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The Persistence of Misconceptions about the Human Blood Circulatory System among Students in Different Grade Levels

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Abstract: In this paper, it is aimed to investigate the persistence of misconceptions in the topic of the human blood circulatory system among students in different grade levels. For this reason, after discussions with biology educators, two tests consisting of open-ended questions were developed by the researcher and administered to students in four different grade levels. The first test was administered to 319 5th and 7th grade students in elementary school and the second one was administered to 400 1st and 4th year university students studying in the departments of elementary school teaching, science education and biology education. Data were analyzed using qualitative methods and a number of misconceptions were detected in different grade levels. According to the results of the study, the distributions of the percentages of students' misconceptions demonstrate a decreasing trend from elementary school students to university students without totally disappearing. The reason of this situation might be the persistence of misconceptions that are difficult to overcome. Due to their functionality, students continue to possess certain misconceptions. Hence, this characteristic of misconceptions should be considered while planning teaching activities in teacher education programs.

Keywords: human circulatory system, misconceptions, persistence of misconceptions

Introduction

When the content of natural sciences is investigated, it can be concluded that different kinds of knowledge such as phenomena, concepts, principles and generalizations, theories and natural laws are involved (Kaptan & Korkmaz, 2001). One of the fundamental focuses of science education

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is to teach students scientific concepts because they are the building blocks of scientific knowledge (Yağbasan & Gülçiçek, 2003). However, research shows that students may come to classroom with conceptions that are different from scientifically acceptable ones (Hewson & Hewson, 1984; Mintzes & Wandersee, 1998). These kinds of conceptions are generally reported as alternative conceptions or misconceptions (Gabel & Bunce, 1994, p.305; Griffiths, 1994; Nakleh, 1992; Wandersee et al., 1994, p. 179; cited in Tanner & Allen, 2005). In this paper, we will use the term misconception according to Sneider and Ohadi (1998). Thus, students' explanations are accepted to be plausible and functional for students.

As stated in the research literature, studies about alternative conceptions especially in biology education have been a developing issue (Duit, 2004 cited in Tanner & Allen, 2005). It is noticed that most of the research about alternative conceptions has been conducted in physics and chemistry education whereas biology education involved one quarter of those studies (Duit, 2004 cited in Tanner & Allen, 2005). However, one of the fundamental aims of biology education is to teach and supply the use of biological concepts, most of which are abstract and difficult (Çakmak & Hevedanlı, 2004). In this respect, misconceptions are the initial point of studies in biology education in terms of concept teaching.

The reason why misconceptions are important to study emerges from their characteristics and their effects on students' learning. One of the proposals about misconceptions is their persistence and resistance to change using traditional instructional strategies (Wandersee et al., 1994 cited in Tanner & Allen, 2005). Due to this reason, students' conceptions should be investigated meticulously by educators because not all conceptions that are held by students are scientifically acceptable. Several misconceptions have been detected in the literature related to biological phenomena (Mintzes, 1984; Arnaudin & Mintzes, 1985; Prokop, Kubiatko & Fančovičová, 2007; Prokop, Prokop, & Tunnicliffe, 2008; Prokop, Fančovičová, & Tunnicliffe, 2009; Prokop, Uşak, Özel & Fančovičová, 2009). Although Güneş and Güneş (2005) have found that the blood circulatory system was easily comprehended by 7th (59.5 %) and 8th (63 %) graders, the research literature reports a number of studies that have been conducted with students in different grade levels in which several misconceptions about the blood circulatory system have been identified.

A review of the research literature shows that several studies have been conducted involving misconceptions about the blood circulatory system that are held by high school (Yeşilyurt & Gül, 2012) and university level students (Micheal, 1998; Sungur, Tekkaya & Geban, 2001; Micheal et al., 2002; Paleaz, 2005; Prokop & Fančovičová, 2006; Bahar, Özel, Prokop & Uşak, 2008; Sezen & Çimer, 2009). One of the most frequent misconceptions in this topic can be stated as follows: "The heart has the function to store, filter, prepare or clean the blood" (Tekkaya, 2002). Arnaudin and Mintzes (1985) conducted a study with students in the 5th, 8th and 10th grades, college freshmen, non-biology majors and biology majors to identify their alternative conceptions about the human blood circulatory system. The findings of the study indicated several alternative conceptions related to the structure of blood, function of blood, structure of the heart, function of the heart, circulatory pattern, circulatory/ respiratory relationship and closed circulation. Despite measuring various frequencies in different grade levels, a number of these alternative conceptions were reported to remain stable among elementary, secondary and college level students: an indication of the tenaciousness nature of these alternative conceptions and their resistance to change (Arnaudin & Mintzes, 1985). Similar to students, biology teachers were found to hold misconceptions in the same topic (Yip, 2010). Such misconceptions held by teachers were transmitted to their students through the questions that the teachers asked (Kwen, 2005).

Despite various strategies used to cope with misconceptions, they cannot be totally

overcome or they reappeared after a while when it was thought that they had been remedied. The reason for this situation might be that some factors have been ignored or were not realized. According to Brouseau (1993), a learning obstacle is present which resists learning of the concept in such as a situation. The learner's functional information, strategies, methods and reasoning result in learning obstacles. According to this researcher, the factors that result in learning obstacles create their own reliability and validity areas. The learning obstacle is functional for the learner. In other words, a new concept is utilized in daily life and it does not prevent learning of other concepts. At the same time, the elements that lead to learning obstacles show themselves as being erroneous, ineffective and dysfunctional in a scientific framework. The learner does not accept his or her concept as erroneous, ineffective or dysfunctional unless he or she experiences contradiction. This situation results in the persistence of misconceptions despite increasing grade level.

Aim and Significance of the Study

To observe the trend in students' conceptions or understandings of biological phenomena with changing grade level, students in different grade levels have been studied in the same research (Nagy, 1953; Arnaudin & Mintzes, 1985; Reiss & Tunnicliffe, 1999; Reiss & Tunnicliffe, 2001; Reiss et al., 2002; Prokop, Kubiatko & Fančovičová, 2007; Prokop, Fančovičová & Tunnicliffe, 2008; Prokop, Prokop & Tunnicliffe, 2008; Prokop, Uşak, Özel & Fančovičová, 2009; Teixeira, 2010). As a result of such studies, the conceptions held by students in varying age groups may be compared and necessary improvements can then be incorporated in classroom instruction.

The purpose of this study is to determine misconceptions about the blood circulatory system that are held by students in different grade levels and to identify their resistance change during various instructional activities. Thus, it could be possible to get idea of how students' conceptualizations about the blood circulatory system change from elementary to university level.

Methodology of the Research

The Research Design

The present study is a survey study. Such type of studies aims to identify the characteristics of views of a wide sample (Büyüköztürk et al., 2010; 231).

The Sample

The sample of the study comprised a total of 719 students of whom 319 students were from two different elementary schools in the city center of Balıkesir District and 400 students were from Balıkesir University. The number of students in each level is summarised in Table 1.

The sample was formed using the purposive sampling method. The study did not also focus on the comparison of the results with respect to gender (Bahar, Özel, Prokop & Uşak, 2008) rather interpretation of data with respect to years is addressed.

At the time of the study, elementary first level in Turkey was made up of 1st to 5th grades and elementary second level was made up of 6th to 8th grades. Subsequently,

Table 1. *Distribution of Students in the Different Grade Levels*

Level	No. of students
Grade 5 elementary (aged 11 years)	146
Grade 7 elementary (aged 13 years)	173
Year 1 Biology Education Department	30
Year 4 Biology Education Department	27
Year 1 Elementary School Teaching Department	103
Year 4 Elementary School Teaching Department	97
Year 1 Science Education Department	81
Year 4 Science Education Department	62
Total	719

students continue in high school from 9th to 12th grades. Based on the scores of the university entrance examination which is taken at the end of 12th grade, students have the opportunity to continue their education at universities. Elementary school teaching and science education at university level involve four year programs whereas biology education is a five year program.

The purpose of the selection of different grade level students for the sample is to compare and interpret the change in misconceptions of students. The blood circulatory system is among the biology topics in the 4th and 6th grades science course. The circulation of blood in the body and the organs that are involved in the circulation are introduced in elementary 4th grade. In the 6th grade, the outcomes of the course include systemic and pulmonary blood circulation, the structure of blood, blood transfusion and the health of the circulatory system. Hence, 5th and 7th grades have already covered these topics in the year before they were involved in the study. For university students, the biology course is a common course in the curricula of the aforementioned three departments. Selected topics are also common for all of them. Biology and science education students are taught this topic in general biology and anatomy courses, while student teachers involved in elementary school teaching are taught the topic in biology and laboratory applications courses. Thus, for this reason these three departments were included in the study. The first and fourth years university students have studied about blood circulation in high school. Hence, the university level students have studied the circulatory system topic at least five times including for the "private entrance exam preparation course". It was therefore considered that the sample was appropriate for investigating the persistence of misconceptions about the blood circulatory system.

Research Instrument

Two different research instruments that involved open ended questions were utilized to determine misconceptions of students about this topic. For elementary level students, the 4th and 6th grade sub-topics – "the anatomy of the blood circulatory system organs", "the functions of blood circulatory system organs" and "functioning of the blood circulatory system organs together" formed the basis of the questions. The instrument for university level students was mainly developed from questions which considered their evaluation ability on the blood circulatory system.

The research instruments were developed by considering students' cognitive development levels and the levels of objectives related to the blood circulatory system in related teaching programs. In this research, misconceptions about systemic, pulmonary circulation, blood vessels, blood and blood groups concepts possessed by different age group students and their resistance to change were highlighted. In scientific studies, students in different age groups can be compared on the same subject.

Table 2. *Moderation of the Common Question for All Levels*

THEME	University 1-5	Elementary 4-7	Moderation
Systemic and pulmonary circulation	1. Show the path that blood follows in systemic and pulmonary blood circulation. 2. What is the reason of systemic and pulmonary blood circulation? Please, explain.	1. Write all that you know related to pulmonary blood circulation in the box below. Show it by drawing on the figure beside. 2. Write the things that you know related to the systemic blood circulation in the box below. Show it by drawing on the figure beside.	University students were asked about systemic and pulmonary blood circulation together. Elementary students were asked about each of the circulation types in different questions in order to provide opportunities for expression and drawing simplicity.

Table 3. *Misconceptions about the Blood Circulatory System*

Misconceptions about the blood circulatory system	Elementary		University		χ^2	*p*
	Grade 5	Grade 7	Year 1	Year 4		
	f(%)	f(%)	f(%)	f(%)		
1. Blood is produced in the heart.	117 (80.1)	84 (48.6)	63 (29.4)	16 (8.6)	65.89	.0001
2. All veins contain dirty blood.	58 (39.7)	65 (37.6)	83 (38.8)	59 (31.7)	1.04	.792
3. The function of the heart is to clean blood.	81 (55.5)	86 (49.7)	122 (57.0)	63 (33.9)	6.88	.076
4. All arteries contain clean blood.	90 (61.6)	67 (38.7)	87 (40.7)	50 (26.9)	15.02	.002
5. The heart produces necessary energy for the body.	74 (50.7)	55 (31.8)	46 (21.5)	23 (12.4)	28.40	.0001
6. The heart is the center of feelings.	72 (49.3)	39 (22.5)	38 (17.8)	13 (7.0)	39.21	.0001
7. Systemic circulation is much more important in function than pulmonary circulation.	78 (53.4)	122 (70.5)	106 (49.5)	37 (19.9)	27.65	.0001
8. Arteries are closer to the heart in the body.	71 (48.6)	99 (57.2)	114 (53.3)	47 (25.3)	13.48	.004
9. Systemic and pulmonary circulations are independent from each other and they take place in different parts of the body.	68 (46.6)	97 (56.1)	69 (32.2)	44 (23.7)	15.72	.001
10. The function of pulmonary circulation is to help systemic circulation.	78 (53.4)	94 (54.3)	114 (53.3)	73 (39.2)	3.11	.375
11. Pulmonary circulation takes place in the upper part of the body while systemic circulation takes place in the lower part of the body.	48 (32.9)	68 (39.3)	52 (24.3)	32 (17.2)	10.01	.018
12. Clean blood circulates in the left side of the body while dirty blood circulates in the right side of the body.	58 (39.7)	111 (64.2)	124 (57.9)	40 (21.5)	23.48	.0001

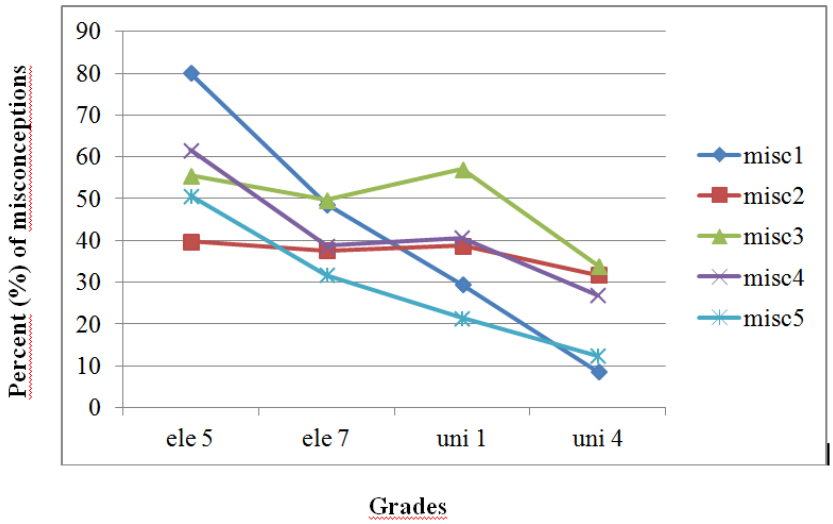

Figure 1. *The Percentage Distribution of Students' Misconceptions for the First Five Proposals*

system in related teaching programs. In this research, misconceptions about systemic, pulmonary circulation, blood vessels, blood and blood groups concepts possessed by different age group students and their resistance to change were highlighted. In scientific studies, students in different age groups can be compared on the same subject. For this reason, several questions in the research instrument had to be moderated. Table 2 demonstrates how this moderation was performed:

The appropriateness of the content validity and reliability of the moderated questions was confirmed by the opinions of 3 subject area experts.

Both research instruments include the common questions below:

Ali possesses the following information about the blood circulatory system. Which aspects of this information are correct? Put ☒ to the correct ones.
Blood is produced in the heart.
There is dirty blood in all veins.
The function of the heart is to clean blood.
There is clean blood in all arteries.
The heart produces the necessary energy for our body.
The center of our feelings is the heart.
Systemic blood circulation has a more significant function than pulmonary blood circulation.
Arteries in the body are closer to the heart.
Systemic and pulmonary blood circulation is independent from each other and they occur in different parts of the body.
The function of pulmonary blood circulation is to assist systemic blood circulation.
Pulmonary blood circulation occurs in the upper part of the body; systemic blood circulation occurs in the lower part of the body.
There is clean blood in the left part of the body and dirty blood in the right part of the body.

Also, there were two questions which were administered to only university level students about blood circulation figure and blood compability.

Data Analyses

Content analyses were performed on the data collected from the research instruments for both elementary and university level students. Percentage distributions were obtained to quantify the data. In addition, the chi-square test was performed to investigate the significance of the data from the first question which involved 12 misconceptions by using SPSS 16.0 program. The findings of two questions that were administered to only university students are presented different from the findings about the elementary graders to support the gathered data. Inside

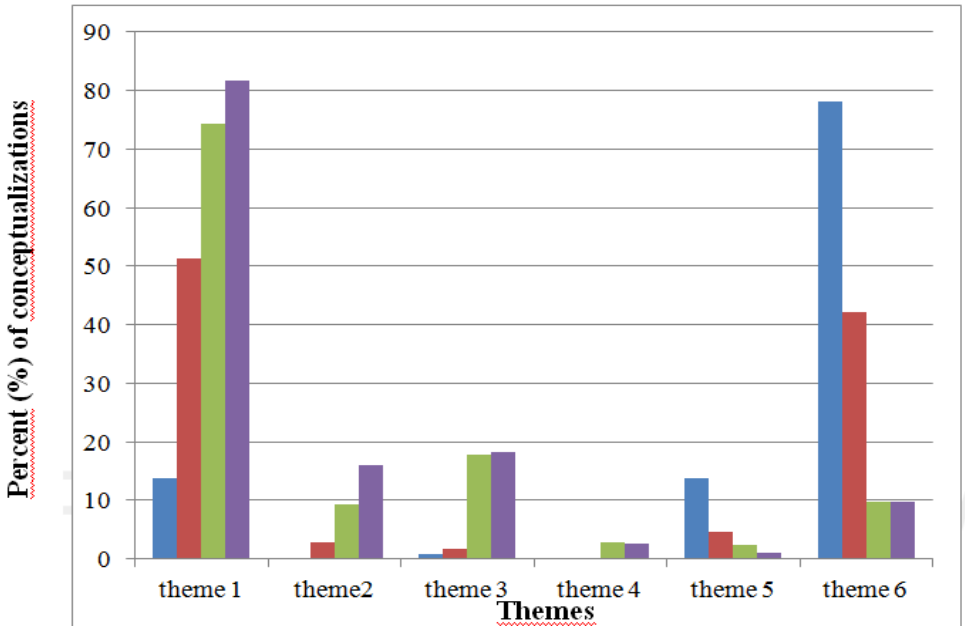

Figure 2. *Percentage Distribution of Student conceptualizations about Systemic Blood Circulation*

passages of the findings of last two questions, several percentage values are provided inside parentheses where the value in the first place refers to the lower grader and the value in the second place refers to the higher grade for mentioned student groups. Also, in the responses of the final question, the total of percentages is more than 100 % due to the presence of more than one theme in one student's response.

Results

Misconceptions related to the Human Blood Circulatory System

A question that involved 12 proposals was given to students in order to determine their misconceptions about the blood circulatory system. This question was common for all students who participated in the study and each of the proposals is a misconception. The students were asked to indicate which of the proposals were correct. Students' correct acceptation of the proposals meant that they held misconceptions about these proposals (see Table 3 for the distributions by grade level). Misconceptions were found to be persistent to instructional activities whether they had epistemological roots (1, 3, 5, 6), didactical roots (11, 12) or cultural roots (2, 4). Even several of them (2, 3, 11) demonstrated a small change in percentage distribution with respect to increasing grade level. In other words they were influenced to a minimum level (Table 3).

Figure 1 demonstrates the change in the percentage of students' misconceptions for the first five proposals. As can be seen, misconceptions show different tendencies as the grade level increases. However, it is clear that they tend to be possessed by all students regardless of their education levels.

According to the results, 80.1% of students studying in elementary 5th grade stated that the function of the heart was to produce blood. This ratio showed a decreasing trend until university 4th year and remained at 8.6%. Generally it was seen that the highest percentage of misconceptions were encountered in elementary 5th grade and this ratio tended to decrease in subsequent years. However, on moving from elementary 5th to 7th grade (7, 8, 9, 10, 11, 12) and elementary 7th to university 1st year (2, 3, 4), there were opposite trends leading to an increase in the percentage of misconceptions. In comparison, the percentage of misconceptions in university 4th year was less that in elementary 5th grade. However, these misconceptions could not be totally eliminated in university 4th year.

When chi-square test results for each of the items were investigated, it is seen that there was not a meaningful difference among grade levels in terms of the percentage distributions of the items 2, 3 and 10 since $p > .05$ (Table 3). This means that

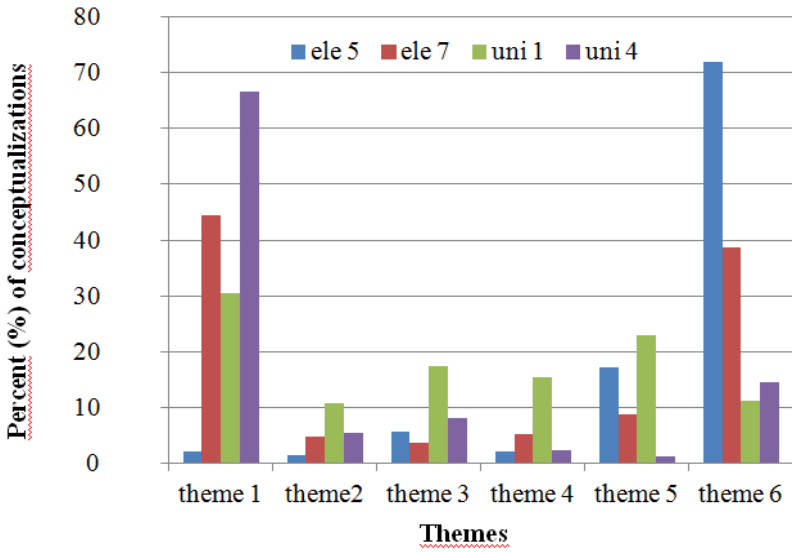

Figure 3. *Percentage Distribution of Students' Conceptualizations about Pulmonary Circulation*

misconceptions are persistent independent of grade levels. In other words, those misconceptions are statistically significant. There is a significant difference among the results for the items 1, 4, 5, 6, 7, 8, 9, 11 and 12 as $p < .05$. The items 1, 4, 5, 6 and 10 show a decreasing trend as grade level increases. On the other hand, the items 7, 8, 9, 11 and 12 demonstrate a rise in the percentages from 5th to 7th grade and then continue to decrease again.

When the numbers of misconceptions in each grade level were analyzed in detail, the following trends were encountered: Students who asserted that all of the proposals were correct held misconceptions for each of the proposals and such students were encountered only among elementary 5th and 7th grades. Students who did not put any sign to the proposals – who stated that all of them were incorrect – did not hold any misconceptions (2.1 % in elementary 5, 1.7 % in elementary 7 and 1.9 % in university 1st year) and the percentage of these students was very low when compared to university 4th year students (13.4 %). When the number of misconceptions was analyzed in terms of grade level, the number of the most frequent misconceptions was 7 for 5th grade with a percentage of 19.9 %, while the number of most frequent misconceptions was 6 for 7th grade with a percentage of 18.5 %. Moving to university year 1, the number of most frequent misconceptions fell to 5 with a percentage of 23.8 % and this number decreased to 3 with a percentage of 18.3 % in the 4th year of university.

The percentage of students who held the largest number of misconceptions clearly increased from elementary 7th grade to university 1st year. This value shows a relative decrease through university 4th year

Figure 4. *A Demonstration Involving Misconceptions related to the Human Blood Circulatory System*

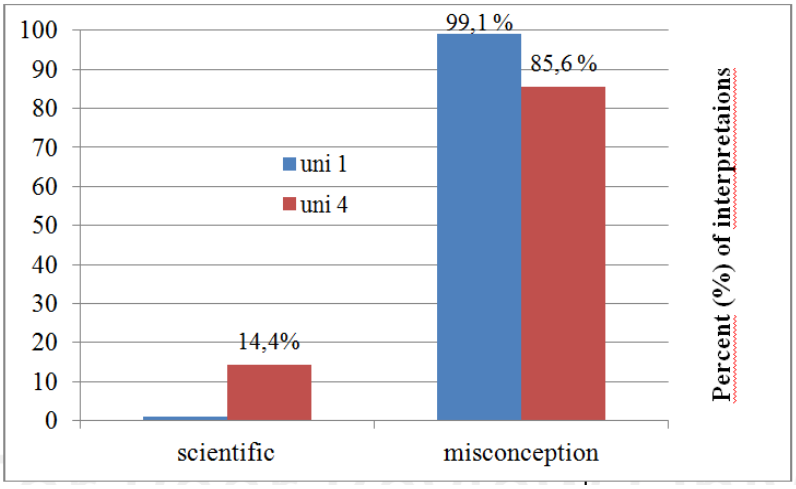

Figure 5. *University Level Students' Interpretation of the Figure*

again without totally being eliminated.

Findings about the Function of Systemic Circulation

According to the analysis of this question, students' responses were collected under six themes: (1) To deliver clean blood to the body and bring dirty blood back to the heart / To enhance blood circulation / To send blood to the organs. (2) To carry food and oxygen to the cells. (3) To clean blood in the heart/liver/lungs. (4) To produce energy. (5) To enhance blood circulation in certain places of the body such as in the head, hand, feet, wrists, upper/lower/middle body, neck. (6) No response. Their percentage distributions are summarised in Figure 2.

As stated above, the themes except 1 and 2 refer to misconceptions (themes 3, 4, 5). Especially elementary level students did not respond to this question. This situation can be accepted since a general introduction is made for the circulatory system in the 4th grade. However, this result cannot be accepted for elementary 7th graders. Even students in university level mixed the function of systemic circulation with pulmonary circulation (cleaning of blood in the lungs) and held a number of misconceptions (cleaning of blood in the heart, energy production, circulation of blood in certain body parts) in this respect.

The rise in the percentage of misconceptions about systemic circulation (3, 4) at university level is a paradox. The possibility of the formation of such misconceptions in the instructional environment is very high.

Findings about the Function of Pulmonary Blood Circulation

Similar to the findings of the functions of systematic circulation, students' responses about the function of pulmonary circulation were also classified under six themes: (1) To clean blood that comes to the heart. (2) To clean dirty blood in the heart/kidneys. (3) To enhance circulation of blood in the body. (4) To help systemic circulation. (5) To enhance blood circulation in certain body parts such as the upper/lower/middle body, the heart, between heart-liver, heart-brain, hands-feet and nerves. (6) No response. The findings are summarised in Figure 3. In this question, the first theme which is accepted as the correct answer tended to increase as grade level increased. However, there was a decrease on moving from elementary 7th grade to university 1st year. Conversely, there was no decrease in the percentage of the other misconceptions (2, 3, 4, 5) about pulmonary circulation with grade level; rather they seemed to increase. The following statements illustrate such misconceptions: *"To help systemic circulation.", "To supply cleaning of blood by bringing it to the heart."* and *"To bring blood to the tip and small parts of the body such as finger tips."* Also, similar to the systemic circulation results, elementary level students tended not to respond this question. Despite the fact that elementary 7th grade students had experienced this issue in the 6th grade, the percentage of correct conceptions among the 7th graders was found to be close to the percentage of items with no responses.

The findings of these two questions can be interpreted more appropriately when the meanings of systemic and pulmonary circulation are translated into the original language of the study (Turkish). In Turkish, systemic circulation means *large circulation* and pulmonary circulation means *small circulation.* Hence, students may have been confused about their functions resulting in displaying misconceptions that stem from linguistic issues. "*To help systemic circulation"* and "*To enhance blood circulation in certain places of the body such as in the upper/lower/middle body, the heart, between heart-liver, heart-brain, hands-feet and nerves"* are misconceptions related to these linguistic issues that were detected about pulmonary circulation. "*To produce energy"* and "*To enhance blood circulation in certain places of the body such as in the head, hand, feet, wrists, upper/lower/middle body, neck*"-were similar misconceptions that were displayed for systemic circulation. This question might be comprehended differently if the study was conducted in English or in another country where the language was not Turkish.

Findings about Interpretations of the Blood Circulatory System Diagram

Figure 4 presents a diagram related to the blood circulatory system. Similar circulatory system diagrams are encountered in the textbooks (Güngör et al., 2002: 73; Keskin, Uysal & Kaşker, 2006: 140). In order to support data collected from the study, university level participants were requested to interpret the diagram.

According to Figure 5, it is surprising that only about 14.4 % of the university students' opinions referred to scientifically correct knowledge. Examples of their interpretations are as follows: "*Clean and dirty blood is everywhere in the body. Therefore it is incorrect to show dirty blood only in the right side and clean blood only in the left side of the body. That is incorrect and may lead to misconceptions among students".* On the other hand, it was observed that misconceptions about the diagram constituted a relatively large proportion of students' opinions (almost 100.0% of university 1st year and 85.0% of university 4th year students' opinions). Examples of these misconceptions can be illustrated by the following: "*It shows the nervous system (3.1%; 0.7%); systemic and pulmonary circulation (3.9%; 9.6%); circulatory system (31.7%; 47.3%); types and structures of blood vessels (32.7%; 30.1%); clean blood in the left and dirty blood in the right side of the body (17.5%; 9.2%). Blue indicates veins – deoxygenated, and red indicates arteries – oxygenated (10.5%; 12.9%).* These statements cannot be considered as scientifically acceptable explanations from university level students who have encountered this topic 4-5 times during their studies.

Misconceptions are functional in students' minds. Hence whether or not knowledge about a subject is integrated in students' cognitive structures without questioning, these misconceptions are resistant to change.

Findings about Blood Transfusion

The text about blood transfusion that was given to university level students is as follows:

"A father has just met his son whom he hasn't seen for years when the son had met with a terrible accident. The father transferred his son who was in severe pain to the hospital. Doctors explained that the son urgently needed blood since he had lost a large amount of blood after the accident. The father did not want to lose his son again after just meeting him. He wanted to give his blood to his son. Unfortunately, after analysis, the doctors stated that his blood was not appropriate for his son. The father was disappointed. He cried "How can that be? He is my own son! Why is my blood not appropriate to transfer to him?" And then he began to ask for the appropriate blood for his son…"

Respondents were asked two questions about this text. The first question was about the reason of incompatibility of the father's blood with his son's. The second was about the sources of appropriate blood.

Analyses of students' responses for the first question led to a number of different meanings as summarised in Figure 6.The most significant finding that was an indication of a misconception was as follows: "The son's blood should be compatible with one of his parents'." (37.8%; 26.9%). This result is evidence of the inability of traditional instructional activities to eliminate misconceptions that have epistemological and cultural roots among university 4th year students. Various correct expressions were: Blood group, gender, etc. are found by crossing of these characteristics of the father and mother characteristics (15.4%; 13.4%) and divergence could be due to the RH factor (9.3%; 12.9 %). The two percentages in each of the above refer to 1st year and 4th year university students, respectively.

The analysis of the second question of the text - sources of appropriate blood were presented as the percentage values in the parentheses; the two percentages in each case refer to 1st year and 4th year university students, respectively. According to the results, students asserted that the source of the appropriate blood was: the mother (32.7%; 16.1%), relatives (28.5%; 16.7%) and sisters/brothers (15.0%; 8.1%). All these opinions contained misconceptions. On the other hand, some of them concluded that it could be found from people with the same blood group (11.2%; 13.4%) or from the blood bank (22.9%; 45.7%). Students'

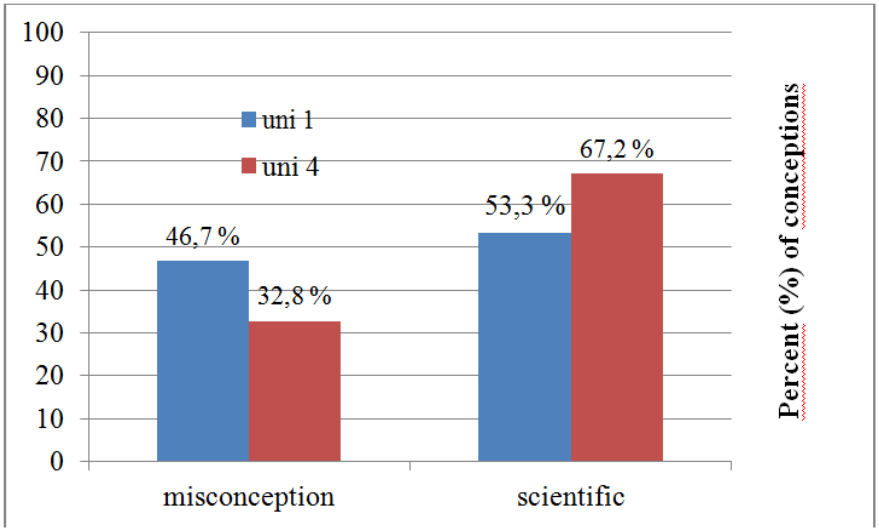

Figure 6. *Students' Conceptions about Blood Incapability*

delusions to sense that a child's blood group to be same with his mother, relatives or sisters/brothers could be explained in terms as relationships with relatives as being more superior to genetic relationships. Similarly, related misconceptions tended to decrease from university 1st to 4th year students without totally being eliminated.Discussion

In the light of the findings of the present study, it is evident that students hold a number of misconceptions about the blood circulatory system. This consequence is not different from what was found in previous studies (Arnaudin & Mintzes, 1985; Micheal, 1998; Sungur, Tekkaya & Geban, 2001; Micheal, 2002; Paleaz, 2005; Prokop, Kubiatko & Fančovičová, 2007; Prokop, Prokop, & Tunnicliffe, 2008; Prokop, Fančovičová, & Tunnicliffe, 2009; Prokop, Uşak, Özel & Fančovičová, 2009; Sezen & Çimer, 2009; Yeşilyurt & Gül, 2012). More specifically, the misconceptions that were identified belong to the functions of systemic and pulmonary blood circulation, blood compatibility and circulation of blood in the body as a whole. When the misconceptions to the first question are considered, the misconception with the highest percentage was among elementary 5th grade students who suggested that blood is produced in heart. The misconception with the highest percentage among elementary 7th grade students was that systemic circulation is much more important in function than pulmonary circulation. Among university level year 1 students the misconception with the highest percentage suggests that clean blood circulates in the left side of the body while dirty blood circulates in the right side of the body. At the same time, among university level year 4 students the most frequent misconception was that the function of pulmonary circulation is to help systemic circulation. However, these misconceptions displayed resistance to changing towards scientific explanations as indicated by Arnaudin and Mintzes (1985). This result is due to persistence of misconceptions. Chi (2005) indicates that students' misconceptions about direct processes such as the blood circulatory system are less robust than misconceptions about emergent processes such as diffusion. However, the present study contradicts this consequence by presenting misconceptions about the blood circulatory system that are relatively resistant to change.

One source of misconceptions is course textbooks (Güngör & Özgür, 2009). Odom (1993) discloses misconceptions about nerve, neurons and impulses from different course textbooks. In the present study, a diagram in science course textbooks is used and it is seen that many students' interpretations of this diagram contradict scientific knowledge. Despite the fact that study sample involved prospective biology teachers, all their misconceptions seem to be reinforced with the help of such materials in science textbooks.

Another finding of this study shows that the amount of misconceptions possessed by elementary level students is less than those of university level students in several cases. However, it is challenging that the percentages of several misconceptions are persistent from elementary 7th grade to university 1st year. This trend could be due to the university entrance examination that is based on multiple choice questions that lead to misconceptions with didactic roots that reinforce these misconceptions (Özgür, 2004; Özgür & Pelitoğlu, 2008; Güngör & Özgür, 2009). Levy Nahum, Hofstein, Mamlok-Naaman and Dov (2004) investigated the effect of the National Proficiency Examination on chemistry instruction in Israel and concluded that this examination triggered several students' misconceptions. Instances supporting this consequence are also present in this study.

To take this study one step further, I propose to study the effect of examination-based education systems on students' misconceptions in different courses and subjects, specifically in the context of Turkish university examinations.

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