overcome these misconceptions and to provide meaningful learning by only using didactive methods, visuals and questioning. However, there are limited studies which prefer alternative student centered teaching methods in order to prevent the formation of students' misconceptions and also to replace the nonscientific knowledge of students with scientific ones.

Soyibo and Evans (2002) examined the effects of co-operative learning on the understanding of students, in terms of human nutrition. Rule and Furletti (2004) examined the effects of object box to teach human body system. Some other researches are also present but they only introduce teaching materials for teachers or other educators such as models or educational games. For example, Lock and Richard (1996) developed an educational game to teach structure of animals and plants for primary and second level students. Based on examined literature it can be said that there are very limited empirical studies in this subject area. Therefore it is thought that introduction of alternative teaching materials for teaching digestive system are important to increase the quality of teaching. This paper will provide a contribution to the literature both empirical data and teaching material specific for digestive system. Different student centered teaching activities were used together in this study. We used 'Swedish Knife Model" term to collect them under a title. Frequently, one method such as concept map, conceptual changing text or analogy etc. is used itself to remedy students' misconceptions (e.g. Heywood, 2002; Coll, 2005; Keppens and Hay, 2008; Aydin et al, 2009; Akamca and Hamurcu, 2009; Chin and Teou, 2009; Çalik, Okur and Taylor, 2011). These materials are also effective to overcome students' learning problems but teaching based on one material may be

boring for the students and may not provide high motivation and effective learning outcomes (Kurnaz and Çalık, 2008). From this perspective, it was used different teaching activities such as puzzle, analogy, structured grid, completion of the story and cut and stick activities and it was introduced as Swedish Knife Model. This means that anybody may use this model chancing the activities. Is is believed that this model will give opportunity to teachers to select activities according to students' levels and property of the subject.

## Significance of the Study

Digestive system which students have misconceptions is fundamental to biology knowledge because all body systems are interrelated. This means that the learning of this subject will be effective in the meaningful learning of other organ systems (Solomon et al, 1993). Students' inability to link new information about digestion may also cause misunderstanding of the concepts related to respiration, photosynthesis and energy in food chain (Sanders and Cramer, 1992). Moreover, a sound understanding of this topic may help students to gain a healthy attitude to nutrition and, in the long term, have a healthier life. Parents and the mass media also pay much attention to food and eating; thus, it is very likely that students may develop misconceptions about these concepts through their interaction with the environment in their daily lives.

An awareness of students' understanding of the subject, in terms of the digestive system, is important in the planning of teaching-learning methods for the classroom. Students' preconceptions or existing misconceptions may be a barrier for the future learning: this has been shown in a number of studies (e.g. Swell, 2002; Tekkaya, 2002). Despite the fact that student' misconceptions in this area are well known to teachers (Yip, 1998), little research has been done to identify the nature and causes of the learning problems and very limited effective instructional strategy has so far been devised to deal with this problem (e.g. Soyibo and Evans, 2002). Moreover, the method of drawing was mostly used to determine the students' misconception about the digestive organs. Drawing provides information about location, but not other aspects of body organs/organ systems (e.g. Teixeira, 2000; Reiss and Tunnicliffe, 2001; Reiss et al, 2002, Cerrah Ö, 2007). It is necessary to gather written response for examining what students know about the organs and their functions. This study attempts to address this deficiency by exploring students' understanding of the digestion and digestive organs. Hake (1998) indicates that participation of students actively in the learning process generally induces a situation in which knowledge has

to be constructed by the students themselves, so that students don't become spoon-fed. In this study, different activities were used to overcome any learning problems of the students about the digestive system and it was called Swedish Knife Model. There may be some studies comprising application of two or three methods for teaching but terming such an application as Swedish Knife Model is new for literature.

In the present study, activities were designed in a worksheet paper. We thought that the worksheet is very suitable for the combination of several activities. The aims of including these different activities are (a) to make learning more fun for the students and (b) to create repetition and enable the construction of meaningful learning. The sample of the study also increases the importance of the study. Elementary school is a place of basic instruction and, if misconceptions of the students could be minimized at this level, transferring of such misconceptions to higher grades may be prevented.

### The Problem of Study

The purpose of this study was to develop a teaching material including different activities called as Swedish Knife Model and to determine its effectiveness on students' misconceptions of digestive system. For this aim the following research questions were addressed:

1. What do the students know about the digestive system? Do they have misconceptions about the functions of the digestive organs and the mechanism of digestion?
2. Does Swedish Knife Model help students to change their misconceptions to more scientific ones?
3. How do the students assess teaching process provided by Swedish Knife Model?

## Method

### Subjects

The subjects involved in this study were 7th grade students at an elementary school in Gumushane. The teaching model under investigation was applied in two classes, a

total of 40 students. The sample was informed of the research subject in a traditional lecture before the study.

## Data Collection

The Digestion System Test (DST) was used in this study and consisted of 7 open-ended questions. The targets of the questions were given in Table 1. The purpose of this test was to evaluate the effectiveness of Swedish Knife Model, by comparing the results of the tests which was given before and after the instruction. The validity and reliability of the DST was established by giving the questions to three science teachers and by conducting interviews with those students who sat the DST. They all agree that the questions were readable, clear and appropriate. The test was administered twice: once on the first day of the study (pre-test) and once in the fifth week of the study, after application of the worksheet had been completed (post-test). The administration of the test was as follows: the papers were distributed to the students and each student wrote his/her answer on the test paper. The total time taken to complete the test was about 20 minutes.

Upon completion of the study, semi-structure interviews were conducted with 10 students. All the participants were individually interviewed. Each interview lasted about 15 min. The students were asked to asses the teaching process.

**Table 1.** Targets of the DST' questions

| Items | Targets |
|---|---|
| 1 | Explanation of digestion |
| 2 | Digestive tract |
| 3 | Mechanical digestion |
| 4 | Chemical digestion |
| 5 | Function of liver |
| 6 | Function of large intestine |
| 7 | Analogies for digestive organs and structures |

## Analysis of the Data

Different criteria are used in the literature, in terms of open-ended questions. In this study, a simple categorization was used, based on students' answers, and each of these categories was identified as different learning levels (given in Table 2).

Students' answers were graded by each of the authors and discussed, until it was agreed which category they would go into.

**Table 2.** Criteria used in the evaluation of the students' answers

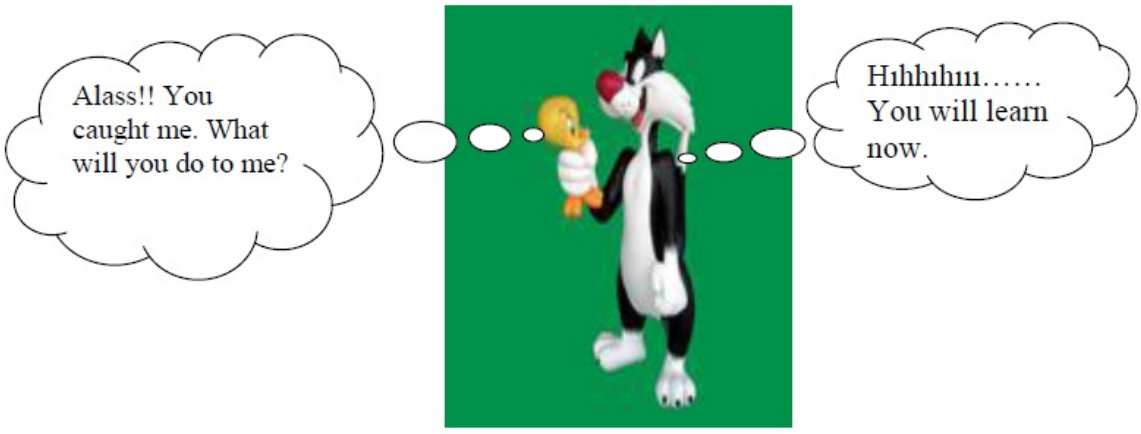
| Levels | Categories | Shortenings |
|---|---|---|
| A | Correct choice, scientifically correct and full explanations | CE |
| B | Partially correct explanations | PC |
| C | Both correct choice and wrong explanations | CW |
| D | Wrong explanations | W |
| E | Unrelated/No explanations | UE/NE |

The data from the interviews were analyzed qualitatively, after completing the data collection; records were transcribed verbatim as soon as possible. Students' answers were categorized according to agreement and disagreement.

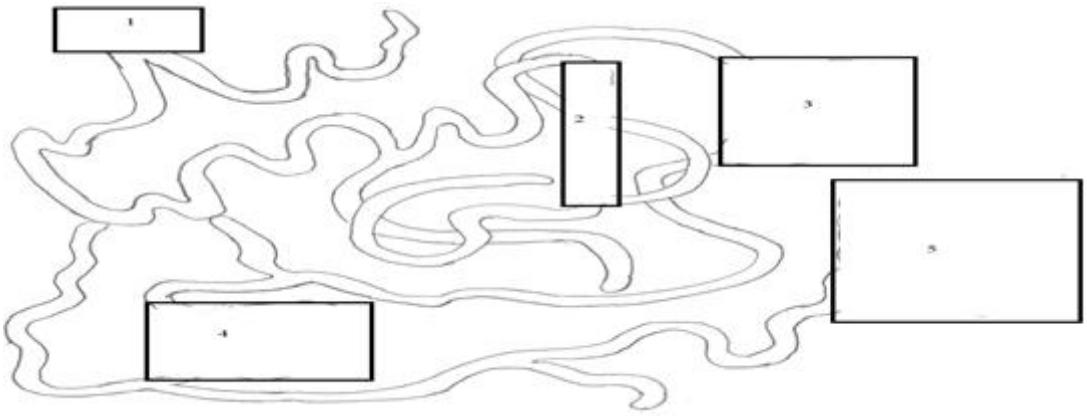
## Teaching Design

The overall study was completed in 6 hours and the prior knowledge of the students was determined by using DCT. After students had grouped and delivered the worksheets (10 mins), the treatment was started and five activities were completed in 110 minutes:

First Activity (10 mins): The lesson began with a class discussion based on the dialogue between Sylvester and Tweety. The aim of this activity was to ascertain the views of the students in terms of digestion in general.



**Second Activity** (20 mins): A general description of digestion was given by the teacher and the students were keen to solve the puzzle, in accordance with the directions given in the worksheet. Five boxes are present on the puzzle; each of them represents a structure of digestive system respectively. Students will find the correct poem for each box firstly and then they will find the drawing and analogy of this structure. After completion of this part, all of the answers of the groups were discussed and the correct answers were repeated by the teacher. The main aim of this part was to teach the functions of the organs and their structures. Following is an example from this activity.



**Poem for box 1:** I am going to stomach from the pharynx
This is a thin, long and muscular path
There is no digestion in this place

**Correct answer:** esophagus

Correct analogy:

Correct drawing:

Third Activity (20 mins): Students were given a structured grid and they were asked to write the answers. After completion of this activity, the answers of the groups were discussed in the class. This activity aimed to examine students' understanding of the topic.

| large intestine | small intestine | mouth |
|---|---|---|
| esophagus | teeth | stomach |
| liver | anus | salivary |

1. In which organs digestion occurs?
2. In which organs mechanical digestion occurs?
3. In which organs chemical digestion occurs?
4. Which of them helps digestion?

**Fourth Activity** (40 mins): 'Fill the blanks in the story' activity aimed to assess what the students had learned. These activities also provide an opportunity to strengthen students' knowledge.

I am an apple, my digestion story started in the ……. Teethes disassembled me smaller parts and I was digested ……. by saliva. Means that I digested both …….. and chemically an moved through the esophagus by the aid of muscular contraction and I conducted to the stomach. There was no digestion in the esophagus. My name was bolus now. There are strong …….. in the stomach. They digested me mechanically and also …….. digested me chemically. Now I was a chime. Stomach propelled me into the small intestine. There was a chemical digestion in the small intestine. After completion of digestion, its walls absorbed me. I changed very much, now I could pass into …….. My waste products passed into the……... and there was no …….in it. As I was passing through the large intestine, ……..was absorbed and the left was eliminated through the rectum.

**blood, large intestine, secretion, water, digestion, mechanically muscles, chemical digestion, mouth.**

**Fifth Activity** (20 mins): This is a cut-and-stick activity. The organs of the digestive system were drawn on the paper separately. The students cut them and

stick on the paper to form digestive tract. The purpose of this activity was to teach the digestive tract and correct place of the digestive organs.

# Findings

## The Results of the Test Items

The tables present the average DST scores at pre-test and post-test: the percentages of students' answers, in terms of digestion and the digestive tract, are shown in Table 3.

**Table 3.** Percentages of students' answers about the digestion and digestive tract

| | Categories | Pre-test (N=40) | Post-test (N=40) |
|---|---|---|---|
| Test Item 1 | CE | 17,5 | 20 |
| | PC | 75 | 80 |
| | CW | 0 | 0 |
| | W | 5 | 0 |
| | UE/NE | 2,5 | 0 |
| Test Item 2a | CE | 47,5 | 35 |
| | PC | 10 | 20 |
| | CW | 32,5 | 27,5 |
| | W | 0 | 0 |
| | UE/NE | 10 | 17,5 |
| Test Item 2b | CE | 42,5 | 85 |
| | PC | 30 | 7,5 |
| | CW | 27,5 | 7,5 |
| | W | 0 | 0 |
| | UE/NE | 0 | 0 |

When the pre-test findings of the first question, regarding the definition of digestion were evaluated, it was ascertained that 75% of the students stated partial definitions of digestion, such as 'nutrients become as small as fitting into the cell membrane' or 'nutrients are broken into pieces by enzymes', without expressing anything about mechanical or chemical digestion. In the post-test, the ratio of students' partial explanations increased 80%. The ratio of the CE increased 20% from 17,5%. In the first part of the second question, it was asked where digestion starts and finishes. As seen in Table 3, in the pre-test, 47,5% of the students gave correct answers, 32,5% of them had some misconceptions and 10% of them did not answer the question. The answers which were categorized under CW included that

'digestion finishes in the large intestine or it finishes in the anus'. In the post-test, these ratios changed as 35%, 27,5% and 17,5% respectively. When the findings of the second part of the test (regarding digestive system organs and structures) were evaluated, it was ascertained that the ratio of CE was 42,5% in the pre-test and that this had increased to 85% in the post-test. In the pre-test, 30% of the students gave partial explanations, without including the terms 'esophagus' and 'large intestine'. This ratio decreased 7,5% in the post-test. 27,5% of the students made CW explanations, stating that the 'pancreas, liver and kidney are also parts of the digestive tract'. Some of the students wrote the large intestine before the small intestine. In the post-test, this ratio decreased by 7,5%. In the third and fourth questions of the test, it was asked in which organs chemical and mechanical digestion occurs and the reasons for their answers. The percentages of the students' answers were given in the Table 4.

**Table 4.** Percentages of students' answers about the mechanic and chemical digestion

| | Categories | Pre-test (N=40) | Post-test (N=40) |
|---|---|---|---|
| Test Item 3a | CE | 60 | 75 |
| | PC | 20 | 15 |
| | CW | 20 | 7,5 |
| | W | 0 | 0 |
| | UE/NE | 0 | 2,5 |
| Test Item 3b | CE | 40 | 55 |
| | PC | 22,5 | 15 |
| | CW | 2,5 | 0 |
| | W | 12,5 | 17,5 |
| | UE/NE | 22,5 | 12,5 |
| Test Item 4a | CE | 22,5 | 27,5 |
| | PC | 17,5 | 10 |
| | CW | 47,5 | 27,5 |
| | W | 7,5 | 12,5 |
| | UE/NE | 5 | 22,5 |
| Test Item 4b | CE | 15 | 32,5 |
| | PC | 7,5 | 12,5 |
| | CW | 35 | 30 |
| | W | 27,5 | 2,5 |
| | UE/NE | 15 | 22,5 |

The pre-test findings of the third question, in which the chemical digestion occurring in organs was evaluated, it was found that 60% of the students had answered correctly, 20% of them had partially answered the question and 20% of

them had misconceptions. In the post-test, these ratios changed as 75%, 15% and 7,5% respectively. Students' CW answers showed that they believed that "foods are digested chemically in the large intestine or liver or esophagus". The students expressed that 'food was broken into pieces chemically by the liquid/acid secreted by these organs' and they did not use the concept of 'enzyme'. The ratios of the answers, regarding the reasons for their answers, were 40% CE; 22,5%, PC; 2,5%, CW, 12,5% W and 22,5% NE. In the post-test, these ratios changed as 55%, 15%, 0%, 17,5% and 12,5% respectively. When Table 4 was evaluated, it was seen that 47,5% of the students had misconceptions. Most of these students wrote mouth and stomach but they also added "esophagus" or "liver" or "small" or "large intestines" to their answers. In the post-test, these ratios were increased to 27,5%. On the other hand 7,5% of the students stated that "mechanical digestion occurs in the liver or large intestine or pharynx" and this ratio increased by 12,5% in the post test. Some of the students expressed how 'mechanical digestion occurs in these organs, as there is no enzyme in these organs'. Other students stated that 'mechanical digestion occurs in these organs, in order to facilitate chemical digestion'. The fifth and sixth questions of the test respectively asked about the functions of the liver and the large intestine in digestion. Table 5 represents the data related with fifth and sixth questions.

**Table 5.** Percentages of students' answers about liver and large intestine

| | Categories | Pre-test (N=40) | Post-test (N=40) |
|---|---|---|---|
| Test Item 5 | CE | 27,5 | 10 |
| | PC | 12,5 | 10 |
| | CW | 40 | 40 |
| | W | 7,5 | 15 |
| | UE/NE | 12,5 | 25 |
| Test Item 6 | CE | 15 | 37,5 |
| | PC | 25 | 35 |
| | CW | 30 | 12,5 |
| | W | 22,5 | 12,5 |
| | UE/NE | 7,5 | 2,5 |

40% of the students had misconceptions about the liver and 7,5% gave wrong answers, stating that 'the liver digests fats mechanically'. In the post-test, the ratio of misconceptions equal to 40% and the ratio of wrong answers increased to 15%. As it can be seen in the table, 30% of students had misconceptions about the large intestine and 22,5% of them gave wrong answers, using statements such as 'the large intestine digests foods' and 'it excrete wastes from the body'. In the post-test,

it was revealed that the ratio of correct answers increased 37,5%; while the ratios of wrong answers decreased 12,5%. All the misconceptions held by the sample in the pre and post-tests were given totally in the Table 6.

**Table 6.** Misconceptions of the students in the pre and pos-test

| No | Misconceptions | Pre-test F | Post-test F |
|---|---|---|---|
| 1 | Digestion is absorption of nutrient we swallowed by the organs | 1 | 0 |
| | Digestion is breaking nutrient into small pieces by grinding | 1 | 0 |
| | Digestion is separating needs from the wastes by breaking nutrient into small pieces | 1 | 0 |
| 2a | Digestion begins in the mouth and ends in large intestine | 4 | 4 |
| | Digestion begins in the mouth and ends in anus | 3 | 0 |
| | Digestion begins in stomach and end in small intestine | 1 | 0 |
| 3a | There is chemical digestion in small intestine because nutrients are absorbed here | 1 | 0 |
| 4a | Nutrients are not digested mechanically in pharynx and esophagus because there is no enzyme in here | 1 | 0 |
| | Liver | 1 | 0 |
| | Large intestine | 1 | 1 |
| | Large intestine and pharynx | 1 | 0 |
| | Esophagus and large intestine | 1 | 0 |
| | Fats are digested mechanically in small intestine | 7 | 14 |
| 5 | Liver turns toxic substance into bile | 1 | 0 |
| | Liver digests fats mechanically | 8 | 4 |
| | Pancreas secretes bile | 1 | 0 |
| | Liver facilitates the absorption of nutrients into the small intestine by the aid of bile | 2 | 0 |
| | Liver digests food chemically | 2 | 0 |
| 6 | Large intestine excretes the wastes from the body | 1 | 0 |
| | Water expels nutrient wastes and urea from the body | 2 | 0 |
| | Large intestine digests minerals and nutrient | 2 | 0 |
| | Large intestine makes chemical and mechanical digestion | 2 | 0 |
| | Large intestine transmits wastes to kidneys | 3 | 0 |
| | Large intestine save some of the fats in small intestine | 1 | 1 |

As seen in the Tables, the majority of these misconceptions were remedied after the treatment.

## The Results of the Students' Analogies

Students developed analogies for the mouth, esophagus, stomach and the small and large intestines and the frequencies of their analogies were set out in the Table 7.

Some of the students didn't write analogy for some organs because of that frequency of some organs are not equal to sample number.

**Table 7.** The frequencies of students' analogies

| *Target Concept* | *Analog* | *f* | **Similarity** |
|---|---|---|---|
| Mouth | grinder | 26 | disintegrate |
| | grater | 4 | disintegrate |
| | blender | 4 | disintegrate |
| | mixer | 3 | disintegrate |
| | electric saw | 1 | disintegrate |
| | washing machine | 2 | mixing |
| Esophagus | water pipe | 30 | transmission |
| | pump | 2 | pumping |
| | sink pipe | 4 | transmission |
| | snake | 1 | shape |
| | elevator | 2 | transmission |
| Stomach | mixer | 25 | mixing and splitting |
| | bag- store | 4 | storage |
| | blender | 4 | blending |
| | food processor | 1 | disintegrate |
| | harbor | 1 | storage and transmission |
| | leaven making machine | 2 | mixing |
| Small intestine | pipe | 14 | transmission |
| | road | 11 | transmission |
| | rope | 4 | thin and long |
| | radiator | 2 | transmission |
| | dishwashing sponge | 2 | absorption |
| | bus | 2 | transmission |
| | roots of tree | 1 | shape |
| | sink | 2 | elimination of waste |
| Large intestine | sponge | 9 | absorption |
| | waste box | 8 | containing waste |
| | trash compactor | 6 | digestion |
| | pipe | 5 | transmission |
| | road | 2 | long |
| | sewer pipe | 3 | elimination of waste |
| | water treatment plant | 2 | elimination of waste |
| | car | 1 | transmission |
| | harbor | 2 | transmission |

As seen in Table 7, students developed simple analogies, in accordance with one or two characteristics of the digestive organ/structure. Most of the students made functional analogies for mouth. Students likened the mouth to a grinder or a

blender or a mixer or a grater. Students made functional and physical analogies for esophagus. They mostly likened the esophagus to a water or sink pipe. The analogies for the stomach were mixer, bag-store and blender due to its function of 'mixing'. The small intestine was likened to a pipe, a road or a rope because of its shape and function. Two of the students likened it to a sink by putting large intestine. Same problems were present for the large intestine. Students confused the functions of large and small intestine.

**Findings of Students' Interviews**

The students were interviewed about the effectiveness of the instructional process. They were asked about their teachers' teaching methods. The answer of the students indicated that the teachers were mostly using traditional teaching methods. Student 1 indicated that:

> Our teacher tells us and then asks questions to detect what we learned. After finishing the lesson, we answer the question in our student workbook. We had a human model; he shows the organs on it.

Student 2 from other class aid that:

> Our teacher mostly tells us. But sometime we watch film related with the subject and make drama.

Students were also asked to assess the teaching process and the activities. All the students indicated that the teaching process was very enjoyable as a whole. They also stated that they learnt much more during the process. Some of the statements of the students as follow:

> …we enjoyed very much, all the activities were interesting and exciting. For example, finding poems, organs and analogs was very interesting. We have not been taught like this. It was new for us (ST3)

> The lessons were very active and interesting. We were active during the teaching process. We prefer to learn other subjects with this kinds of activities (ST5).

Students indicated that the cut-and-stick activity supported their learning of organs and their connection with each others. They also stated that the activities increased their motivation and attitudes to science.

## Discussion and conclusion

The main purpose of this paper was to evaluate the effectiveness of the Swedish Knife Model to overcome students' misconceptions of digestion and the organs of the digestive system. According to the students' pre and post-test scores, it can be said that the ratio of the students' correct explanations to the questions increased in general after the teaching process. It is thought that teaching activities supported students in actively participating in the learning process and improved their learning. Before the study, the students had misconceptions and limited knowledge about 'the definition of digestion' (see Table 3). Students had defined digestion as 'ingested food broken down into small pieces with enzymes or biting, in order to pass the cell membrane', with no mention of 'chemical' or 'mechanical' digestion. They also did not emphasize the chemical changes of the food after digestion. It was revealed that 4th and 5th grade students also described digestion as 'nutrients broken into pieces' (Teiexera, 2000; Cakici, 2005). After the application of teaching model, it was observed that the ratio of students' correct and partial explanations increased and misconceptions disappeared (see Table 3). During teaching process, the concept of digestion was generally defined; mechanical and chemical digestion was not explained in detail. It was thought that the ratio of students' partial explanations was increased through this definition.

When the replies of the students, relating to the starting and ending point of digestion, were examined before the study, it was ascertained that the students had misconceptions, indicating that digestion ended in the anus or large intestine. It was also determined that the same misconceptions existed amongst 5th grade students: these students also tended to believe that digestion occurred in the anus, as it was the last part of digestion (Cakici, 2005). After the activities, it was observed that the proportion of the students' correct answers increased, while the ratio of the misconceptions decreased (see Table 5). It was supposed that the puzzle activity supported this situation.

When the findings of the pre-test, regarding the organs and the structure of the digestion system, were examined, it was ascertained that the students had

misconceptions and missing knowledge beforehand. After the teaching process students' misconceptions and the correct answer ratios increased significantly (see Table 5). The activities of the model, 'what you've learnt' and 'cut and stick', helped the students to reinforce their learning and eliminate any misconceptions. In their interviews, students indicated that they had great fun while doing 'cut and stick' activity, supporting the claim in the previous sentence: in the pre-test, the students had marked 'pancreas', 'liver' and 'kidney' in the digestive tract. Cerrah and Urey (2010) revealed that second-year students of primary school education teaching listed the kidney and liver amongst the digestive organs. This situation can be interpreted as an indication of the transportation of misconceptions to higher education grades, if unchallenged. It attracts attention to the fact that, if the misconceptions of teacher candidates are not challenged, such misconceptions will possibly be transferred to their students. Another reason for students' misconceptions was confusion of the 'excretion' and 'elimination' concepts. Students use excretion instead of elimination, teachers also don't mention waste product of digestion as elimination. Because 'metabolism wastes' and 'digestion wastes' are expelled from the body, students use excretion as synonyms of elimination (Güngör & Özgür, 2009). When the findings of the pre-test, regarding organs and the structure of the digestive system, were examined, it was apparent that most of the students correctly identified the organs in which chemical digestion occurred and stated the large intestine in their misconceptions. In their analogies, students made simulations stating that digestion occurred in the large intestine. After the study, it was observed that the ratio of correct answers decreased, whilst the ratio of misconceptions and the number of the students stating the large intestine increased (see Table 6). The students indicated that 'nutrients were broken into small pieces chemically by the liquid/acid secretion of these organs'. Similarly, young students stated that 'nutrients were dissolved by the help of water, acid and liquid' (Teixera, 200; Cakici, 2005).

Before the study, it was revealed that students had misconceptions such as 'mechanical digestion occurs in the esophagus, the liver and the small and large intestines'. After the study, the ratio of the students stating the small intestine increased, while the ratio of the students stating the large intestine decreased (see table 5). As a result of this, students stated that 'fats are chemically digested in the small intestine. Some students stated: 'in these organs, mechanical digestion occurs, as there is no enzyme', while others stated that the reason mechanical digestion occurs in these organs was in order to facilitate chemical digestion. Although the

purpose of the large intestine was emphasized in the applied material, it was noted that students were reluctant to change their ideas. Similarly, it was very difficult to change students' misconceptions regarding the mechanical digestion of fats in the small intestine. Before the study, the students had misconceptions about the liver, such as 'it digests fats mechanically, it helps the stomach to digest, its helps the blood and it expels water and nutritional waste from the body as excretion'. After the study, it was observed that there was no significant changes in their ideas (see Table 5). With regards to the functions of the large intestine, before the study, it was observed that there were misconceptions and wrong answers. The students defined the liver as 'filtering wastes and expelling them from the body' and likened the large intestine to a sponge, as a result of its filtering function. Prokop and Fanéoviéova (2006) revealed that university students knew that it was the job of the large intestine to absorb nutrients. After the study, it was observed that the ratio of misconceptions and wrong answers were decreased (see Table 5).

When the analogies of the students were evaluated, it was revealed that the students formed simple metaphors, according to one aspect of the organs, and such metaphors allowed misconceptions to emerge. None of the students developed an analogy by paying attention to chemical digestion through the mouth; instead, they formed metaphors according to the shape of the small intestine and they stated that the large intestine ground waste and the stomach saved nutrients (see Table 7). We attempted to change these thoughts through discussions held in the classroom.

Despite treatment, some students were reluctant to change their misconceptions. In general, the Swedish Knife Teaching Model positively affected students' learning and had a positive effect in banishing most of their misconceptions. And also the process made science enjoyable for them; it was a different experience for the students. The findings of the interviews supported this situation. The activities in the model can be changed or some other activities may be added according to students' and topic characteristics. It is suggested to applicators of this model to change the definition of digestion in the first activity by adding chemical and mechanical digestion concepts. Teachers should be give feedback the students' answers in each activity part. Teachers need effective teaching activities, however they had no time to develop new materials. This kind of studies would be guiding for teachers.

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