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Thinking about digestive system in early childhood: A comparative study about biological knowledge

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Abstract: The current study aims to explore how children explain the concepts of biology and how biological knowledge develops across ages by focusing on the structure and functions of the digestive system. The study was conducted with 60 children. The data were collected through the interviews conducted within a think-aloud protocol. The interview data revealed that 5-year-olds think that the digestive system before the stomach and the stomach is a large empty space. Results similar to those found for 5-year-olds were also found for 7-year-olds. The children in the 10-year age group were able to offer comprehensive explanations on the digestive system and 10 children from this age group stated that while some of the food eaten is discharged from the body, some of it is retained in the body. While children from all the age groups develop thoughts on the basis of vitalistic thinking, intuitive and animistic thinking patterns were observed in some of the 5-year-olds. Within the scope of the obtained results, it is thought that carrying out the biology education given at the elementary education level through the supporting methods and materials of the vitalistic thinking will contribute to the understanding of the biology and raising the interest of the children on the topic. In addition, teachers' usage of physical materials in teaching processes could be useful in order to abolish the limitation of animistic thinking on the acquisition of biological knowledge in early childhood.

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PUBLIC INTEREST STATEMENT

Biology education is one of the most important component of science education in elementary education level in Turkey. For this reason, it is important that teachers and program builders should understand the factors that affect the acquisition of biological knowledge according to age levels. The aim of this research is to determine how children in primary education level in Turkey are getting biological knowledge according to their ages. As a result of the research, it is understood that pre-school children were under the influence of animistic thinking and that they were able to get away from this effect in primary school and obtain biological concepts by means of vitality thinking. It is important for educators to know that children are learning biological knowledge under the influence of animistic thinking and they must acquire a scientifically based dimension over time, which is important in terms of the permanence of early biology education.

Subjects: Educational Research; Primary/Elementary Education; Childhood

Keywords: early childhood; biological knowledge; digestive system; think-aloud protocol; drawing

1. Introduction

The developments in the fields of developmental psychology and cognitive psychology have speeded up the quest for the answers to the question of how discipline-specific knowledge is formed. One of these disciplines is biology. Investigation of children's knowledge about the concepts of biology, living and non-living entities, and efforts to understand how biological knowledge is formed have gathered momentum in pre-school education research in the last 30 years. The basis of the research directed toward how children make sense of a biological concept and construct it is laid by Piaget' works (1929/1960) (Zaitchik, Iqbal, & Carey, 2014). As a result of a series of works, Piaget (1929/1960) found out that a child's classification of an entity as a living thing depends on whether it demonstrates a human-specific vital activity or not (e.g. a bicycle is a living thing as it moves). According to Piaget, this basic viewpoint of children results from the dominant influence of animistic thinking on cognitive processes. On the basis of Piaget's works, while it might be difficult to explain physical, psychological and biological entities, and facts for children, it can be concluded that in the explanation of natural phenomenon, children are affected from human actions and animistic thinking (Goldberg & Thompson-Schill, 2009; Schult & Wellman, 1997).

Different explanations have been offered in the last 30 years about how a biological concept or phenomenon is possessed. Carey (1985) argues that under the influence of intuitive psychology biological information is intuitively understood and defines this as intuitive biology. Though Keil (1992, 1994) could not determine where biological information comes from, he states that concepts of biology are acquired autonomously and defines this as autonomous domain of biology. In more recent years, Hatano and Inagaki (1997) have maintained that biological information is acquired vitalistically and defines this as vitalistic biology.

Carey is the first person to systematically explain the acquisition of biological knowledge (Slaughter & Lyons, 2003). Though Carey (1985) agrees with the opinions stated by Piaget (1929/1960) about the effect of animistic thinking on the acquisition of biological knowledge, his point of departure from Piaget is that children prefer animistic thinking and personifying not because their biological concepts have not attained the sufficient cognitive maturity, but because they do not have adequate biological knowledge. In a similar manner, Inagaki and Hatano (1996) argue that pre-school children can explain the personification of biological concepts and animistic thinking. Carey (1985) states that pre-school children focus on the concepts such as *animal, life, death, growth and baby* as biological concepts and tend to explain these concepts on the basis of their intuitions from an anthrophocentric viewpoint. Carey (1988) found that children, before they are 10 years old, are under the influence of naïve psychology and explain knowledge intuitively. Similarly, Piaget (1929/1960) also stated that before the age of 10, biological knowledge develops intuitively in children. According to Carey (1988), for children to learn a biological concept autonomously, they need to know various entities related to biology and can explain at least one specific domain of biology. However, the existing research (Inagaki & Hatano, 1996, 2002; Nguyen & Rosengren, 2004; Piaget, 1929/1960) shows that children aged 5–6 experience difficulties in explaining the difference between living and non-living organisms precisely. On the other hand, experiences are stated to distance children from intuitivism and direct them to more sophisticated patterns of biological knowledge acquisition (Geerdts, Van de Walle, & LoBue, 2015).

Keil (1992, 1994) contends that for children to acquire knowledge about an autonomous domain of biology, the knowledge and its related domain should be in compliance with each other. In a similar way, Wellman and Gelman (1992) argue that connection should be established between the knowledge of a domain of biology and the related concept. Keil (1992, 1994) states that for children to explain any biological concept, they need to posses beliefs in the depths of their minds about the

concept and they make their first explanations about a biological phenomenon on the basis of functional-teleological approach. Teleology is termed as "Erekbilim" in Turkish. Erek means "*designed to be realized*" (Turkish Language Society, 2016). There are two types of teleological viewpoint. First is selective teleology discussing that knowledge is innate as the most basic dimension of thinking and continues to develop throughout the growth process. Second is promiscuous teleology arguing that teleological reasons are derived from the knowledge targeted by the child and cannot be restricted to any category belonging to the phenomenon up to the end of development (Kelemen, 1999). According to Keil (1992), the child explains a characteristic belonging to a biological entity as it exists to help the survival of the entity (e.g. The woodpecker has a sharp beak; thus, they can make holes in trees to shelter).

Hatano and Inagaki (1994) revealed that up to the age of 8, children make use of the concept of vitalist biology as a teleological point of view as well as autonomous domain of biology in the construction of biological knowledge. In a series of works conducted by Inagaki and Hatano (1993, 1996, 2002), it was found that children make explanations on the basis of "*ki*" in Japanese and "*living*" and "*vital energy*" in Turkish to explain biological concepts. According to Inagaki and Hatanoü, "*living*" is a term frequently used by children to explain biological phenomena and entities. It is particularly utilized to explain concepts and phenomena such as nutrition, growth, disease, and body functions to a great extent. For instance, in a study, the students stated that there is vital energy within nutritional items and using it, organs can carry out their vital functions (Inagaki & Hatano, 1993). Vital biology viewpoint is commonly observed among children aged 4–7 (Inagaki & Hatano, 2002; Slaughter, Jaakkola, & Carey, 1999). The reason for vital biology to emerge in this age period is closely associated with the fact that working memory starts to serve one of its main functions; that is, executive function, precisely in this age period (Zaitchik et al., 2014). The existing research (Diamond, Barnett, Thomas, & Munro, 2007) shows that this skill is much more influential on school readiness and academic achievement than IQ, mathematics or reading skills. Therefore, particularly in the last 10 years, the amount of research in the field of vitalistic biology has been increasing.

Opfer and Gelman (2001) in a study, asked children to predict the behaviors exhibited by certain living things and tried to determine the reasons behind their predictions. They concluded that while 12% of the five year olds emphasized the concepts of life, death, survival and functioning, the percentage of those emphasizing the same concepts was found to be 41 among the ten year olds. Jaakkola and Slaughter (2002) on the other hand, asked questions to children about 13 inner and outer parts of human body (e.g. Where is your heart? Why does your heart beat? etc.). At the end of the study, 33% of the four-year olds, 92% of the six-year olds, and all of the children aged 8 and 10 emphasized the bodily functions such as "living", "surviving" or "not dying". On the basis of this research, it can be argued that the concepts of "living" and "vital energy" embedded in vitalistic biology do not only belong to Japanese children but they are also encountered in different cultures in general (e.g. American and Australian children) (Inagaki & Hatano, 2006).

Though the amount of research focusing on these three main viewpoints of how biological knowledge is acquired is increasing, there is a paucity of research focusing on how biological knowledge changes over time and depending on the developmental process (Geerdts et al., 2015). Teixeira (2000) attempted to determine the knowledge of children aged at 4, 6, 8, and 10 about the digestive system. At the end of the research, it was found that the children aged 4–5 made intuitive explanations in general and particularly the children aged 8 and 10 made biology-based explanations about the digestive system. Carvalho, Silva, Lima, Coquet, and Clément (2004) also tried to determine the opinions of children aged at 5–10 about the digestive system. They reported that the children aged 5–7 have limited knowledge about the system and biology-based explanations mostly develop at the age of 8–10. Geerdts et al. (2015) conducted a study to determine the biological knowledge of children about pets and found that daily life experiences facilitate the learning of biological concepts. Majority of the few studies reported in the existing literature was conducted on children who were at their early childhood period. Inagaki and Hatano (2002) argue that biology education should

be initiated during pre-school period. However, as there is very little research in the literature, it is very difficult to make strong judgments about how biological knowledge is acquired (Teixeira, 2000). In addition, it is stated that biological knowledge is affected from cultural factors (Goldberg & Thompson-Schill, 2009); thus, contributions of studies to be conducted within different cultural contexts are deemed to be necessary in the field (Geerdts et al., 2015). Evans (2001) proposed a different viewpoint, contending that religious and cultural beliefs are influential on the acquisition of biological knowledge and the explanation of related phenomena. Given the delineations above, the current study is believed to be a great contribution to the literature as it will provide data about biological knowledge of Muslim children hardly ever dealt with in the literature and make comparisons among different age groups. Inagaki and Hatano (2002) argue that children commonly utilize vitalistic biological explanations to explain bodily functions such as the digestive system and the respiratory system; therefore, culture-specific studies should be conducted to understand the explanations made about biological concepts in different cultures. Therefore, the current study was conducted over the digestive system to see biological knowledge development and explanations. Answers to the following questions were sought within the context of the current study:

(1) What is the children's knowledge about the structure and functions of the digestive system across ages?

(2) What is the biology-based viewpoint employed by the children to explain the structure and functions of the digestive system?

2. Methodology

The current study aiming to investigate how children explain the knowledge related to biological concepts and how biological knowledge develops by focusing on the structure and functions of the digestive system is a phenomenological study based on social constructivist philosophy. Social constructivism maintains that cultures direct their members, they shape the visible and audible things and impart a specific view of the world to their members (Patton, 2014). In phenomenological research, a concept, an event, a phenomenon, or a domain can be called a phenome (Kvale, 1996). Such research focuses on the structure and meaning of the experiences lived in relation to a phenome by a group of people or an individual (Creswell, 2007; Patton, 2014). The purpose of this research is to elicit information about the experience possessed by the participant (Fraenkel & Wallen, 2008). As, within the current study, the development of knowledge related to a biological concept stated to be affected by cultural factors as well as cognitive processes is investigated, the research was designed to be a phenomenological qualitative study based on social constructivist philosophy.

2.1. Study group

The study group of the current research comprised pre-school children and first-grade and fourth-grade elementary school children from a city located in the northwest of Turkey. The children's ages vary from 5 to 10. In the construction of the sampling, typical case sampling technique, one of the sampling techniques used in qualitative studies, was used. This technique is used to underline the ones who are normal or average among the participants (Miles & Huberman, 2015). The mean age was calculated to be 7.3 (SD = .82). The personal information of the participants is presented in Table 1.

Table 1. Personal information of the participants

Schooling								
Gender	**Pre-school**		**First grade**		**Fourth grade**		**Total**	
	Age 5		**Age 7**		**Age 10**			
	f	**%**	***f***	**%**	***f***	**%**	***f***	**%**
Male	10	50.0	10	50.0	11	55.0	31	51.7
Female	10	50.0	10	50.0	9	45.0	29	48.3
Total	20	100.0	20	100.0	20	100.0	60	100.0

2.2. Data collection procedures

The data of the study were collected using think-aloud protocol. Think-aloud protocol is employed to elicit cognitive processes and internal thoughts so that what is happening in the brain while the individual is conducting a performance task such as drawing or problem-solving can be understood (Patton, 2014). This interview is conducted while the individual is performing the related task and the researcher can make interpretations to understand the internal processes. A similar data collection technique was also used by Piaget (1929/1960) in his research. The data collection process of the current study was carried out similar to that of Teixeira (2000). The think-aloud protocol within the current study was conducted with individual children through face-to-face interviews. First required permissions were granted from the school director and teachers, and the suitable schedule was planned. The interviews with the children were conducted in pre-set times and days in settings suitable for individual interview within the school (e.g. the room of the vice director, teachers' room, guidance and counseling office).

At the beginning of the interviews, a short introduction was made for the researcher to meet the children and to inform them about the research. When the data collection process was initiated, a bar of chocolate, a pencil and a piece of paper including a human figure whose outer lines are indicated were given to the child. First, the child was asked to eat the chocolate. Then, the child was asked to draw the path of the chocolate on the given human figure using the pencil. Then, a conversation was started about the organs indicated and what might be their functions. Each interview was tape-recorded. Each interview lasted for 20–30 min.

2.3. Data analysis

The procedure followed in the analysis of the collected data is similar to the one followed by Teixeira (2000). First, the children's opinions stated during the interviews were classified into two groups depending on whether they are related to the structure of the digestive system or its function. Under the heading of the structure, opinions about the organs viewed to be related to the digestive system, locations of these organs and their shapes were collected and under the heading of function, opinions about which processes occur in each organ through which the food passes, whether the ingested food remains in the body and what happens in the body were collected.

The interviews conducted to elicit how biological knowledge is explained and to classify it according to ages, the interviews were transcribed. A total of 168 min tape recording was transcribed into 62-page data file in Word. The interview conducted with each child was individually analyzed and types of their explanations were classified. The emerging classification lists were sent to an expert specialized in the field of pre-school science teaching and to another expert specialized in the field of biology education. Between the lists constructed by the researchers and the experts, Cramer's V correlation coefficient was calculated and Cramer's V was found to be .82. In this way, reliability and validity of the classifications constructed were established and agreement between the experts was found to be high (Pallant, 2007).

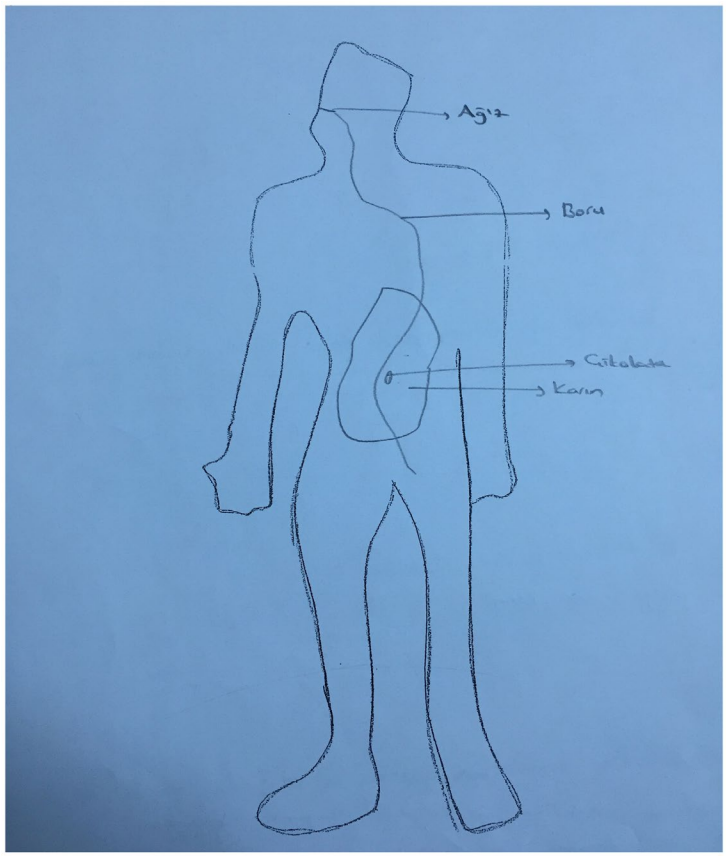
3. Findings

The data collected during the interviews will be presented below. First, the data collected from the children about the structure and function of the digestive system and how children explain biological knowledge will be presented below:

3.1. The structure of the digestive system

From the drawings of the children and the data collected during the interviews, it was found that the children divided the digestive system into four parts within the body. These are mouth; pharynx, laryngeal and oesophagus; abdomen and anus. However, some differences depending on ages were detected in the indication of these parts. Though some of the five-year olds ($f = 7$, 35%) stated that the food goes from mouth to stomach through a pipe, they did not name this pipe as (oesophagus) (see Figure 1). Pharynx on the other hand was only indicated by some of the 10-year olds ($f = 6$, 30%). This also holds true for stomach. High majority of the five-year olds ($f = 12$, 60%) and some of

Figure 1. Representation of five years old children (pre-school education).

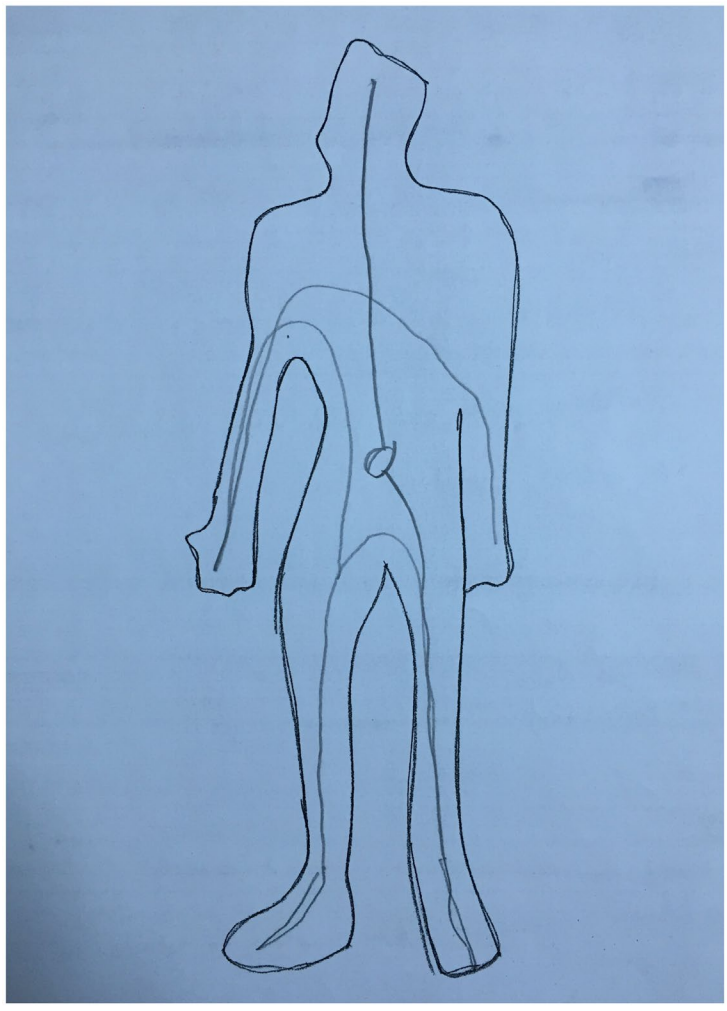


the seven-year olds (f = 7, 35%) used the word "tummy" instead of stomach (see Figure 2); yet, 10-year olds used the word "stomach". In terms of using the biological names of the organs, the 10-year olds are much more successful. In addition, the five-year olds were determined to be viewing abdomen as an empty space. Some of the seven-year olds (f = 5, 25%) and majority of 10-year olds (f = 13, 65%) divided abdomen into several different parts (see Figure 3). Intestines were indicated the least by the five-year olds (f = 1, 5%) and the most by the 10-year olds (f = 13, 65%). The children avoided illustrating and talking about anus. High majority of the children did not include anus in their drawings (f = 48, 80%); yet, some children mentioned anus and pooh, though hesitantly, during the interviews. In general, the seven-year olds did not mention anus at all, some of the five-year olds (f = 5, 25%) and the 10-year olds (f = 7, 35%) mentioned anus as an organ.

3.2. Functions of the organs operating within the digestive system

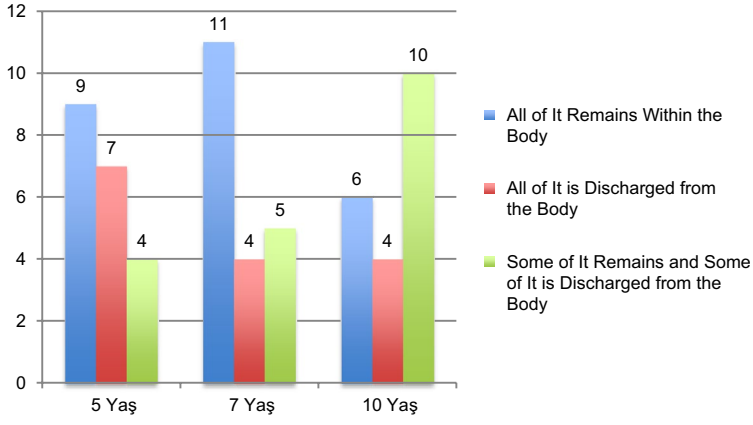
Almost all the children in the study group stated that food enters the body through the mouth and passes through the pharynx, laryngeal, and oesophagus and then is processed in the stomach. Most of the children defined the oesophagus as a pipe or a tube through which food goes to the stomach (f = 39, 65%). It is an interesting finding that during the interviews, high majority of the children stated that food in the stomach is somehow crashed or dissolved. Thus, it can be argued that basically, the children know the function of the stomach in the digestion process. However, many of the five-year olds and some of the seven-year olds stated that the process of digestion ends after the stomach. The functions of the intestines were only mentioned by 5% of the five-year olds, 25% of the seven-year olds, and 65% of the 10-year olds. In general, children defined the intestine as a channel carrying food crashed or dissolved in the stomach to the anus. The function of the anus was defined by some children as discharging the harmful parts of food from the body.

Figure 2. Representation of seven years old children (elementary first grade).



The children's responses to the question "what will happen to the chocolate at the end can be classified under three categories: (a) all of it remains within the body, (b) all of it is discharged from the body and (c) some of it remains and some of it is discharged from the body. The distribution of these responses across the ages is shown in Graph 1.

Graph 1. The distribution of these responses across the ages.



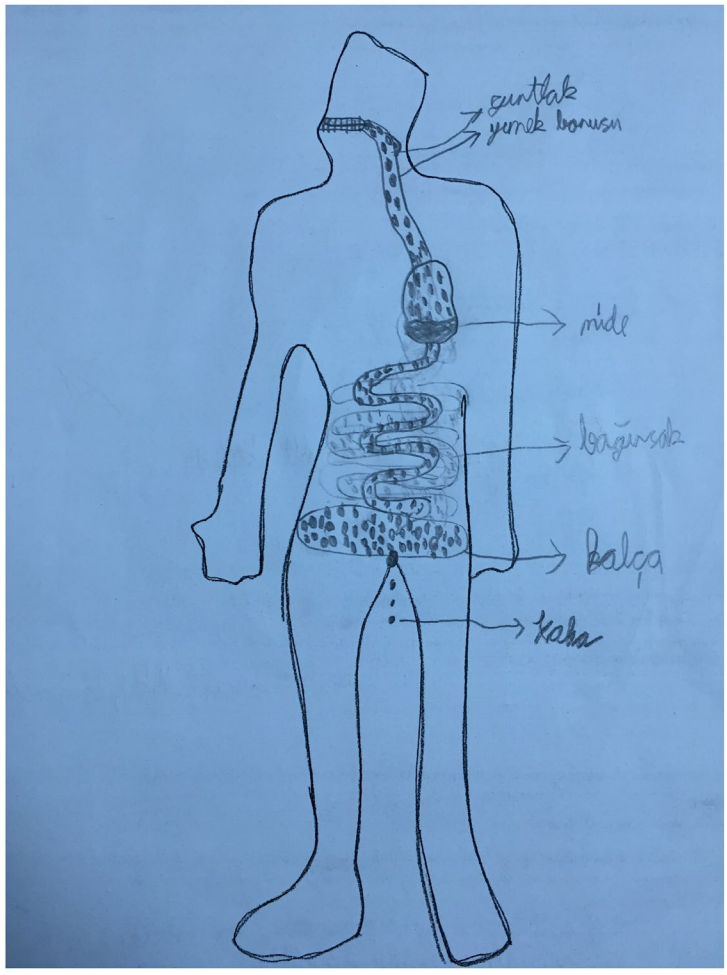


Figure 3. Representation of 10 -year-old children (elementary school fourth grade).

When Graph 1 is examined, it is seen that high majority of the five-year olds attending pre-school education institutions ($f = 16$, 80%) stated that all of the food is either retained in the body or discharged from it. Half of the 10-year olds who are in the last year of their elementary school education ($f = 10$, 50%) stated that while some of the food is retained in the body some of it is discharged. Some of the excerpts of the students demonstrating their opinions about the themes are presented below.

(C) stands for the child, (G) stands for the researcher.

(a) A sample dialog for the theme of all of the food is retained in the body.

(G) Well, the chocolate you have eaten went through a pipe (meaning oesophagus) into your stomach. Then, what happens to it in your stomach?

(Ç) It remains in the stomach. Then while we are running or doing any activity, they are dissolved in the stomach and give us the energy necessary to move.

(G) Is this true for the whole chocolate?

(Ç) Yes, all of it is dissolved in our stomach.

(G) and does the chocolate digested give you the energy that you need to move?

(Ç) Yes, because it may travel across the body. It produces energy for us, gives us power.

(G) While the chocolate is dissolved, it spreads throughout our body but it never goes out. Do I understand you correctly?

(Ç) Yes, it does not go out.

(M. A. a 5-year old pre-school child)

(b) A sample dialogue for the theme of all of the food is discharged from the body.

(G) From the picture you drew, it is understood that the chocolate you ate went through the oesophagus into your stomach. Then you showed that it came to your intestines. How much of the chocolate do you think came to the intestines?

(Ç) All of it. I ate all of the chocolate.

(G) Don't you think that some of it may remain in other organs?

(Ç) No it can't. They (showing the organs he/she drew) can not keep the chocolate. If they keep it, they will burst out.

(G) How does an organ burst out?

(Ç) If we continually eat and what we eat is not discharged from the body, then the organ bursts out.

(G) I see. Is this true for all kinds of foods? Or is it only chocolate that is completely discharged from the body?

(Ç) All of the food we have eaten is discharged from the body; nothing is left in the body.

(Z. R. a 7 year-old elementary first grade student)

(c) A sample dialogue related to the theme of some of the food is retained in the body and some of it is discharged.

(G) A. When your drawing is examined, it is seen that you sent the chocolate from the stomach to the intestines and then you discharged it through the anus. What I want to ask is: Does this pooh account for all of the chocolate?

(Ç) No, it can't be all of it.

(G) Why? What happens to the part of the chocolate staying inside?

(Ç) The chocolate is digested in the stomach and some useful compounds of it remain in the body. They are useful for our body. They give us energy. They make use our brain work.

(G) In this case, is the part that is discharged from the body not useful?

(Ç) Yes, the part that is discharged is harmful to the body or useless for it.

(G) Is this true for all foods? Or, only for chocolate?

(Ç) The useful part of everything we eat is retained and utilized. Useless part of it is discharged.

(T. O. a 10 year-old elementary school fourth grade student)

Different from the themes given above, some children presented striking opinions about the digestive system. Particularly among the five-year olds, B. G. is the only child indicating the chemical processes occurring in the digestive system.

(G) You said after the intake of the food, it goes to the stomach. Good. Then, what happens to the chocolate in the stomach?

(Ç) It goes to the stomach after being swallowed. When it comes to the stomach, it contacts with water and it is dissolved in the water. When it is dissolved, it disappears in the stomach.

(G) Well, what kind of water is this in the stomach? Is it like the water we know?

(Ç) No, it is not like the water we drink. It is different, but the water we drink may add to it in the stomach. I do not know. But it is different.

(B. G. a 5 year-old pre-school child)

Three of the seven-year olds emphasized the conversion of food within the body. In the opinion of the children, some of the chocolate is converted into blood and mixed into blood. However, they did not state any opinions about how food is converted to blood.

(G) What happens to food coming to the stomach?

(Ç) The chocolate turns to blood there.

(G) Well, how does this happen?

(Ç) Hmmmm. I do not know but I know that some of food is converted to blood before being digested in the stomach.

(S. Ç. 7-year old elementary school first grader)

Only some of the 10-year olds (f = 6, 30%) mentioned the pharynx. None of the children in the age groups of five and seven years did draw the pharynx in their drawings and did mention during the interviews. Six of the 10-year olds; on the other hand, depicted the pharynx in their drawings and mentioned it during their interviews.

(G) Can we talk about the thing that you depicted as the pharynx here? It is quite interesting for me. What is the function of the pharynx?

(Ç) The pharynx pushes the chocolate we chew in the mouth into the oesophagus.

(G) How does it push?

(Ç) When we gulp down, the pharynx pushes it.

(N. A. a 10-year old elementary school fourth grader)

When all the findings related to the structure and function of the digestive system were evaluated altogether, it was found that the five-year olds having pre-school education think that the digestive system comprised the mouth and the tummy, and high majority of them (f = 16, 80%) think that all the food is either retained in the body or discharged from the body. Another interesting finding related to the five-year olds is that they are the children most mentioning pooh (f = 8, 40%) among all the groups. From many respects, the seven-year olds attending elementary school first grade expressed opinions similar to those mentioned by the five-year olds. Fifteen (75%) of the seven-year olds stated that all the food is either retained in the body or discharged from the body. However, the seven-year olds mentioned the names of more organs in the digestive system. High majority of them (f = 15, 75%) were able to clearly indicate the oesophagus that was named by the five-year olds as pipe. Most of the seven-year olds again (f = 12, 60%) used the term of stomach and some of them (f = 5, 25%) emphasized the concept of intestine. As expected, the most sophisticated depiction and theme of the digestive system were constructed by the seven-year olds. The 10-year olds were more successful in the depiction of the organs and the use of their biological names than the other age groups. Moreover, the emphasis on the intestine (f = 13, 65%) and anus (f = 7, 35%) was also found to be more in this age group. Half of the children in this age group (f = 10, 50%) stated that some of the food in the digestive system is retained in the body and some of it is discharged from the body.

3.3. Findings related to the basis of biological knowledge and types of its explanations

In the literature, there are three basic schools of thought to explain how children construct and learn biological concepts (Carey, 1985; Inagaki & Hatano, 2006; Keil, 1992, 1994). In general, the traces of vitalistic biology can be clearly seen in the explanations of the opinions of the children from all the age groups. On the explanations provided by the seven-year olds, the effect of autonomous domain of biology can be seen. Again, within the explanations given by one of the seven-year olds, the traces of intuitional and animistic thoughts can also be seen. Examples of these are given below.

(a) Examples of the opinions based on vitalistic biology:

(G) What do you think happens to the chocolate coming to the stomach here?

(Ç) It is dissolved here. It is discharged as pooh. Half of it is discharged and the other half is retained.

(G) Well, do you think that the part retained in the stomach serves any function? Why does it stay in the stomach?

(Ç) Because if all of it is discharged, we can not grow.

(G) The remaining helps us to grow?

(Ç) Yes, because it gives us energy. For growth.

(S. B. a 5 year-old pre-school child)

(G) What happens if the food is not discharged from our body?

(Ç) We become ill.

(G) Why?

(Ç) Because the food is accumulated in our stomach. And when they accumulate too much, they become harmful. They make us ill.

(M. A. a 7 year-old elementary school first grader)

(G) If it is as you stated, what happens to food not discharged from our body and remaining inside?

(Ç) They give us energy. Thus, we can carry out our functions. If we are not fed good enough, we can not survive. People may die of hunger.

(O. K. a 10 year-old elementary school fourth grader)

(b) An example for the opinions based on autonomous domain of biology:

(G) What do you think happens to the chocolate in the stomach?

(Ç) It is dissolved there.

(G) How does the chocolate dissolve in the stomach?

(Ç) While waiting there, it melts.

(G) What about other foods? Do they dissolve?

(Ç) Yes, they do. Thus, our stomach feels relaxed.

(G) Then what happens to the dissolved food?

(Ç) They become blood. They are distributed across the body.

(G) How do you think food is converted to blood? Do you know this?

(Ç) I do not know this.

(U. D. a 7 year-old elementary school first grader)

(b) An example for the opinions based on intuitive and animistic thought:

(G) Foods come through the mouth. Then, how do they reach the stomach?

(Ç) There is a pipe. This pipe works like a lift. It sends the food in the mouth into the stomach.

(G) How does food go to the stomach, through the pipe?

(Ç) No, not the pipe. This pipe is just like a road. And it goes down from the mouth. It is like a pen falling down from a desk.

(A. I. a 5 year-old pre-school child)

It was observed that vitalistic explanations are dominant among the explanations proposed by the children from all the age groups for the structure and function of the digestive system. The children view the food as a source of energy and think that lack of food can be a cause of illnesses. Opinions based on intuitive and animistic though were clearly detected in the explanations presented one of the five-year olds. He/she likened the oesophagus to a lift and this is a clear indication of this. Opinions based on autonomous domain of biology were generally observed while the children were explaining the travel of the food after the stomach. Though children stated that the food is converted to things chemically and structurally different (e.g. blood), they did not express any opinions how this happens.

Elementary education consists of pre-school and primary school education in Turkey. While five-year-old children (60 months) getting into the pre-school education, 5.5-year olds (66 months) are getting into primary school by their parent's consent, or six-year olds (72 months) are getting into mandatorily. In the pre-school curriculum, science education is conducted under the topic of science activities. Also, pre-school education program needs specified learning centers that are defined for definite disciplines to be built in the classroom. Education activities in specific disciplines are conducted in this learning centers. Science learning center is also advised in the curriculum (National Ministry of Education, [NMoE], 2013a). The main purpose of the science education is to provide a basic level of scientific thinking skill for children. Biology is one of the science disciplines in the pre-school curriculum. The purpose of the biology in the pre-school curriculum is to develop children's awareness toward non-human livings, understanding, and respect for them and acknowledge their right to live. Also, the curriculum also covers the understanding operation of systems in the human body and a basic introduction of specific organs (NMoE, 2013a).

Primary school is consist of children between seven and 10 years old in Turkey. Seven and ten years old children groups of this research are in primary school. Children in first grade (7 years old) sees topics in science education as a part of social studies. In first-grade social studies curriculum, "body" is placed as a topic that should be taught (NMoE, 2013b). But in fourth grade, Science Class are taught and scientific knowledge on "structure in livings, organ, and systems" are covered under "Livings and Life" topic. In fourth grade, "Solving Puzzle of Our Body" consist of eight earning and 21 class hours under "Livings and Life" subdomain (NMoE, 2013c). The excretory system is also included in this class. By considering a place of biology education in relevant education stage in Turkey's education system, it can be said that findings of the research discussed above are not surprising. From a brief summary of the findings generally, it can be said that in pre-school term and first-grade children are under the effect of animistic thinking but in fourth grade (10 years) they have based on scientific based biological knowledge.

4. Results and discussion

It is a difficult process for children to attain a cognitive understanding of the digestive system. A process starting concretely goes through invisible processes at the end of which the food undergoing structural and chemical changes is discharged from a different part of the body. Thorough comprehension of this whole process requires the possession of basic biological knowledge. Particularly as what happens in the body cannot be clearly seen, the importance of biological knowledge increases to a great extent.

The current study intends to figure out the biological knowledge and the basis of this knowledge possessed by the 5-year olds (pre-school children), 7-year olds (elementary school first graders) and 10-year olds (elementary school fourth graders) about the digestive system. In light of the findings of the study, some conclusions were reached. Paucity of similar research in the literature makes it difficult to discuss the results from different viewpoints. The findings of the current study seem to be partially concurring with the findings reported by Banet and Núñez (1997), Nuñez and Banet (1997), Teixeira (2000), Carvalho et al. (2004), Çakıcı (2005) and Özgür and Çıldır Pelitoğlu (2008).

The findings of the current study show that many of the children in the study group start the digestion at the mouth and finish at the stomach. This is particularly notable in some of the five-year olds and seven-year olds. High majority of the 10-year olds extend digestion to include the anus. Again high majority of the five-year olds and some of the seven-year olds think that abdominal area is an empty space. Some children in these age groups did not mention the stomach and they identified the entire abdominal region as an area where food is stored. The 10-year olds; on the other hand, divided abdominal region into parts such as the stomach and the intestines. These findings are parallel to the findings of Teixeira (2000).

The group most successful in terms of using organ names is the 10-year olds. This is the only group mentioning the pharynx. Majority of the five-year olds and some of the seven-year olds do not know the name of oesophagus and call it as pipe. On the other hand, it is clear that all the age groups have basic information about its function. Some cultural obstacles in front of drawing and mentioning the disposal of the food in the form of poop were observed. While the 5-year olds more clearly depicted and expressed the term of pooh, high majority of the 7-year olds and the 10-year olds avoided drawing it. Moreover, the children in these age groups made great effort to avoid using the terms of anus and pooh during the interviews. Some children first asked whether it would be shameful to talk about these concepts and then talked about them. Thus, it can be argued that the children experience difficulty in distinguishing the daily language from the academic language and this can be considered to be normal for children in these age groups.

The best known organ in terms of its function is the stomach. All the children drawing and mentioning the stomach defined it as an organ dissolving the food and digesting it. The functions of almost all the organs were correctly explained by the 10-year olds. Yet, they did not mention some detailed information such as peristalsis and contractions of the oesophagus. In Çakıcı's study (2005), the stomach was identified as an important organ of the digestive system. Teixeira (2000) also reached similar conclusions in his study and reported that with increasing age, explanations presented by the participants about organs and the system in general became clearer. Carvalho et al. (2004) found that high majority (92%) of the children aged at 5–10 possess correct information about the basic function of the stomach. As cited by Özgür and Çıldır Pelitoğlu (2008) from Bachelard (1938), this might be because of the overt emphasis put on the stomach in course materials. Thus, according to Banet and Núñez (1997), for a clear understanding of the digestive system, rather than individual organs, the system should be taught as a whole.

Teixeira (2000) emphasized the importance of chemical processes in the digestive system and stated that high majority of the children could not explain these processes and they experienced difficulties in explaining the conversion of the food into blood or excrement. In a similar manner, Nuñez and Banet (1997) emphasized that teaching the chemical processes involved in the digestion to students can be really difficult. In Çakıcı's study (2005), majority of the children thought of digestion as dissolving the food and made no comment on chemical processes involved. Özgür and Çıldır Pelitoğlu (2008) found that though the 6th graders know the name of the organs in the digestive system, they do not have adequate information about the functions of the organs. Carvalho et al. (2004) also found that the children do not have adequate information about the mechanical and chemical processes of the digestive system and defined this situation as learning obstacle. In the current study, in a similar manner, particularly the children in the age group of 5 years old expressed the opinion that the food is crashed or dissolved in the stomach. Even among the opinions of the 10-year olds, nothing related to the chemical processes was detected.

Another important finding of the study is that high majority of the five-year olds and seven-year olds believe that all the food digested in the digestive system is either retained in the body or discharged from the body. The five-year olds and seven-year olds generally finish the digestive process in the stomach. While the children arguing that all the food is retained in the body think that this food is utilized as energy in the body, the children maintaining that all the food is discharged from the body think that the food dissolved and is converted into energy when it enters the body and then

all of it is discharged from the body; otherwise, the human body can not stand the accumulation of the food intake. Half of the 10-year olds stated that some of the food is retained in the body and some of it is discharged from the body in the form of poop. Teixeira (2000) and Carvalho et al. (2004) reported that with increasing age, children share more detailed information about what happens to digested food.

The most frequently utilized opinions to explain biological knowledge are generally based on vital biology. In the explanations provided by all the age groups, the effect of vitalistic thinking is clearly visible. Inagaki and Hatano (2002) also reported that vitalistic explanations are commonly detected among the explanations of children aged 4–10 and in the explanations of diseases, the children in the age group of 4–6 completely adopted vitalistic explanations. One of the children emphasized that lack of energy may lead to diseases and even to death. Particularly, this age group (4–6 years old) makes use of vitalistic explanations to explain life and death (Slaughter et al., 1999). Intuitive and animistic explanations are more commonly seen among five-year olds (Piaget, 1929/1960). Within the context of the current study, one of the children likened the oesophagus to a lift carrying food from the mouth to the stomach and this is a clear indication of intuitive and animistic thinking; however, such explanations were not given by any of the 7-year olds and 10-year olds. At this point, Piaget (1929/1960) contends that the reason for the use of animistic and intuitive explanations is uncompleted cognitive maturation. Carey (1985); on the other hand, stresses that the reason for this is lack of information. In the current study, lack of explanations based on this viewpoint among the 7-year olds and 10-year olds supports both of these arguments. In general, at this point, it can be difficult to make a decision. However, the author of the current research thinks that both arguments are complementary to each other and cognitive development having reached the desired level will enhance information processing skills and information itself and animistic and intuitive thinking will be replaced by empirical explanations. Explanations based on autonomous domain of biology were mostly used in situations not requiring empirical evidence (e.g. conversion of food into blood and poop) but whose factuality is not suspected of. It was found that vitalistic biological explanations were used by all the age groups making up the study group of the current research; animistic and intuitive explanations were also observed among the explanations provided by the five-year olds and seven-year olds and in cases that could not be proved or were not known how to happen, explanations based on autonomous domain of biology were presented.

By considering all of these arguments, it is becoming more important that biology education on primary school level should be constructed by taking cognitive restriction of children into account. Especially, physical materials have to be used in order to smooth away from limitations on animistic thinking. Also, teachers should make improvements in classroom design towards this. Another educational inference of the research is that teachers should realize the effect of an autonomous mechanism of children on learning (Hatano & Inagaki, 1997) and they should prefer physical activities in order to let them restructure their knowledge towards biological concepts.

5. Suggestions

In light of the findings of the study, following suggestions were made.

A large number of the children could not determine the physical and chemical processes related to the digestive system. Thus, teaching of body functions including those of the digestive system and other systems in the education programs should be revised.

Given that the children are hesitant about using some terms (e.g. anus, poop), more academic language should be used in the instructional process and it should be emphasized that using such words is quite normal within academic discussions. Knowledge about a field is directly related to correct use of the basic concepts of this field. Therefore, regardless of the issue under discussion, children should be encouraged to use the correct concepts.

Future research may look at how naïve biological knowledge develops and how it evolves as a result of environmental impacts and learning-teaching process. Such research is believed to have implications in many fields ranging from program development to instructional techniques and methods.

The current study has some methodological limitations. If the future research to be conducted in this field adopts experimental designs, it may yield better explanations for the causes in the field.

This research has some limitations on methodological aspects. By designing further research in an experimental pattern, it can be said that the said method will be helpful for the determination of other factors (teaching method, program, material etc.) which are effective on obtaining knowledge on biology. Also, this research has conducted with a limited working group. It is believed that research with a wider working group may show wider results and it is believed that this will contribute and provide stronger discussion to the literature.

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