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The most important concept of transport and circulatory systems: Turkish biology student teachers' cognitive structure

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The purpose of this study is to determine biology student teachers' cognitive structure with regard to "Blood". Qualitative research method has been used. The free word association test and the draw-write technique have been used in collection of data. The data obtained have been evaluated and divided into categories based on content analysis. According to the analysis results, in biology student teachers' conceptual structures with regard to blood, while nine categories have been determined for the free word association test, eight categories have been determined for the draw-write technique. Rich data supporting, dilating and explaining one another have been obtained through both measuring tools. In this context, it has been determined through two measuring tools that student teachers' cognitive structures are concentrated in the "*blood cells*" and "blood *groups and determination of blood groups*" categories. Furthermore, in the data collected through both measuring tools in the determined categories. It has been determined that student teachers have alternative concepts on blood concept.

Key words: Blood, cognitive structure, free word association test, draw-write technique, and alternative concept

INTRODUCTION

The issue of how individuals learn and in this context, how they configure information in their minds have always attracted interest of researchers. In this context, one of the mostly used concepts has been the concept of cognitive structure. Cognitive structure is a hypothetical structure that indicates the concepts and the degree of the relationships between the concepts in long term memory (Shavelson, 1974). It plays a pivotal role in learning and recalling. It is possible to define the cognitive structure as organizing previous experience due to arrangement of information in result of the connection or the association established between concepts/objects (Neisser, 1967), and in this process, as the mental schema/framework that arranges and holds the elements that compose information in the mind. Ausubel (1963) remarked that this structure has individual and hierarchical features. The hierarchy is an important concept here and is very effective in learning. Because, in the cognitive structure arrangement, understanding, communication and learning take place with the help of a hierarchy that has individual feature (Van Gigch, 1991). The individuals who can build effective hierarchy can

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accomplish successful learning and hence can form strong cognitive structures. This affects individual's academic success as well as his/her ability to use information in daily life (Tsai and Huang, 2002). It is stated that there are two main components of the cognitive structure: "information units" and "organization of information units" (Shavelson 1974; West et al., 1985; West and Pines, 1985). When the studies conducted in previous years are examined, it is observed that they have more focused on searching the accuracy and the width of the cognitive structure, that is, on the component of *information units*. As for the studies of recent years, they, mainly searching relationships and some qualitative features in students' information organizations, have focused on the component of *the organization of the information units* (Bahar et al., 1999; Novak, 1990; Tsai, 1999, 2001). It is observed that the researchers conducted on this issue have mainly focused on the topics about determining participants' cognitive structures with regard to concepts. It is highly difficult to account for students' cognitive structures that are formed as a result of learning, however; significant data can be obtained by unveiling their opinions through key concepts, and thus individuals' cognitive structures can be revealed (Gilbert et al., 1998a,b; Gilbert and Boulter, 2000). Researches on concepts demonstrate individuals' cognitive structures pertaining to those concepts. Conceptual structure is not only to know the name or definition of a concept, but also is to be able to see the transitions and relations between concepts. Biology is a course which requires students to be able to see the micro and macro relations among concepts. Otherwise, learning cannot be realized (Cimer, 2012; Jones and Rua, 2006; Lukin, 2013; Lazarowitz and Penso, 1992; Prokop et al., 2007; Seymour and Longdon, 1991; Simpson and Marek, 1988). For this reason, biology is among the courses in which students struggle to learn; due to their failure in comprehending the unity at the level of biological organization, in understanding the micro and macro level relations among concepts, and in making sense of abstract subjects. In this process, they struggle to learn those concepts that point to the micro and macro relations inherent in biological events.

Cognitive structure plays a pivotal role in learning and recalling. It determines how new information is and how the links between pieces of information are. Individuals can understand a new piece of information only if they have a pre-acquired piece of information related to it (Driscoll, 1993). Cognitive structures of students reveal what they know and do not know about a given subject. Therefore, the present studies made an attempt to analyze the cognitive structures of prospective students about the subject "*BLOOD*". While various methods are employed in order to determine cognitive structures about concepts, especially those techniques labeled as alternative measurement and evaluation techniques are frequently used. These techniques are employed not only to determine students' knowledge; but also to determine the relations that students establish between concepts, students' cognitive structures, whether they manage to accomplish meaningful learning by linking existing knowledge with new information, the extents to which they make sense of the operation of events in the natural life by associating them with their conceptual knowledge (Bahar, 2003; Bahar et al., 2006; Ercan et al., 2010; Kurt, 2013) and alternative conceptions they develop. In this respect, in order to determine the cognitive structures and alternative conceptions related to the concept of blood; two-step multiple choice tests (Odom and Barrow, 1995; Tekkaya, 2003), drawings (Ainsworth et al., 2011; Cetin et al., 2013; Cinici, 2013; Nyachwayaa et. al., 2011; Patrick and Tunnicliffe 2010; Yayla and Eyceyurt, 2011; Zoldosova and Prokop 2007), interviews (Kose, 2008), free word association test, (Ercan and Tasdere, 2010; Koseoglu and Bayir, 2011; Kurt, 2013), structured grid, diagnostic tree, concept maps, conceptual change texts, analogy, prediction-observation-explanation and other techniques can be used (Bahar et al., 2008; White and Gunstone, 1998). In this research, the free word association test and drawing-writing technique were employed.

COGNITIVE STRUCTURE RESEARCHES ON BLOOD CONCEPT

In the biology course one of the issues related to the systems which are difficult to understand is "Transport and Circulation Systems". One of the most important concepts with regard to transport and circulatory systems in human is "Blood". In researches on the subject, no study has been found that examines students' cognitive structures only on the concept of blood. The concept of the blood is usually studied within the concepts of transport and circulation systems. In this context, in almost all studies different concepts have been identified, depending on the nature of researches. These different conceptions generated by students have been called naive beliefs (Caramazza et al.,1980), alternative conceptions (Arnaudin and Mintzes, 1985), children science (Gilbert et al., 1982) or misconceptions (Fisher, 1985). Throughout this article, the term alternative conceptions will be used to refer to students' conceptions that are different from scientific conceptions about blood.

In the studies conducted in this context, whereas it is stated that students have too many alternative concepts on the human transport and circulation system (Arnaudin and Mintzes, 1985), it has been determined that middle school students have alternative concepts regarding the open and closed circulation, regarding the structure and work of heart, regarding the blood vessels, regarding blood and its cells, and regarding blood pressure (Yesilyurt and Gul, 2012); that classroom student teachers

have alternative concepts on blood circulation regarding blood circulation, blood vessels, gas exchange, gas distribution and its benefits, and function of the lungs (Palaez et al., 2005); that students studying at different levels (students at 5th and 7th grade of secondary school, at 1st and 4th grade of university biology, at 1st and 4th grade of classroom teaching, and at 1st and 4th grade of science) have alternative concepts related to circulation system (Ozgur, 2013); that university students have alternative concepts about blood circulation system (Bahar et al., 2008; Micheal, 1998; Micheal et. al., 2002; Paleaz et al., 2005; Prokop and Fančovičová, 2006; Sungur et al., 2001); that high school students have alternative concepts on blood circulation system (Alkhawaldeh, 2007); that students at different levels (students at 5th, 8th, and 10th grade, university freshmen students, at biology and non-biology classrooms) have alternative concepts regarding closed circulation and respiration / circulation relationship, breathing method, function of heart and structure of heart (Mintzes, 1984); that students at nursing, classroom teaching and biology have insufficient attitudes and information towards / about blood donation (Kaya et al., 2007); that 6th grade students have alternative concepts about "exchange scheme between blood groups" (Kete, 2006); that teachers have alternative conceptions about blood flow, blood pressure, and vessel diameter (Yip, 1998a) and that undergraduate students have alternative concepts about functions of heart and blood vessels (Michael et. al., 2002).

As can be seen in the literature on the related samples of research, studies on the blood concept indicate that students with different levels and even teachers have alternative concepts. At this point, students' conceptual ceilings can be determined and their incomplete or incorrect information can be discovered, using the free word association test and the draw-write technique. However, at review of the literature on the subject it has been not observed any study on biology student teachers' conceptual structures regarding the concept of blood which uses the free word association test and the draw-write technique. Therefore, the results of this research are considered to gain the literature on the subject highly qualified data.

PURPOSE OF STUDY AND RESEARCH QUESTIONS

The purpose of this study is to examine biology student teachers' cognitive structure with regard to blood, using the free word association test and the draw-write technique. The following questions are sought to be answered in the context of this purpose:

1. How is the biology student teachers' cognitive structure regarding the blood, with the free word association test?
2. How is the biology student teachers' cognitive structure regarding the blood, with the draw-write technique?
3. What are the biology student teachers' alternative concepts about the "blood"?

METHODOLOGY

Qualitative research method was applied in this study (Hitchcock and Hughes, 1995; Miles and Huberman 1994; Patton, 1990; Silverman, 2000). The basic aim of the qualitative studies is not to obtain results that can be generalized through numbers, but to present a descriptive and realistic case related to the issue investigated. Considering the reliability and validity of the results, it is important to provide the data in detail and directly as much as possible. Accordingly, in this study, the views provided by the biology student teachers on the concept of blood were described as they were, and the results obtained were not generalized. According to Yildirim and Simsek (2006), qualitative study is a method of research that aims to provide the opportunity to consider a fact through individuals" own perspective and present the processes included in this perspective.

Participants

The study was comprised of 44 biology student teachers' studying at the 4th and 5th grades of Biology Education Department in Necmettin Erbakan University. Of the participants, 35 (79.5%) are females, and 9 (20.5%) are males. In addition, 19 of the participants (43.20%) are 4th year students, and 25 (56.80%) are 5th year students. This study benefited from purposive sampling. Some criteria were taken into consideration in order to minimize the problems in purposive sampling (Coyne, 1997; Given, 2008; Knight et. al., 2013; Patton, 1990). In this vein, several criteria were taken into consideration while selecting the participants such as having completed the field courses in biology, willingness to participate in the study, being seniors in the department of biology teaching and having completed the courses, and being available to the researcher. Moreover, the student biology teachers were informed by the researcher of the aim of the study and how to complete the measurement tool.

Research instruments

In this research it is aimed to collect detailed data on the biology student teachers' conceptual structures with regard to concept of "blood", using the free word association test and the draw-write technique as means of data collection. The following information is given about these measuring instruments;

The free word association test

This technique is used for collecting data in many researches in the field of science (Aydin and Tasar, 2010; Ozatli and Bahar, 2010; Cardellini and Bahar, 2000; Daskolia et al., 2006; Dove et al., 1999; Hovardas and Korfiatis, 2006; Isikli et al., 2011; Koseoglu and Bayir, 2011; Polat, 2013; Wagner et al., 1996; Yalvac, 2008).

The free word association test is one of the oldest and most widely used techniques, which is used for analyzing individual's cognitive structure regarding concepts and inter-conceptual bonds that is the information network in this structure and for determining whether the relationship between the concepts in his/her long term memory is sufficient or not (Atasoy, 2004; Bahar and Kilicli, 2001;

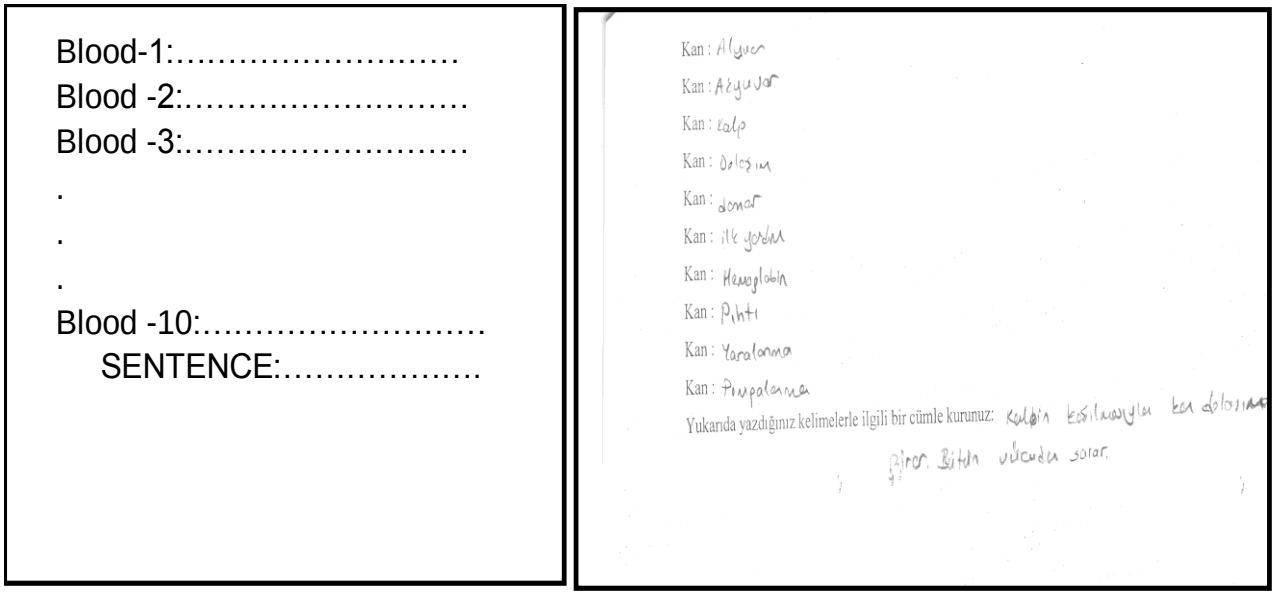


Figure 1. P30's answer sheet (Words in the Figure 1: red blood cell, white blood cell, first aid, heart, circulation, arteries, hemoglobin, blood clot, injury, pumping. Sentence *in the answer sheet: Blood enters into the circulation through contraction of the heart. Wraps the whole body*).

Bahar and Ozatli, 2003; Cardellini and Bahar, 2000; Hovardas and Korfiatis, 2006). This technique is based on the assumption of answering which is related independently to stimulating word without limiting the ideas coming to mind (Bahar et al., 1999; Sato and James, 1999). In this research, biology student teachers have been asked about the concept of "blood" to complete the free word association test. In this test the concept of blood is asked in the following format as a stimulating word. In Figure 1, an example from the participant K30 is given about the data collected through the free word association test.

As seen in the test sample in Figure 1, the word association test consists of two phases.

At the first stage of the free word association test, participants are required to indicate concepts brought to mind by the stimulating word as answers, in a certain period of time, which is 40 seconds in this research (Gussarsky and Gorodetsky, 1990). Biology student teachers were asked to write in 40 seconds the first ten words that come to their minds when they read or hear the concept of blood. The reason that the key concept is written one under the other is to prevent the risk of the successive answer. Because if the student does not return to the key concept upon writing each concept, he/she may write words brought to his/her mind by words that he/she write as answer instead of the key concept. In this case, the purpose of the test is damaged.

In the second stage of the free word association test, the participants were requested to write sentence related to the key concept in 20 seconds and at the stage of data analysis these written sentences were examined one by one. Because the response sentence related to the key concept may be also only a product of association without a meaningful relation with the key concept at the level of recall. Additionally, because the related sentence will be more complex and high-level structure in comparison with a single word response, cases such as whether the sentence is scientific or not, whether it includes misconceptions of different natures affect the evaluation process.

The draw-write technique

Drawings of the participants are very important to put forth their cognitive models and main ideas about scientific concepts or events. Because drawings may easily provide comparison of students' beliefs and ideas (Cinici, 2013; Ozden, 2009; Patrick and Tunnicliffe, 2010; Prokop and Fancóvicóva, 2006; Prokop et al., 2009b; Prokop et al., 2007; Reiss and Tunnicliffe 2001; Zoldosova and Prokop 2007), and for children who have difficulty in in-depth expression of verbal information is considered as an alternative way (Rennie and Jarvis, 1995). Biology educators may use the drawing method because of these basic reasons. On the other hand, there are also some limitations to the drawing method beside its advantages. Despite the use of the drawings as a useful tool to reveal understandings, it is emphasized that the scoring of the drawing reliability is quite difficult because it is a technique which is limited by the drawing capabilities of the students (White and Gunstone, 2000), that the drawing method would be in the wrong direction and inadequate in case no additional method is used (Strommen, 1995), that in case this method is combined with interviews it would be successfully used to determine students' conceptual understanding and alternative concepts (Kose, 2008), and that the drawing of participants may be appropriate but not sufficient for determining alternative concepts (Cinici, 2013). In order to minimize these negative reasons the free word association test and the draw-write technique are used together in this study to enable collection of data that is qualified and supporting each other. The draw-write technique has been used in many studies in the field of science and for different subjects (Bartoszeck et al., 2008; Cetin et al., 2013; Nyachwayaa et. al., 2011; Pluhar et al., 2009; Prokop et al., 2009a; Shepardson et al., 2007; Yayla and Eyceyurt, 2011; Yorek et al., 2010). It was aimed with the draw-write technique to deeply investigate teachers' views on the concept of blood. Because it is very useful in terms of obtaining natural and high quality data about the hidden thoughts, understanding and

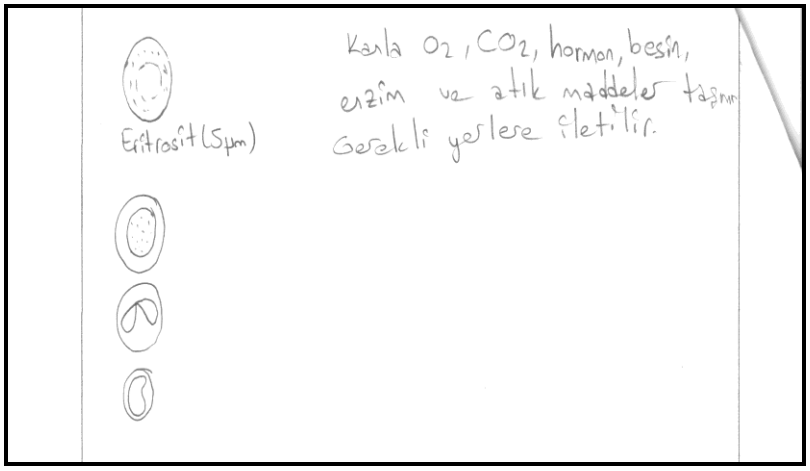


Figure 2. The participant drawing (P19) depicting how erythrocyte is. The participant mentions, *"With blood, O_2, CO_2, hormones, nutrients, and enzymes, waste materials are carried. Forwarded to where they are needed".*

attitudes related to the technical concepts (Backett-Milburn and McKie, 1999; Fellows, 1994; Pridmore and Bendelow, 1995; Rennie and Jarvis 1995; White and Gunstone, 1992). In this context, the participants were asked to express their views freely and without limitation in response to the question of "*Explain through drawing what you know about the concept of blood?*". An example of the draw-write technique is shown in Figure 2.

Reliability and validity of the data collection tools

Reliability and validity are important for qualitative research method. For this reason, two important processes were realized to ensure the validity of the results of the study. (a) Data coding and analysis (how conceptual categories were obtained) were discussed in detail. (b) Biology student teachers' views that were believed to best represent each and every category obtained through the study were selected as examples, and these examples were provided in the findings section (Hitchcock and Hughes, 1995; Hruschka et al., 2004; Marvasti, 2004; Miles and Huberman 1994; Roberts and Priest, 2006; Silverman, 2001; Yildirim and Simsek, 2006).

Considering the reliability of the study, the codes and the categories provided by two researchers were compared in order to confirm whether the codes provided under each conceptual category represented the aforementioned conceptual categories. The list of codes and themes were finalized after two experts in the field of biology coded the data individually. The reliability of the data analysis was calculated using the formula [Agreement/ (Agreement+Disagreement)x100] (Miles and Huberman, 1994). Average reliability between coders was found to be 92% for the free word association test and 95% for the draw-write technique.

DATA ANALYSIS

In this study, the content analysis, which is one of the data evaluation methods used in researches in social areas, has been used (Bilgin, 2006; Lichtman, 2010; Stemler, 2001; Weber, 1990; Wimmer and Dominick, 2000). The content analysis is a scientific approach that allows to objectively and systematically examine verbal, written and other materials and to organize them in line with certain categories (Bogdan and Biklen, 2007; Cohen et al., 2007; Hill et al., 1997; Leblebici and Kilic, 2004; Tavsancil and Aslan, 2001). In short, the content analysis is to gather together similar data within the framework of specific concepts and themes and to interpret them, arranging them in a way so as to be understood by the reader. The content analysis is used in processing qualitative research data in four stages: (1) Coding of the data, (2) Finding themes, (3) Arrangement of the codes and the themes, and (4) The identification and interpretation of findings (Corbin and Strauss, 2007; Yildirim and Simsek, 2006). Also in this study, these processes have been used in the analysis of the free word association test data as well as the draw-write technique data.

Before the data analysis, the participants' answer sheets were numbered from 1 to 44. The data collected through the free word association test were analyzed using the techniques of number of words, number of answers and semantic relationship (Atasoy, 2004). The words that had the same meanings were classified under the category of the frequently stated words. The words that were not considered related, that were not related to the other words, and that were repeated 1 times were not taken into consideration during the data analysis. The words were categorized using the criterion of semantic relation, and the frequency calculations of these words under each category were made. In many studies, using this kind of data analysis is stated to provide reliable results (Daskolia et al., 2006; Kostova and Radoynovska, 2008, 2010).

In the draw-write technique, draw-write data regarding the concept of blood were analyzed according to the method of content analysis. By means of the drawing task, the students' ideas about the blood were investigated, not the ability to draw it, so the precision in shape was ignored. It was a struggle to provide a scoring scale which gave minimum credit to the artistic quality of the drawing (Reiss et al., 2002). First of all the drawings of the participants on the concept of blood were collected under specific categories and sub categories. Then cognitive structures put forward by the participants through the draw-write technique were analyzed according to levels. In determining these levels, the data is grouped from level 1 to level 5 (Bahar et al., 2008; Bartoszeck et al., 2008; Cinici, 2013; Reiss and Tunnicliffe, 2001). The groups of levels that are formed for the evaluation of the participants' cognitive structures on blood by means of their drawings are given

Table 1. The groups of levels that are formed for the evaluation of the participants' cognitive structures on blood by means of their drawings

Levels	Drawings
Level 1:	No drawing
Level 2:	Non-representational-carton drawings (*drawings related to one or two dimensions of the concept)*
Level 3:	Drawings with alternative concepts (*drawings that are related to two or three dimensions of the concept and that include alternative conceptions)*
Level 4:	Partially correct drawings (*drawings that are related to three or more dimensions of the concept but that include imperfect knowledge)*
Level 5:	Comprehensive representation drawings (*comprehensive drawings that are related to three or more dimensions of the concept)*

in Table 1.

Also the participants' interesting explanations in the text regarding blood both in the free word association test and the draw-write technique are quoted in the sign " " (K30) as it is in the text by specifying the number of participant. In the draw-write technique, samples of drawings from the participants about the blood are presented in the text again by specifying the number of participant, for example as P17 and P33.

The data have been analyzed with the Nvivo9.3 programme for preparing Model 1.

FINDINGS

In this section, the findings obtained are given in a way supporting each other, depending on the measurement tools used. First, the findings obtained through the free word association test and then the findings obtained through the draw-write technique were interpreted. In addition, alternative concepts on blood that were identified through both measuring tools are given under a separate heading.

The findings obtained from the free word association test

In result of the analysis of the obtained data on the student teachers' cognitive structures with regard to the concept of blood, a total of 9 categories were formed by listing the indicated words. If these words were repeated one time they were not combined with other words. Therefore, 16.17% of the total 439 words answered (71 words) are not included in the categories (Kostova and Radoynovska, 2008,2010; Kurt, 2013; Torkar and Bajd, 2006). These words were removed from the Table 2 in terms of the nature of the research, but indicated in the related section of comments at the end of each category evaluated. As a result, the remaining 48 different words associated with the concept of blood are divided into 9 categories. The words answered in each category and the categories are listed in Table 2. In total 368 response words are obtained in this context.

In the result of analysis of the data, in the first category biology student teachers' associated answers to the concept of blood most intensely concentrate under "*blood cells*" and this has emerged as the dominant category (f=101). Whereas most participants in this category focused on "*red blood cell*", "*white blood cell*", "*blood platelets*", it is observed that a portion of the participants expressed the concepts of "*lymphocyte", "neutrophil"*, and "*basophil".* The words that the participants wrote in this category but are not included in this category have been determined as "*monocyte*" and "*granulocytes*". These results show that with the concept of blood the participants have established close links more with regard to "*blood cells*" category.

In the second category participants have demonstrated associations with regard to "*body fluid content and its task*" (f=60). In this category, it is observed that the associations indicated by the participants mostly specified words of "*plasma", "oxygen", "carbon dioxide", "nutrient"* and "*vital liquid*". Some words that the participants wrote in this category but are not included in this category because they were written one time are determined as "*necessary ingredients", "mineral", "dirty blood", "fresh blood*" and *"plasma cells".*

The third category is formed as "*the definition of blood, its color and its proteins*" (f=46). Whereas participants' associations in this category are mostly "*hemoglobin"* and "*red"* words, a smaller number of participants determined the words of *"fibrinogen", "protein"* and *"myoglobin".* Some words that the participants wrote in this category but are not included in this category because they were written one time are listed as "*albumin", "fibrin", "hemoeritrin", "hemocyanin", "heparin*" and "*pigment*".

In the fourth category the participants specified response words related to "the blood and transport system" (f=43). The participants in this category focused on the words "*vessel", "transport", "artery", "vein*" and *"capillary".* Some words that the participants wrote in this category but are not included in this category because they were repeated one time are listed as "*vascular",*

Table 2. Findings on the concept of blood that belong to categories and sub-categories, which were obtained through free word association test.

Categories	Concepts in the categories and their frequencies	Total frequencies of the category
1. Blood cells	“red blood cell” (35) “white blood cell” (33) “blood platelets” (20) "lymphocyte"(4) "neutrophils"(4) "basophil"(3) "eizonofil"(2)	101
2. Blood fluid, its content, and its task	“plasma” (12) “oxygen” (11) "carbon dioxide" (9) “aliment” (9) “vital fluid” (5) “liquid” (4) “body fluid” (3) “water” (3) “glucose” (2) “white blood” (2)	60
3. Description of blood, its color, and its proteins	“hemoglobin” (20) “red” (19) “fibrinogen” (3) “protein” (2) “myoglobin” (2)	46
4. Blood and its transportation system	“vessel” (15) “transport” (8) “arterial” (6) “vein” (6) “capillary” (6) “aorta” (2)	43
5. Blood groups and determination of blood groups	“blood groups” (6) “Rh” (5) “ group B” (5) “group A ” (3) “group AB takes from everyone” (3) “group O gives to everybody” (3) “group AB” (2) “group O” (2) “Rh+” (2) “Rh-“ (2) “group A gives blood” (2)	35
6. Blood and its circulation system	“heart” (12) “circulation (system)” (12) “lungs” (6)	30

Table 2. Contd.

7. Blood-immunity	“serum” (9) “immunity” (8) “antigen” (5) “antibody” (5) “vaccine” (2)	29
8. Blood diseases	“clotting”(6) “anemia” (4) “blood incompatibility” (3) “leukemia” (3)	16
9. Reminders of blood	“needle-injection” (3) “injury” (2) “traffic accident” (2) “life” (2) “surgery” (2)	11
Total	48 words	368

"lymph capillaries" and "*tissue".*

The fifth category formed from the participants' response words, associations collected under the category of "*blood groups and determination of blood groups*" (f=35). Most of the participants in this category focused on "*blood groups", "Rh"* and *"B group*" words. It was determined that a very small part of biology student teachers wrote the words of *"group A*", "*AB group" "group 0", "Rh +"* and "*Rh-".* Some words that the participants wrote in this category but are not included in this category because they were repeated one time are listed as *"blood test", "negative"* and "*positive".*

The sixth category is formed as "*the blood and circulatory system*" from the response words written by the participants (f=30). It was determined that the concepts indicated by the participants with regard to this category are *"heart", "circulatory system*" and *"lung*". Some words that the participants wrote in this category but are not included in this category because they were repeated one time are listed as "*large circulation", "small circulation", "spleen"* and *"liver*".

Seventh category is formed as "*blood-immunity*" (f=29). It has been observed that the participants expressed the words of *"serum", "immunity", "antigen"* and "*antibody"*. It can be said that biology student teachers' associations with this category is not sufficient.

Eighth category has emerged as *"blood diseases*" (f=16). It was determined that the words the participants indicated in relation with this category are *"coagulation*" and "*anemia"*. Some words that the participants wrote in this category but are not included in this category because they were repeated one time are listed as "*hepatitis", "blood deficiency*" and "*fainting*".

The last category has emerged as "*the reminders of blood*" (f=11). It was seen that a very little portion of the participants focused on the words of "*needle-injection", "injury", "traffic accident", "surgery*", and "*life"*. The words of "*first aid*" and "*hospital*" are not included in the category due to their one time repetition.

The findings obtained through the draw-write technique

It has been determined through the draw-write technique that the biology student teachers' conceptual structures on blood are collected under total 8 categories. The 7 categories that have emerged from the drawings are *the blood groups and determination of the blood groups (48), blood cells (29), blood fluid, its content, and its task (2), blood and its transport system (12), the color of blood and its proteins (4), blood and its circulation system (4), and the reminders of blood (6).* The 7 categories that have merged from the writings are *at the most the blood groups and determination of the blood groups (31), blood cells (26), blood fluid, its content, and its task (23), blood and its transport system (12), the color of blood and its proteins (6), blood and its circulation system (6) and blood-immunity system (6)* (Table 3).

It has been observed that the biology student teachers, in their cognitive structures related to blood, with the draw-write technique dominantly thought about the concepts with regard to "*the blood groups and determination*

Table 3. Findings on the concept of blood that belong to categories and sub-categories, which were obtained through the draw-write technique.

Main categories	Sub categories	Drawing (f)	Writing (f)
1. Blood groups and determination of blood groups	Group 0	10	4
	Group A	10	4
	Group B	10	4
	Group AB	10	3
	Antibody A	3	2
	Antibody B	3	2
	Antibody D	2	2
	Ab general receiver	-	2
	0 general giver	-	2
	Total	48	31
2. Blood cells	Red blood cell	13	9
	White blood cell	7	9
	Blood platelets	5	8
	Eizonofil	2	-
	Basophil	2	-
	Total	29	26
3. Blood fluid, its content, and its task	Vital fluid	-	3
	Giving of red color by the red blood cell	-	2
	Carrying of o_2 to cells by the red blood	-	2
	Sediment transport	-	2
	White blood cell in defense	-	2
	Possession of nutrients	-	2
	Possession of oxygen	-	2
	Transmission to cells	-	2
	Plasma	-	2
	Platelets in clotting	-	2
	Serum	2	-
	Creating muscle tissue	-	2
	Total	2	23
4. Blood and its transportation system	Blood vessels	4	-
	Capillary	2	-
	Vein	2	-
	Pulmonary artery	2	-
	Pulmonary vein	2	-
	Co_2 transport	-	2
	O_2 transport	-	2
	Hormone transport	-	2
	Nutrient	-	2
	Enzyme transport	-	2
	Transport of waste substances	-	2
	Total	12	12
5. Description of blood, its color, and its proteins	Fibrinogen	2	2
	Red colored	-	2
	Hemoglobin	-	2

Table 3. Contd.

	Blood proteins	2	-
	Total	4	6
6. Blood and its circulation system	Closed circulation system	-	4
	Circulation	-	2
	Lung	2	-
	Heart	2	-
	Total	4	6
7. Blood-immunity	Antigen	-	2
	Antibody	-	2
	Immunity	-	2
	Total	0	6
8. Reminders of the blood	Needle	2	-
	Nurse	2	-
	Scrubs	2	-
	Total	6	0
	Total	105	110

of the blood groups", drew relevant figures, and made explanations. It has been noticed that in the category of "the blood groups and determination of the blood groups" the figures of *"group 0", "group A", "group B"* and *"group AB"* are commonly together. On the other hand, according to Figure 3 the student teachers' drawing findings regarding the concept of blood are grouped under seven categories. The student teachers' samples of drawings related to the concept of blood are given in Figure 3 according to the relevant categories.

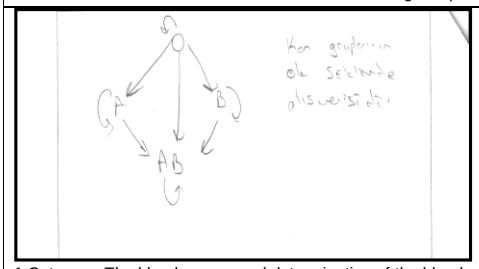
Furthermore, the analyses about the biology student teachers' drawings on the concept of blood are presented in Figure 4, Figure 5 and Figure 6 under the relevant levels of the cognitive structures. According to this, the drawings of the students regarding the concept of blood are collected under three levels. These have been determined as level 2 *non-representative drawings* (31), level 3 *drawings including alternative concepts* (7) and level 4 *partial correct drawings* (6). On the other hand, whereas at level 1 not any non-drawing participant has been determined, at level 5 not any drawing participant has been observed. Therefore, it has been found that the participants have no conceptual representative drawings and that generally they produced non-representative drawings. This means that the biology student teachers inadequate. Samples of drawings at relevant levels are cognitive structures related to the concept of blood are given and evaluations made below.

As can be seen in Figure 4, 31 participants, about ¾ of the participants, tried to put forward their conceptual structures with regard to blood through simple drawings. These drawings are non-representative cartoon illustrations which are not understood. Without thinking about the subject with its aspects they explained it only through drawings which are simple, not well-understood, and not related to the scientific truth.

As shown in Figure 5, 7 participants made drawings with alternative concepts. Therefore, along with the relevant scientific information on the subject they expressed what they know about blood especially through expressions used in colloquial language. At this level, they made drawings on blood thinking about several aspects, but they are drawings with the emphasis on alternative concepts.

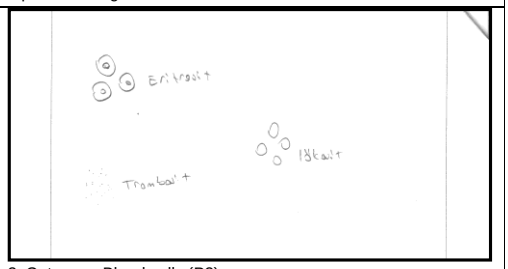
As seen in Figure 6, 6 participants made partially accurate drawings. At this level too it was determined that they could not express their information on the subject clearly and in detail. In these drawings they tried to explain blood with more than two aspects. However, it has been observed that there are no comprehensive drawings. From this situation it may be deduced that the biology student teachers' cognitive structures related to blood is not adequate. When all the above data are evaluated it has been determined that student teachers'

Drawing samples as per the categories



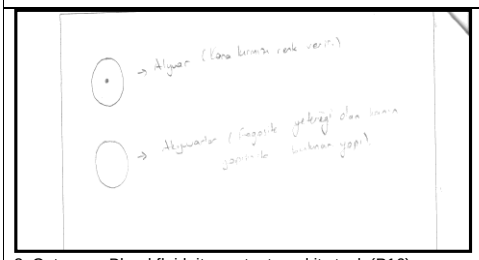
1.Category: The blood groups and determination of the blood groups (P1)

The participant drawing (P19) depicting how exchange of blood groups is.
The participant mentions, "Exchange of blood groups in the direction of the arrow shape".



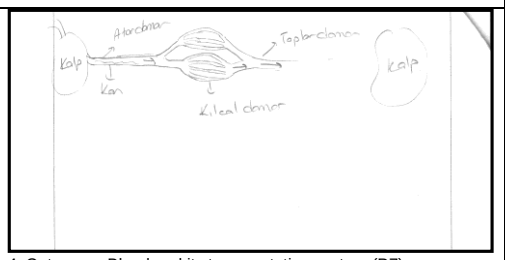
2. Category: Blood cells (P2)

The participant drawing (P2) depicting how erythrocyte, thrombocyte, leukocyte *are.*



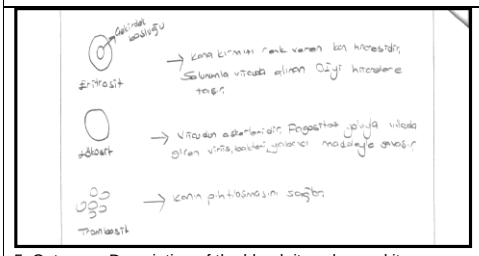
3. Category: Blood fluid, its content, and its task (P16)

The participant drawing (P16) depicting how red blood cell, white blood cell are.
The participant mentions, "Red blood cell gives blood its red color. White blood cell that is capable of phagocytosis that is not found in the construction of the blood".



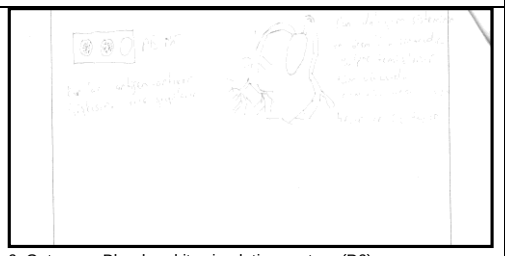
4. Category: Blood and its transportation system (P7)

*The participant drawing (P16) depicting how b*lood and its transportation system are.
The participant mentions, "blood, heart, capillaries, arteries*".*



5. Category: Description of the blood, its color, and its proteins (P17)

The participant drawing (P17) depicting how erythrocyte, leukocyte, thrombocyte are.
The participant mentions, "erythrocyte: Core gap –red blood cell giving blood its red color. Carries O2 which is taken into the body by breathing.
Leukocyte: are the soldiers of the body. Fights virus, bacteria and foreign substance which enter the body through phagocytosis.
Thrombocyte: provides blood clotting".



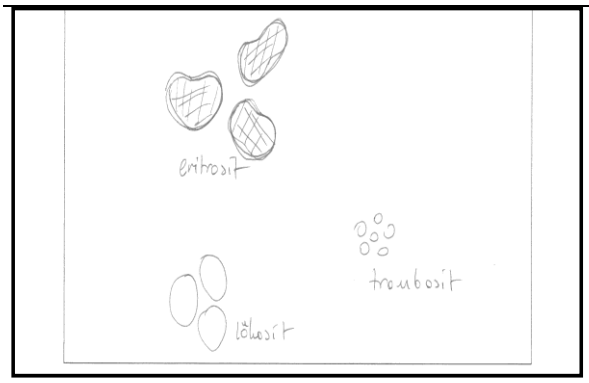
6. Category: Blood and its circulation system (P6)

The participant drawing (P6) depicting how Bloods group and circulation system *are.*
*The participant mentions, "Blood is the most important element of the circulation system. Cleared in the heart and circulates the whole body through vessels" and "*Blood are grouped according to the Antigen-antibody relation*".*

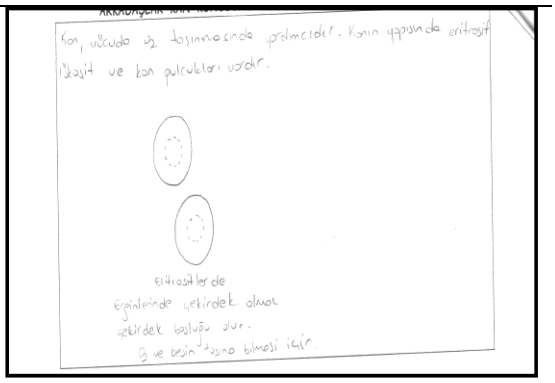
Figure 3. The samples of the concept of blood obtained through the draw-write technique.

cognitive structures are collected under certain themes. In this context, a model has been built on the biology student teachers' cognitive structures related to blood through evaluating the data obtained with the free word association test and the draw-write technique (Model 1). According to the analysis results, in the biology student teachers' conceptual structures with regard to blood, while nine categories have been determined for the free word association test, eight categories have been determined for the draw-write technique. As also seen in the model, it has been determined that the biology student teachers' cognitive structures with regard to blood have emerged in relation with a total of 9 categories.

Level 2: Non-representational-carton drawings (Total number of drawings: 31)



The participant drawing (P12) depicting how erythrocyte, leukocyte, thrombocyte are.

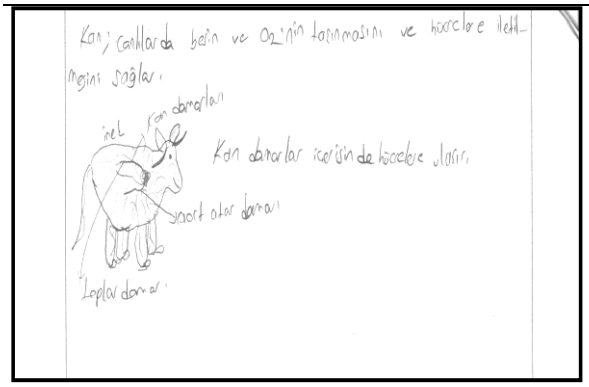


The participant drawing (P18) depicting how erythrocyte is.

The participant mentions, "Blood helps in carrying O2 to the body. There are erythrocytes, leukocytes, thrombocytes, and platelets in the structure of blood" and "In matures there is no core in erythrocytes. There is core gap. For carrying O2 and nutrients".

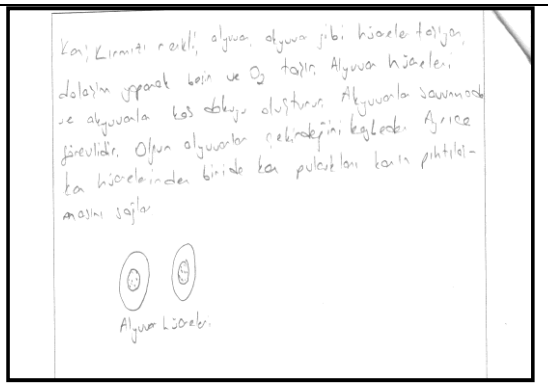
Figure 4. Samples of drawings on the concept of blood at level 2.

Level 3: Drawings with alternative concepts (Total number of drawings: 7)



The participant drawing (P20) depicting how the cow's blood circulation *is.*

The participant mentions," Blood carries nutrients and O2 in living beings and transmits them to cells. The arterial, venous, aortic vessels, blood vessels".



The participant drawing (P28) depicting how the red blood cell *is.*

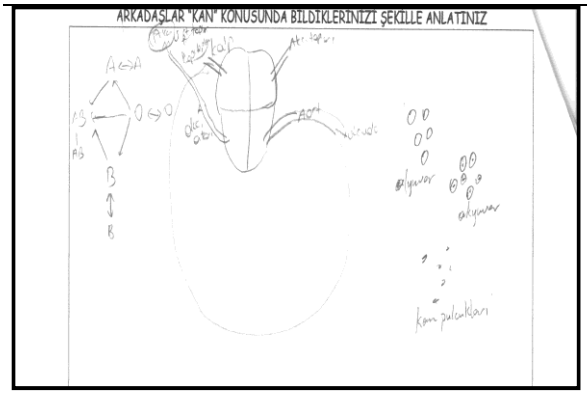
The participant mentions,"Blood: carries cells like red blood cells, white blood cells. Carries O2 and nutrients through circulation. Red blood cells and white blood cells form muscle tissue. White blood cells have duty of defense. Mature red blood cell loses its nucleus. Furthermore, platelets, one of the blood cells, allow the blood to clot. Red blood cells".

Figure 5. Samples of drawings on the concept of blood at level 3.

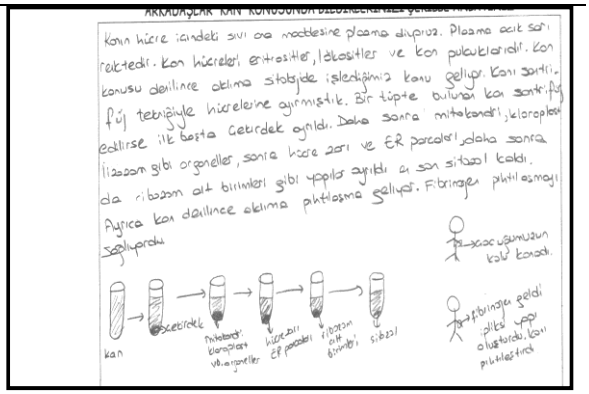
The findings of biology student teachers' alternative concepts on the concept of blood

Some examples of the biology student teachers' incomplete or incorrect information about their explanations on the concept of blood as well as their analyses are presented below under the determined categories according to both the free word association test and

Level 4: Partially correct drawings (Total number of drawings: 6)



The participant drawing (P10) depicting how the blood groups, red blood cell, white blood cell and blood platelets, *blood vessels and blood circulation* are*.*



The participant drawing (P32) depicting how the centrifuge technique and blood coagulation are.
The participant mentions,"The main liquid of the blood in the cell is called plasma. Plasma is light yellow in color. Blood cells are erythrocytes, leukocytes, and platelets. When the topic of blood is mentioned, the cytology course comes to my mind. We decomposed blood into its cells through the centrifuge technique. When the blood was centrifuged in a tube, first the core decomposed. Then the blood cells separated into their units. Only the cytosol remained at the end. In addition, when blood is mentioned clotting comes to my mind. Fibrinogen provides clotting. Centrifugal stages" and "Clotting of the blood of the child whose arm is bleeding".

Figure 6. Samples of drawings on the concept of blood at level 4.

the draw-write technique. In this context, it has been determined that the participants in the draw-write technique have incomplete or incorrect information only in the categories of "blood cells", "blood fluid, its content and its task" and "blood and its circulation system". In other words, whereas in the data obtained through the draw-write technique not much incomplete and inaccurate information were expressed, in the free word association test incomplete and incorrect information has been found almost in all categories**.**

The biology student teachers' explanations on the category of "blood cells"

Sample from the free word association test

"The blood cells are red blood cells and white blood cells" (K30), *"... the red blood cells and white blood cells from the blood"* (K13). The participants consider white blood cells and red blood cells as blood cells. However, they did not express blood platelets. It was found that the participants have incomplete information. One other participant *"blood cells are red blood cells, white blood cells and erythrocytes ..."* (K33). The participant described erythrocyte as cell different from the red blood cell.

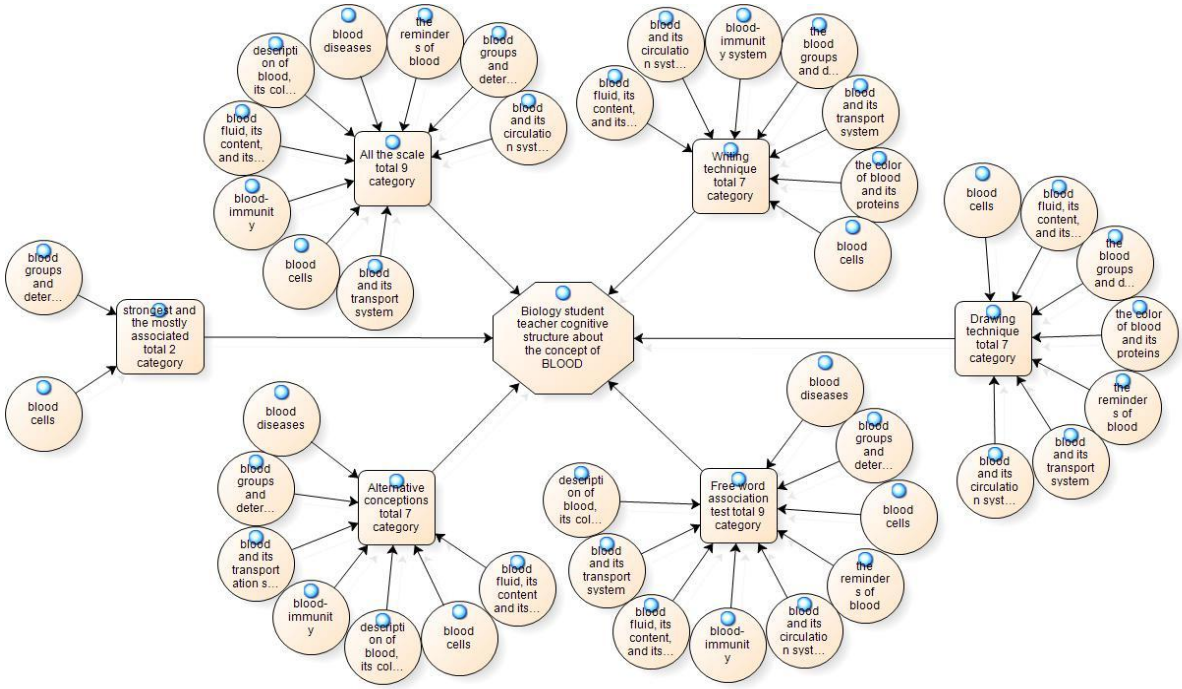
Sample from the draw-write technique

"Red blood cell makes anaerobic respiration" (K19). There is no scientific information that the red blood cells make anaerobic respiration.

The biology student teachers' explanations about the category of *"blood fluid, its content and its task"*

Sample from the free word association test

"... Is the substance that provides exchange of nutrients and oxygen in the tissues ..." (K28), *"blood carries oxygen and hormones to the tissues"* (K33). The participants



Model 1. The biology student teachers' cognitive structures with regard to concept of blood.

expressed the exchange of nutrients and oxygen in the tissues, but did not express the exchange of carbon dioxide and waste produced in cells.

Furthermore, these substances are blood-borne substances. *"Platelets are involved in blood clotting ..."* (K32). In fact, scientifically, the molecule in the structure of protein which is called fibrinogen provides blood clotting.

Sample from the draw-write technique

"red blood cells together with white blood cells form muscle tissue ..." (K28). This information is not scientific information. Muscle cells form muscle tissue.*"Blood platelets provide blood clotting"* (K28, K32). Scientifically, the molecule in the structure of protein which is called fibrinogen provides blood clotting.

The biology student teachers' explanations about the category of *"description of blood, its color, and its proteins"*

Sample from the free word association test

"... Blood is a red-colored substance" (K29), *"blood is as red-colored liquid"* (K36, K17). The participants consider blood as a red-colored substance. However, the blood is not a red-colored substance. Because, hemoglobin gives blood its red color.

"The task of hemoglobin is the transportation of oxygen" (K34). Scientifically, hemoglobin is a protein which is not only responsible for the transportation of oxygen but also for the transportation of carbon dioxide.

The biology student teachers' explanations about the category of *"blood and its transportation system"*

Sample from the free word association test

"Red blood cells and white blood cells in blood fulfill the task of transportation" (K8). As the blood cells are tasked with the transportation, other contents in the blood (blood plasma) are tasked with it, too.

The biology student teachers' explanations about the category of *"blood groups and determination of the blood groups"*

Sample from the free word association test

"There are four types of blood groups which are A, B, 0, and AB" (K43). The participant expressed the blood groups at a very simple level, but did not emphasize the important RH+ and Rh- factors.

The biology student teachers' explanations about the category of *"blood and its transportation system"*

Sample from the free word association test

"The blood which is carried by the circulation system has many tasks in our body" (K27). The participant thinks that the blood is carried by the circulation system. In fact, scientifically the blood is carried by the blood transport system. It was determined that the participant has incomplete information about the systems.

"In circulation system heart pumps blood and it is enriched with O2 in the lungs. Blood, coming back to the heart, is directed to the systemic circulation" (K39). It is observed that the participant expressed the systemic and micro circulation, but used incorrect statements.

Sample from draw-write technique;

"... blood is cleaned up the in the heart and spread throughout the entire body." (K6). Blood is enriched with oxygen in the lung. That the blood is cleaned up in the heart is incorrect information.

The biology student teachers' explanations about the category of *"blood-immunity"*

Sample from the free word association test

"What is important for the immune system is the hemoglobin that carries oxygen in the blood circulation and myoglobin that gives color" (K37). What are important in the immune system is the white blood cells. Furthermore, what gives blood its red color is not myoglobin but hemoglobin.

"Thanks to the white and red blood cells blood fulfills the task of cellular defense" (K38). The participant thinks here that red blood cells play a role in the immunity, too.

The biology student teachers' explanations about the category of *"blood diseases"*

Sample from the free word association test

"...bloodlessness disease is called anemia" (K31). The weakening of the production of blood is called anemia. But bloodlessness cannot be described as anemia.

RESULTS AND SUGGESTIONS

At the end of the research, the answers in the free word association test expressed by the biology student teachers regarding their conceptual structure were collected under a total of 9 categories. These are listed as "*blood cells", "blood fluid, its content, and its task", "description of blood, its color, and its proteins", "blood and its transport system", "blood groups and determination of the blood groups", "blood and its circulation system", "blood-immunity", "blood diseases", and "the reminders of blood".* On the other hand, 8 categories were emerged from the drawings and writings with regard to the concept of blood. These are *"blood groups and determination of the blood groups", "blood cells"*, *"blood fluid, its content, and its task", "blood and its transport system", "description of blood, its color, and its proteins", "blood and its circulation system", "blood-immunity", and " the reminders of blood"*. The categories which were obtained through both measuring tools are in nature of supporting, dilating and explaining one another. This situation shows that in cognitive structure studies regarding concepts on the same subject, detailed information can be obtained by using measurement tools which are different and supporting each other. Therefore, in this study it has been revealed that rich data which in nature is supporting each other can be obtained through different measurement tools. In the results, whereas the dominant category of the student teachers that is emerged in the free word association test is "*blood cells*", the dominant category that is emerged in the draw-write technique is "*blood groups and determination of the blood groups*".

It has been found in the researches that students inadequately associate the information they learned in different sciences with daily life, that their comprehension of the relationship between scientific and non-scientific concepts and establishing associations are inadequate (Enginar et al., 2002; Kurt et al., 2009; Ozmen, 2003; Palmer, 1999; Tasdemir and Demirbas, 2010; Yigit et al., 2002). Also in the results obtained in this study, it has been determined that the biology student teachers expressed in their answers regarding blood usually positive associations, but they also expressed negative associations. These associations reflect words that the biology student teachers use in their daily life and words with regard to blood that are emphasized at lessons and scientifically accepted. In this context, they reflect biology student teachers' response words obtained through free word association test and their scientific concepts with regard to blood obtained through the draw-write technique, their associations of these concepts with their daily lives, their explanations of scientific concepts through expressions of daily conversation etc. One of the main objectives in science is to be able to associate the learned scientific knowledge with everyday life and to use them, however what is important here is that the scientific concept is correctly configured and scientifically expressed in correct way. Teacher candidates are determined to be insufficient at this point. But in recent years the main purpose of the reform efforts in the field of science education is emphasized as creating a scientifically literate society (Bybee, 1997; Millar and Osborne, 1998; Shwartz et al.,

2005). It can be said that biology student teachers are not satisfying at this point. In the same way, also in the results obtained through the draw-write technique it has been found that, mostly with non-representative drawings, the student teachers' cognitive structures with regard to blood are inadequate. Therefore, it has been observed that the biology student teachers' information on the subject of blood is superficial, that they cannot establish the connections between the macro and micro levels of biological systems which are important for biological literacy (Brown and Schwartz, 2009).

In the context of the results reached in the categories obtained with regard to these connections mentioned above; it cannot be said that some of the biology student teachers' cognitive structures with regard to blood have conceptual validity. Because both in the free word association test and the draw-write technique it has been determined that nearly half of the participants have incomplete and inaccurate information about blood. This information also negatively affects the students' comprehension of the subject. Therefore, it is absolutely necessary to compensate for this incomplete and inaccurate information. Because, this information which cannot be compensated for by means of traditional approaches to education and training persist even in adulthood (Strike and Posner, 1982). This indicates quite a serious problem in terms of the student teachers. He/she would teach incomplete and inaccurate information to his/her students.

The incomplete and inaccurate information that commonly emerged in both measurement tools have been determined in the categories of "blood cells", "blood fluid, its content and its task" and "blood and its circulation system". When looked at these categories, it has emerged that the student teachers have incomplete and incorrect information in the main categories, which is quite a serious problem. This situation has emerged in the drawings section including alternative concepts, in which the drawings are analyzed, as supporting other data. In this context, Yesilyurt and Gul (2012) identified findings such as inaccurate and false statements determined in "blood cells" category, in their study they conducted with the participation of secondary school students.

On the other hand, the incomplete and false information identified in the category of "blood fluid, its content and its task" in this study has not been found in the literature. Yip (1998a) in his survey determined that the teachers cannot understand the relation between blood flow, blood pressure and vessel diameter. In this context, it is stated that the participants could not sufficiently understand the mechanism of exchange of substances between blood and blood cells, that they have incomplete and inaccurate information.Similar or different information as the participants' incomplete and incorrect information determined in the category of "blood and its circulation system" have been found in the literature (Micheal, 1998; Sungur et al., 2001; Micheal et al. 2002; Paleaz, 2005; Prokop and Fančovičová, 2006; Bahar et al., 2008). These concepts are often as "the heart has the function of blood cleaning or preparation, filtration and storage". The false information that "the heart cleans the blood" have also been found in the researchers conducted with the participation of secondary, university biology, classroom and science students in science (Ozgur, 2013).

Incomplete and incorrect information that emerged only in the free word association test has been in the category of "the definition of blood, its color, and its proteins". Kete (2006) in his study, in which they related blood groups that were expressed in form to the reality, determined the similarities of incomplete and incorrect information. Incomplete and incorrect information obtained in the category of "blood-immunity" is also quite remarkable. However, Yesilyurt and Gul (2012) found similar results in their research they conducted with secondary school students. Mosothwane (2009) remark that when science student teachers were asked the question of how diseases in humans occur, they had conceptual errors such as "the key organ of the immune system is the blood", "blood carries the immune cells" and "white blood cells are the key immune cells". As for Jones and Rua (2006), they indicate that students in their definitions of the immune system often emphasized the information of "white blood cells fighting germs". While it is stated that it is quite insufficient that the participants understand the immune system with regard to blood, it is because of that the integrity at level of biological organization is not understood, that the issues are abstract (Jones and Rua, 2006; Lukin, 2013; Tripto et al., 2013), and that small units constituting biological systems are not understood.

While there are several reasons for being unable to form the conceptual structure, that similar incorrect identify-cation are made in textbooks, that these make it difficult for concepts to be understood and cause confusion is just one of the reasons for students to learn incomplete and incorrect information. Towards this end, teacher education programs are required to facilitate student teachers' conceptual development, to develop their professional skills and raise their awareness in the direction of being able to identify the learning difficulties of students when they start work (Yip, 1998b). If it is considered that students have difficulties to change the wrong concepts even when they are educated (Donovan and Bransford, 2005), it should not be ignored that it is a process that needs to be taken seriously. It is expressed that many biology teachers do not have enough domain knowledge to teach the secondary school course content (Yip, 1998b). Consequently, in the researches about the concept of blood, it is stated that the participants at any level have incomplete and incorrect information. What is important is to be able to arrange effective educational

activities, through determining these incomplete and incorrect information at all levels of education in the phase of preliminary information, in the direction of trying to eliminate or minimize them. This result supports the view that non-scientific understanding in any topic also causes faulty understanding and interpretation of various other topics (Yen et al., 2007).

On the other hand, when the drawings are evaluated according to the levels similar results were obtained in support of the above mentioned results. Because ¾ of the student teachers explained their conceptual structure with regard to blood without thinking about the dimensions of the subject and through figures which are just simple, not very well understood and scientifically unrelated to the reality. It was found that they have a lot of alternative concepts. That the alternative concepts are plenty may be due to naive experiences of student teachers and/or due to insufficient and inappropriate teaching of the sections in the biology course programs emphasizing the topic of blood in the different educational levels of pre-university Turkish education system.

As a result, to attach importance to teaching of concept and conceptual learning at all levels of education and to arrange teaching and educational activities in this direction are very necessary for meaningful learning. Due to insufficient and inaccurate preliminary information may fail in further learning. On the other hand, by educating biology student teachers in the direction of effectively using cognitive strategies with a view to providing their successful learning of the concepts, it could be ensured that their cognitive structures with regard to concepts would be permanent and accurate (Tasci and Soran, 2012). Also both at university and pre-university levels of education, experts who prepare curriculum should prepare contents that focus on applications for students to learn concepts well. It should be kept in mind that that the biology student teachers who will be teachers in the future take quality education means they will give quality education to their students.

In conclusion, it has been determined that cognitive structures of the biology student teachers with regard to the concept of blood is not sufficient, they cannot specify the relationship between the concept of blood and other related concepts, they cannot adapt the features of the concept of blood to their daily lives, and they have alternative concepts in all categories obtained in relation with the concept of blood. These specified results may stem from the inadequacy of student teachers' education in college as well as in pre-university education institutions. According to the results, guidelines have been derived in order to enable a better and more fruitful way of teaching about the concept of blood. For example;

* A range of learning materials such as charts, leaflets, posters, slide presentations and laboratory materials can be developed to support the teaching of blood' (in transport and circulation systems) related issues in the primary, secondary, and high school science curriculum.

*It was found that they have a lot of alternative concepts. That the alternative concepts are plenty may be due to naive experiences of student teachers and / or due to insufficient and inappropriate teaching of the sections in the biology course programs emphasizing the topic of blood (in transport and circulation systems) in the different educational levels of pre-university Turkish education system.

*In teaching the invisible abstract concepts, drawings may be included intensively in every education level for the development of visual images of students. Thus, students' cognitive structures can be formed as more powerful.

*Appropriate course contents may be incorporated into the teacher education programs to gain biological literacy and associative thinking skills with daily life. Thus, students may be more interested in courses; their learning may be facilitated because they could find answers to the biological, social and individual questions they are curious about.

On the other hand, through arranging researches of concept like this as interviews, achievement test, experimental researches etc., collection of different data can be provided.

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