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Full Length Research Paper

On the concept "Microscope": Biology student teachers' cognitive structure

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The purpose of the current study is to determine biology student teachers' cognitive structures on the concept of microscope. Qualitative research methodology has been applied in the study. The data were collected from biology student teachers. Free word association test and drawing-writing test were used to collect data. The data collected were subject to content analysis and divided into categories. According to the analyses conducted, while 6 categories were determined through the free word association test in biology student teachers' cognitive structures on the concept of microscope, in the drawing-writing technique, 5 categories were specified. Through both measurement tools, rich data were obtained, supporting, expanding on, and explaining one another. In this context, it was determined through both measurement tools that student teachers' cognitive structures focused on "*microscope tools*". Moreover, the data collected through these data collection instruments indicated that student teachers had alternative conceptions about the concept of microscope. Alternative conceptions were determined in almost all categories, which may be attributed to the fact that student teachers have naive experiences and/or the units that require the use of microscopes during the laboratory work included in biology curriculum which is provided in different teaching levels at university or pre-university education cannot be explored efficiently and appropriately.

Key words: Microscope, free word association test, drawing-writing technique, alternative conceptions, cognitive structure.

INTRODUCTION

Microscopes are one of the most important inventions in the world of science since microscopes enable us to see the small and abstracts structures that cannot be seen with naked eyes (Figure 1). Though microbes are used in many fields, Biology is one of the fields where microbes are the most commonly used. Microscopes were first used in Biology in the 17th century. The work authored by Stelluti Francisco in 1625 on the bodies of bees is the very first scientific publication that is based on microscopes. Several fields within biology are based on microscopes, including cellular and molecular biology, microbiology, bacteriology and many others. Microscopes come in a variety of styles and are designed for use in different situations. In school biology labs, the most common type is a single-lens, optical microscope, which uses light to magnify biological or cellular material that is stained or prepared on a slide. Compound microscopes use multiple lenses that offer improved magnification

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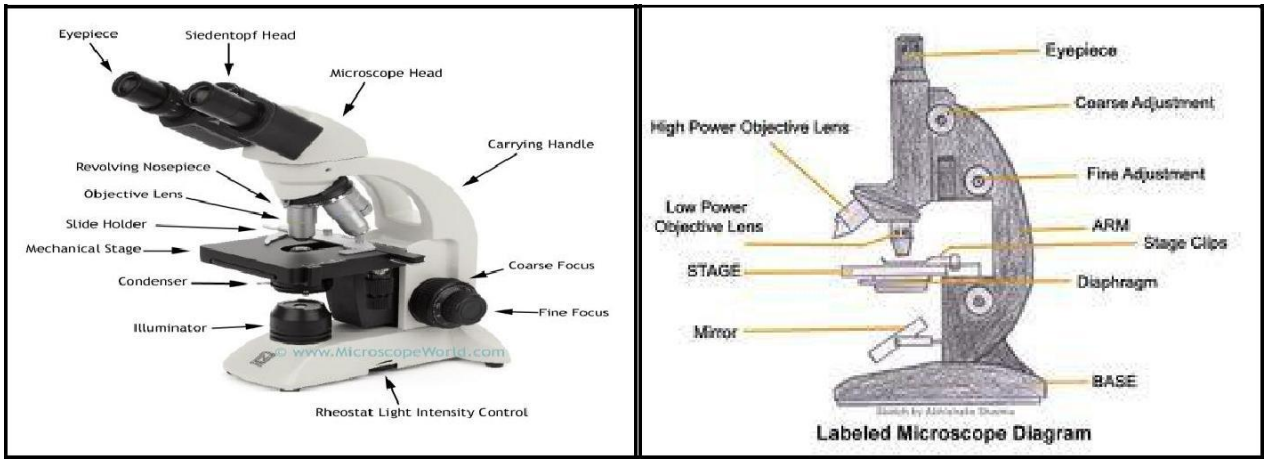


Figure 1. Microscopes.

and contrast to better study cells, tissues or other materials. Other types of microscopes used in biological studies include powerful electron transmission scopes, phase contrast scopes, and florescence scopes.

Biology is a unique discipline where experiments with living organisms can take place both in the laboratory and in the field. Although biology is interesting in that it aims to examine living things, it is one of the courses that students have difficulty in learning, and thus forming cognitive structures as students cannot grasp the integrity in the topic at the level of biological organization and the course includes abstract topics that cannot be seen (Bahar et al., 1999; Cimer, 2012; Jones and Rua, 2006; Lukin, 2013; Lazarowitz and Penso, 1992; Prokop et al., 2007; Seymour and Longdon, 1991; Udovic et al., 2002; Treagust, 1988).

Although microscopes are one of the important tools that contribute to learning the field of biology, not having sufficient information about microscopes emerges as a dimension that makes learning difficult, rather than easy. Accordingly, particularity the teachers that are responsible for teaching biology and the future teachers that will assume this duty need to have sufficient cognitive structures on microscopes, which is an effective factor that play an important role in students' high success in biology since microbes are generally used to obtain the concrete images of the objects in accordance with the appropriate rules with the support of teachers as well as it is a tool used in laboratory work during biology class to improve students' skills such as thinking, doing research, investigating, seeing, and observing (Basey et al., 2000). Accordingly, microscopes can contribute to students' creating visual images related to concepts. Teachers should know the characteristics and the use of such an important tool, and thus have good cognitive structures on microbes.

Cognitive structures are hypothetical structures that represent the relationships of the concepts in an individual's long term memory. One of the reasons at the heart of learning difficulties is that individuals cannot associate the conceptual structures related to the topics in their minds. At this point, educators should lead students to increase meaningful learning. In order to achieve this, knowing students' prior knowledge (Pines and West, 1986; Treagust et al., 1996; Tsai and Huang, 2002) helps teachers not only to improve teaching strategies, but also do research on students' conceptual changes. Otherwise incorrect prior knowledge always affects learning adversely (CUSE, 1997; Linder, 1993; Posner et al., 1982; Wandersee et al., 1994). In this vein, biology educators also, in practice, try to use the results suggested by research on cognitive structures. According to Gilbert et al. (1998 a, b), it may be difficult to determine individuals' cognitive structures. However, in line with this, it is crucial to reveal individuals' ideas about the key concepts. Gilbert and Boulter (2000) stress that they consider mental models as unreachable and thus concepts mean cognitive models, and at this point emerges the importance of learning conceptual learning.

Various methods and strategies are used to determine conceptual learning and conceptual changes (Vance et al., 1995). The researchers have turned to techniques that measure not only students' existing knowledge but also students' relationships among concepts, cognitive structures, and whether they can achieve meaningful leaning through associating existing knowledge with the new one and to what extent they have grasped the similarities between the knowledge they have created on their minds and functioning of the events in the natural life and these techniques have gained attention (Bahar, 2003; Bahar et al., 2006). In this regards, the free word association test and the drawing-writing technique used

in this study are one of the important measurement tools.

THE STUDIES ON CONCEPTUAL STRUCTURE RELATED TO THE CONCEPT OF MICROSCOPE

The use of microscope in laboratory work contribute significantly to students' learning since students can gain experience in learning by exploring freely and using microscopes during laboratory work (Puckering et al., 2003). Through microscopes, students can observe various animal cells, red blood cells, differentiate between mammalian and non-mammalian cells, see small objects that they cannot see through naked eyes, and thus students have the opportunity to see the hidden and wonderful world thanks to microscopes. This situation will provide students with the opportunity to learn by exploring freely while learning biology and students will experience the happiness of learning biology.

To the best knowledge of the authors, there is not any study conducted to determine the participants' conceptual structures on microbes, one of the most important tools used in Biology education. There are several studies that investigate the issues faced in the use of microscopes, the causes of these issues and the use of microscopes within the context of laboratory work/method. In their study, Uzel et al. (2011) obtained findings on student teachers' views of the parts of microbes, their levels of knowledge on the use of microscopes, the issues that these student teachers faced while using microscopes, and the causes of these problems. In this regard, it was determined that student teachers had incomplete knowledge about the parts of microscopes, and that the most well-known parts of microscopes were the base, course focus, and fine focus. On the other hand, in another study conducted by Harman (2012), it was determined classroom student teachers knew the parts of microscopes in general; however, they had incomplete and inaccurate knowledge about their use.

As seen in the example studies selected from the literature in which theoretical knowledge about microscopes, their use, and the issues faced in using microscopes are discussed, the studies conducted so far reveals that the participants have incomplete and inaccurate knowledge about microscopes; as a result, they cannot use microscopes in line with their aims and effectively. Among the main reasons for this might be the previously gained knowledge that is inaccurate as well as not being able to use microbes efficiently since prior knowledge always affects subsequent learning adversely (CUSE, 1997; Posner et al., 1982; Wandersee et al., 1994). Accordingly, it is crucial to determine cognitive structures related to the topic in focus and to eliminate inaccurate prior knowledge to ensure effective learning. Gilbert et al. (1998a, b), stress that it is difficult to account for individuals' cognitive structure, but it is crucial in this direction to reveal their thoughts on the key concepts. On the other hand, Gilbert and Boulter (2000) stress that they consider mental models as unreachable, and thus concepts mean cognitive models, and at this point the studies conducted on concepts reveal individuals' cognitive models related to these concepts.

In this context, there exist techniques that measure not only students' existing knowledge but also students' relationships among concepts, cognitive structures, and whether they can achieve meaningful learning through associating existing knowledge with the new one and to what extent they have grasped the similarities between the knowledge they have created on their minds and functioning of the events in the natural life (Bahar, 2003; Bahar et al., 2006; Vance et al., 1995). The free word association test and the drawing-writing technique used in this study are among the important measurement tools within this context. It is possible to determine students' conceptual structures and reveal their alternative conceptions using the free word association test and the drawing-writing technique. In the literature review conducted on this issue, it is found out that there is not any study conducted through using both free word association test and drawing-writing technique to reveal biology student teachers' conceptual structures on "microscopes". Therefore, it is believed that the results of the current study conducted through using free-word association test and drawing-writing technique will fill this gap in the literature providing quality data. However, the literature review conducted indicates that there are few and insufficient studies that investigate the participants' cognitive structures on the concept of microscope. Therefore, this study is believed to contribute to the literature through quality findings in terms of a variety of dimensions such as the data collection methods of the study, the data collected, the prospective Biology student teachers as the participants, pointing to the use of microscopes through presenting student teachers' cognitive efficacy in the concept of microscope. As there are not enough studies on the concept of microscope, which is one of the most important instruments in science education, the results of this study will be quite remarkable.

THE AIM OF THE STUDY

The aim of the current study is to investigate Biology student teachers' cognitive structures on the concept of "microscope" using free word association test and drawing-writing technique. In this vein, the following research questions were investigated:

1. How are biology student teachers' cognitive structures on microscope as determined by free word association test?

2. How are biology student teachers' cognitive structures on microscope as determined by drawing-writing technique?
3. What are biology student teachers' alternative conceptions on "microscope"?

METHODOLOGY

Research design

In this research, the qualitative research method was employed. Examination of different aspects of education through the qualitative research method has been a very widespread approach especially in the last 20 years (Gall et al., 2002; Hitchcock and Hughes, 1995; Verma and Mallick, 1999). A qualitative research approaches the subject with an interpretative and natural perspective and focuses on more than one method. The main purpose in such researches is to present the subject in a detailed and realistic manner. Therefore, it is of importance to present the data as detailed and direct as possible (Cohen and Manion, 1997; Punch, 2005). The qualitative research method was preferred in this study, since the cognitive structures of pre-service biology teachers are presented in detail using the independent word association test and the drawing-writing technique in this research.

Participants

The study was comprised of 44 biology student teachers" studying at the 4^{th} and 5^{th} grades of Biology Education Department in Necmettin Erbakan University in spring term of 2011 to 2012 academic years. 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. Of the participants, 35 (79.5%) are females, and 9 (20.5%) are males. In addition, 19 of the participants (43.20%) are 4^{th} year students, and 25 (56.80%) are 5^{th} year students.

Research instruments and procedure

The current study aimed to collect detailed data on biology student teachers' conceptual structures on the concept of "*microscopes*" using free word association test and drawing-writing technique as data collection instruments. More information is provided below on these measurement tools;

Free word association test

This technique is used to collect data in many studies conducted in science (Aydin and Tasar, 2010; Daskolia et al., 2006; Dove et al., 1999; Ercan et al., 2010; Koseoglu and Bayir, 2011; Ozatli and Bahar, 2010; Timur and Tasar, 2011; Torkar and Bajd, 2006).

Free word association test is one of the oldest and the most commonly used techniques that are used to determine individuals' cognitive structures on concepts, the bonds among these concepts; in other words, it uncovers information network and determines whether the relationships between the concepts in the long term memories are sufficient or not (Atasoy, 2004; Bahar and Kilicli, 2001; Bahar and Ozatli, 2003; Cardellini and Bahar, 2000; Hovardas and Korfiatis, 2006). This technique is based on the assumption that individuals provide responses related to the stimulus word without limiting the ideas that come to mind (Bahar et al., 1999; Sato and James, 1999). In the current study, the concept of *"Microscope"* was provided to the biology student teachers to complete the free word association test. In this test, the concept of microscope was provided in the following format as a stimulus word. In Figure 2, an example of the drawings collected from participants through free word association test was provided, which was dawn by one of the participants, P28.

As can be seen in the test sample provided in Figure 2, the word association test is composed of two phases:

In the first phase, in the free word association test, the participants are required to provide the concepts that the stimulus word brings to their minds in a specific period of time, which is 40 seconds (Gussarsky and Gorodetsky, 1990) for the current study. Biology student teachers were asked to write the very first five words that come to their minds when they read or listen to the concept of microscope and to do so in 40 seconds. The reason why the participants were asked to write the key concept one under the other is to prevent the risk of providing chain answers since if students did not read the key concept while providing each concept, they could write the words that the previously provided answer words bring to their minds, rather than the key concept. This would harm the aim of the study.

In the second phase, the participants were asked to provide sentences related to the key concept in a period of 20 seconds and during the data analysis, these sentences were analyzed one by one since the answer sentence associated with the key concept could only be, at the level of remembering, a result of an association which is not meaningfully associated with the key concept. Furthermore, since the related sentence would be more complex and have a higher-level structure compared to an answer word, the evaluation process is affected by whether this sentence is scientific and whether it includes misconceptions of different nature.

Drawing-writing technique

This technique is observed to be used in many studies in science (Cetin et al., 2013; Nyachwayaa et al., 2011; Pluhar et al., 2009; Prokop et al., 2009; Shepardson et al., 2007; Stafstrom et al., 2002; Yayla and Eyceyurt, 2011; Yorek et al., 2010). Through using drawing-writing technique, it was aimed to analyze student teachers' views of the concept of microscope thoroughly since this technique is very useful as it helps collect natural and high quality data on hidden thoughts, understanding, and attitudes related to concepts (Backett-Milburn and Mckie, 1999; Pridmore and Bendelow, 1995; White and Gunstone, 1998). In this vein, the participants were asked to provide their views and ideas freely without limiting themselves in 5 minutes regarding the question of "*Please explain what you know about the concept of microscope through drawing"*. Below is an example of the drawing-writing technique (Figure 3).

As mentioned above, free word association test and drawing-writing technique have been used separately in different studies and in different issues. However, this study aimed to collect rich data that detail each other using these two measurement tools together. In addition, unlike other studies, the drawing data obtained through this study have been evaluated based on cognitive

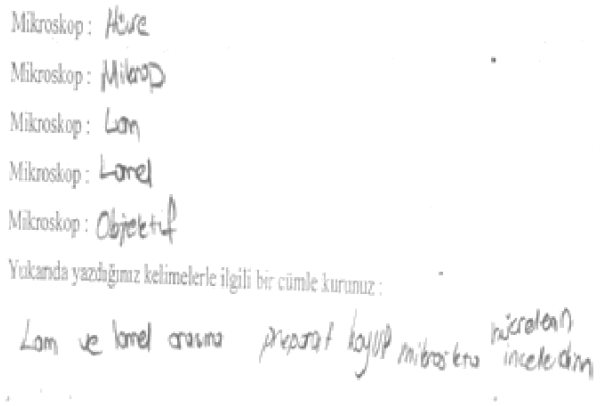


Figure 2. P28's answer sheet
(Words in the Figure 1: Cell, Microscope, Microscope Slide, Cover Glass, Objective.
Sentence *in the* Figure 1*:* I analyzed the cells by putting the slide between the microscope slide and the cover glass.

STIMULANT WORD: MICROSCOPE

Microscope-1:.....
Microscope-2:.....
Microscope-3:.....
Microscope-4:.....
Microscope-5:.....
SENTENCE:.....

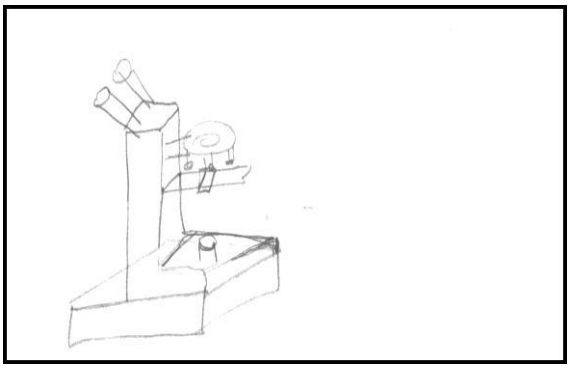


Figure 3. *P10's answer sheet,* Microscope figure

levels. There is not any study conducted in this way and it can be stated that this study is one of the first studies conducted in the literature.

Reliability and validity of the data collection tool

In this study, 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 (Hruschka et al., 2004; Marvasti, 2004; Roberts and Priest, 2006)

(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 (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) x 100] (Miles and Huberman, 1994). The average reliability between the coders was calculated as 95%.

DATA ANALYSIS

Before the data analysis, the participants" answer sheets were numbered from 1 to 44. The data collected were subject to content analysis. In content analysis, the main aim is to determine the concepts and the relationships that will account for the data. In order to achieve this, the similar data are categorized under specific concepts and themes and organized for easy understanding by readers.

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; Nakiboglu, 2008). 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 drawing-writing technique, the data collected through drawing and writing on the concept of microscope was subject to content analysis. By means of the drawing task, the students" ideas about the microscope 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). The participants' drawings related to the concept of microscope were first divided into specific categories and subcategories. Later, the participants' cognitive structures as revealed by the drawing-writing technique were analyzed according to levels. While determining these levels, the data were divided into categories from level 1 to level 5. (Bahar et al., 2008; Bartoszeck et al., 2008; Cinici, 2013; Reiss and Tunnicliffe, 2001). Table 1 pro-vides the group levels created for the evaluation of the participants' cognitive structures on the concept of microscope through their drawings.

Moreover, in free word association test and drawing-writing technique, the interesting statements on the concept of microscope in the text provided by the participants were numbered and quoted within the quotation marks, " " (P23). In the drawing-writing technique, the examples of the drawings provided by the participants were numbered and provided in the text such as P13 and P33.The data of the free word association test have been analyzed with the Nvivo programme for preparing Model 1.

FINDINGS

The findings obtained through the free word association test

As a result of the data analysis conducted on student

Table 1. The group levels created for the evaluation of the participants' cognitive structures on the concept of microscope through their drawings.

Levels	Drawings
Level 1:	No drawing
Level 2:	Non-representational-carton drawings
Level 3:	Drawings with alternative concepts
Level 4:	Partially correct drawings
Level 5:	Comprehensive representation drawings

teachers' cognitive structures on the concept of microscope, a total of 6 categories were formed by listing the words provided. These categories and the words provided in each category are listed. When these words were repeated only once, they were not joined with the other words (Kostova and Radoynovska, 2008; Kostova and Radoynovska, 2010; Kurt, 2013; Torkar and Bajd, 2006). Therefore, 11.06% (26 words) of these answer words were not included in the categories. These words were excluded from Table 2 considering the nature of the research; however, they were stated in the section of comments in each category evaluated. Accordingly, 24 different words left associated with the concept of microscope were divided into 6 categories. Table 2 lists the words provided in each category and the categories. 209 answer words were obtained in total.

As a result of the analysis of the data collected, in the first category, the related answers provided by biology student teachers in response to the concept of microscope mostly fell into the category of "*microscope tools*" and appeared as the dominant category (f=73). While most of the participants focused on the words, *"microscope slide"*, *"cover glass"* and *"slide"*, few of them provided the words, *"cells"* and *"fraction"*. However, it was observed that there were any words that were not included in this category as they were stated but repeated only once. These results indicate that the participants had more close and related associations with the concept of microscope in the category of "*microscope tools*"

In the second category, the participants had associations with *"the optical part of the microscope*" (f=50). While the associations that the participants had were mostly the concepts, "*objective*" and "*ocular*", few of the participants focused on the words such as *"magnifier"* and *"condenser"*. The words that were not included in this category as they were repeated only once were determined as *"microscopic glass"* and *"reduction"*. Based on these results, it was determined that the participants did not mention the other parts related to "the optical part of the microscope" such as condenser. It can be put forward that the participants' cognitive structures are incomplete.

The third category emerged as "the mechanical part of the microscope" (f=30). The participants' associations with this category were mostly the words, *"course focus", "fine focus", and "microscope stage"*, few of the participants mentioned the concept, *"exposure"*. Moreover, the word that was mentioned by the participants in this category, but was not included in this category as it was repeated only once, was determined as "*dial plate*". It was determined that biology student teachers' cognitive structures on "*the mechanical part of the microscope*" were sufficient.

In the fourth category, the participants provided answer words related to "*the definition of the microscope and aims of use*" (f=26). In this category, the participants mentioned the statements, *"analyzing small microscopic living things"* and *"magnifying"*. The words that were not included in this category as they were repeated only once were determined as *"microbe"* and *"analyzing living things"*, and "*science*".

The fifth category included the associations under the category of "*fields of microscope use*" (f=17). Most of the participants focused on the concept of *"laboratory"*. It was determined that few of the biology student teachers mentioned the concepts of "biology", "biotechnology" and "microbiology". However, it was determined that there were not any words that were not included in this category as they were stated but repeated only once.

The last category emerged as the "*types of microscopes*" (f=13). The concepts associated by the participants with this category were determined as *"light microscope"* and *"electron microscope"*. Considering the answer words provided, it was observed that the participants could not associate with the other types of living things and the conceptual validity was not ensured. The word that was mentioned by the participants in this category, but was not included in this category as it was repeated only once, was determined as *"stereo microscope"*.

The findings obtained through drawing-writing technique

It was determined that the data collected through drawing-writing technique to investigate biology student teachers' cognitive structures related to the concept of microscope fell into 5 categories in total. While the drawings were under 5 categories entitled, *respectively, microscope tools* (46), *the optical part of the microscope* (33), *the mechanical part of the microscope* (28), *types of microscopes* (16) and *the definition of microscope and aims of use* (10), the writings were mostly under 4 categories entitled *the mechanical part of the microscope* (14), *the optical part of the microscope* (13), *types of microscopes* (6) and *microscope tools* (2). In this context, it is seen that the findings of drawing-writing fall into 5

Table 2. The distribution of the Biology student teachers' cognitive structures on the concept of "microscope" according to the categories determined

Categories	Included in the category concepts and frequencies	Total frequencies of the category
1. Microscope tools	“microscope slide” (28) “cover glass” (28) “slide” (11) “cells” (4) “fraction” (2)	73
2. The optical part of the microscope	“objective” (22) “ocular” (20) “magnifier” (4) “condenser” (4)	50
3. The mechanical part of the microscope	“macro screw” (10) “micro screw” (10) “microscope stage” (6) “exposure” (4)	30
4. Definition of the microscope and aims of use	“analyzing small living things” (12) “magnifier” (5) “research” (4) “experiment” (3) “measurement” (2)	26
5. Fields of microscope use	“laboratory” (11) “biology” (2) “biotechnology” (2) “microbiology” (2)	17
6. Types of microscopes	“light” (8) “electron microscope” (5)	13
Total	24 words	209

categories (Table 3).

It was observed that in the drawing and writing technique, Biology student students focused on the concepts related to "microscope tools" and drew related figures. *"Microscope slide"* and *"cover glass"* were the mostly stated words in the category of *"microscope tools"*. The category of *Microscope tools* was determined as the common category in the free word association test and drawing-writing technique.

However, according to Table 3, the findings of the biology student teachers' drawings related to the concept of microscope fall into 5 categories. It was determined that they drew figures related to *microscope tools* (46), *the optical part of the microscope* (33), *the mechanical part of the microscope* (28), *types of microscopes* (16) and *definition of microscope and aims of use* (10). Figure 4 provides sample figures related to the concept of microscope.

Moreover, the analyses of the biology student teachers' drawings related to the concept of microscope and the related levels of cognitive structures are provided in Table 4, Figure 5, and Figure 6. Accordingly, the participants' drawings were categorized under 4 levels. These are, *No drawing* (1)*, Non-representational drawings* (30), Drawings with misconceptions (11), Partial drawings (2). The participants did not provide any representational conceptual drawings related to microscopes.

The student teacher coded as P19 did not draw anything about the concept of microscope at Level 1. This might be attributed to the fact that this student teacher did not want to explain the subject through drawing, that s/he had incomplete knowledge, or that

Table 3. The findings of the categories and subcategories obtained through drawing-writing technique related to the concept of microscope

Main category	Sub category	Drawing (f)	Writing (f)
1. Microscope tools	microscope slide	14	-
	cover glass	14	-
	slide	8	-
	fraction	2	-
	beaker	2	-
	pipette	2	-
	cell of an onion skin	2	-
	chloroplast	2	-
	elodea plant	-	2
	Total	46	2
2. The optical part of the microscope	ocular	14	5
	objective	14	4
	light source	3	2
	condenser	2	2
	Total	33	13
3. The Mechanical part of the microscope	microscope stage	13	6
	macroscrew	4	3
	microscrew	4	3
	microscope arm	4	2
	microscope base	3	-
	Total	28	14
4. Types of microscopes	light microscope	10	3
	electron microscope	4	3
	scanning microscope	2	-
	Total	16	6
5. Definition of the microscope and aims of use	magnifying	10	-
	Total	*10*	-
Total		133	35

Table 4. Sample drawings related to the concept of microscope at Level 1

Level 1: No drawing (Total number of drawings: 1)
P19 did not draw anything.

s/he was unable to reveal his/her knowledge through drawing.

As can be seen in Figure 5, 30 of the participants, approximately ¾, tried to reveal their conceptual structures on the concept of microscope through simple drawings. These drawings are not representational; in other words, they are cartoon drawings whose scientific stress cannot be understood completely. These participants tried to explain the subject without thinking in detail through figures that are simple, cannot be understood easily and are not related to scientific facts. Therefore, they tried to reveal their cognitive structures through the figures that they personalized.

As indicated in Figure 6, 11 of the participants, approximately, approximately ¼, provided drawings that included alternative concepts. Accordingly, they stated what they knew about the concept of microscope through both the relevant scientific information and the colloquial expressions used to describe a situation. At this level, they only drew figures such as slide, microscope slide, and cover glass by focusing on a few dimensions; however, in their expressions, they stressed the concept of microscope through drawings-statements that included

Sample figures drawings based on categories

1. Category: Microscope tools

2. Category

3. Category

4. Category

5. Category

Figure 4. Sample figures related to the concept of microscopes obtained through the drawing-writing technique.

1. Category: Microscope tools

Drawing words *P4's answer sheet:* microscope slide, cover glass, pipette, beaker 2. Category: The optical part of the microscope

Drawing words *P3's answer sheet:* ocular, objective, microscope stage, light source 3. Category: The Mechanical part of the microscope

Drawing words *P9's answer sheet:* ocular, x5-x10-x20-x100, exposure, light, macro screw, micro crew. Light microscopes help us analyze microscopic living things by magnifying them.

Electron microbes, on the other hand, provide the opportunity to conduct more detailed and three-dimensional analyses. Microscopes with mirrors enable us to obtain images through its mirror located in the light part and the setting of the mirror that reflects sunlight or outdoor light.

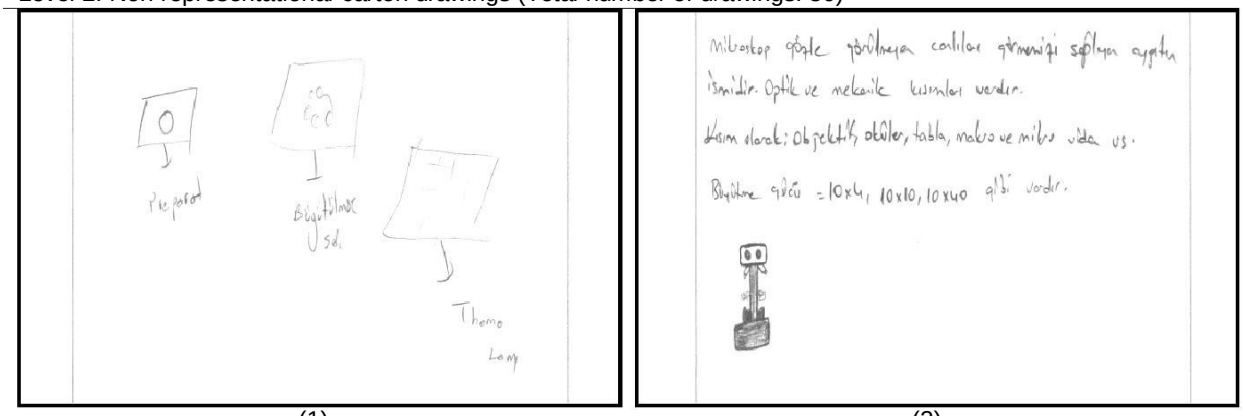
4. Category: Types of microscopes

Drawing words *P23's answer sheet:* macro screw, micro crew, ocular, microscope stage, microscope arm, light microscope, electron microscope

5. Category: Definition of the microscope and aims of use

Drawing words *P18's answer sheet:* Microscopes enable us to see living things that cannot be possible to see with the naked eyes. There are many microscopes developed and produced in this issue. The most important one is the electron microscope.

Level 2: Non-representational-carton drawings (Total number of drawings: 30)

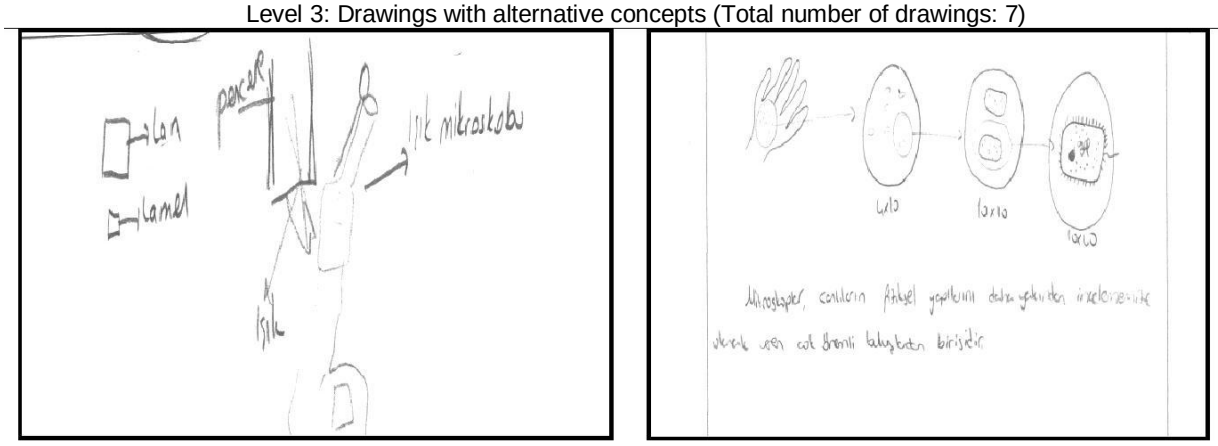


(1) (2)

Figure 5. Sample drawings related to the concept of microscope at Level 2

(1) Drawing words *P11's answer sheet:* slide, magnifier
(2) Drawing words *P18's answer sheet:* Microscopes is the name of the tool that enable us to see living things that cannot be possible to see with the naked eyes. It has optical and mechanical parts. Considering parts: objective, ocular, stage, course focus and fine focus etc.
Magnifying power: such as 10x4, 10x10, 10x40

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



(1) (2)

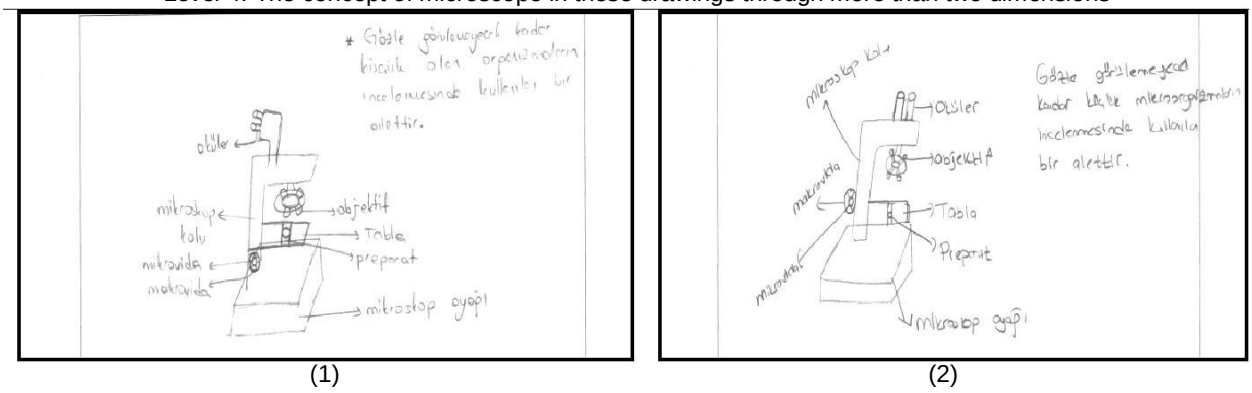
Figure 6. Sample drawings related to the concept of microscope at Level 3

(1) Drawing words *P28's answer sheet:* microscope slide, cover glass, light, light microscope
(2) Drawing words *P13's answer sheet:* Microscopes are one of the most important inventions that enable us to analyze the physical structures of living things more closely.4x10, 10x10, 10x40

alternative concepts.

As can be seen in Figure 7, 2 of the participants provided drawings that were partially correct and explanatory. However, it was determined that they could not reveal what they knew in detail and clearly at this level. They tried to explain the concept of microscope in these drawings through more than two dimensions. In this vein, the parts of the microscope were drawn in detail; explanations and the statements related to the definition of microscopes were provided. However, the drawings were not found to be comprehensive. This situation indicates that biology student teachers' cognitive structures on the concept of microscope are not sufficient.

Level 4: The concept of microscope in these drawings through more than two dimensions



(1) (2)

Figure 7. Sample drawings related to the concept of microscope at Level 4

(1) Drawing words *P14's answer sheet:* Microscopes are the tools that are used to analyze organisms that are too small to see with the naked eyes.
ocular, objective, microscope stage, light source
microscope stage, macroscrew, microscrew, microscope arm, slide; microscope base
(2) Drawing words *P15's answer sheet:* Microscopes are the tools that are used to analyze microorganisms that are too small to see with the naked eyes.

Taking all data discussed above into consideration, it was determined that student teachers' cognitive structures on the concept of microscope were grouped under specific categories. In this vein, a model on biology student teachers' cognitive structures on the concept of microscope was developed by analyzing the data collected through free word association test and drawing-writing technique (Model 1). According to the analyses conducted, while 6 categories were determined through the free word association test in biology student teachers' cognitive structures on the concept of microscope, in the drawing-writing technique, 5 categories were specified. As can be seen in the model, it was determined that biology student teachers' cognitive structures on the concept of microscope were related to a total of 6 categories.

THE BIOLOGY STUDENT TEACHERS' ALTERNATIVE CONCEPTIONS ON THE CONCEPT OF MICROSCOPE

The analyses of the incomplete and inaccurate samples of biology student teachers' explanations about the concept of the microscope are provided below under the categories determined according to both free word association test and drawing-writing technique. In this vein, while there was not much incomplete inaccurate information in the data collected through drawing-writing technique, there is incomplete and inaccurate information almost in each category in the free word association test. Alternative misconceptions are what to be avoided in learning contexts since alternative misconceptions can lead students to misleading results during the data collection and analyses phases in the microscopic experiments conducted in laboratory work and affect students' structuring new information in their minds adversely (Albanese and Vicentini, 1997; Tsai, 1999).

PARTICIPANTS' EXPLANATIONS RELATED TO THE CATEGORY OF *"THE OPTICAL PART OF THE MICROSCOPE"*;

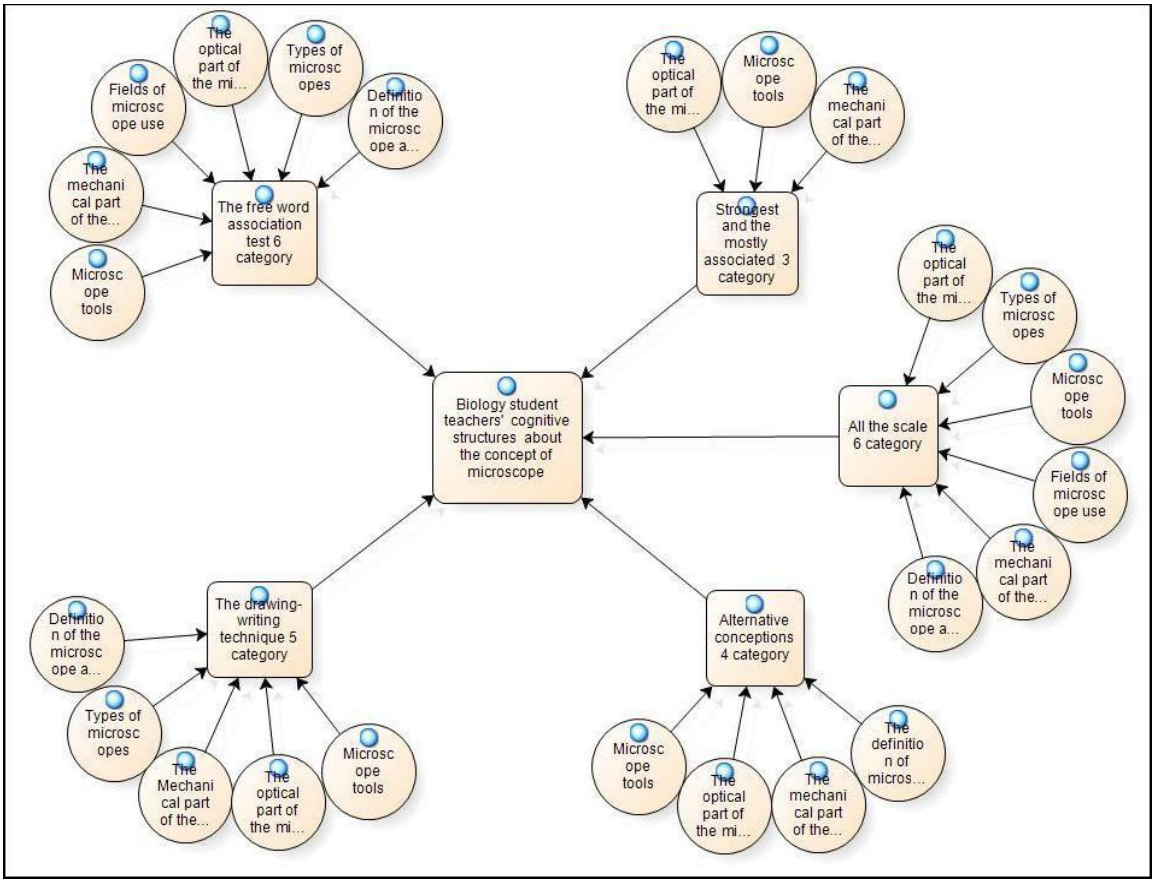
A sample statement provided in the drawing-writing technique;

"Lenses provide clarification of the image" (P3). Lenses are not the only part that provides a clearer image. The system composed of lenses as a whole (lenses, ocular, light adjustment, etc.) and the settings of the course focus and fine focus also enable obtaining clear images.

Participants' explanations related to the category of *"microscope tools";*

A sample statement provided in the free word association test;

"*We analyze the cells by putting the slide between the microscope slide and the cover glass."* (P29). The participant could not understand that the process of



Model 1. Biology student teachers' cognitive structures related to the concept of microscope.

microscope slide-cover glass is a process of slide.

"The slides are magnified and analyzed through microscopes" (P31). The sample on the slide is magnified and analyzed on the microscope, not the slides.

"Microscope slide, cover glass, dial plate, and stage are the small parts of a microscope." (P42). Some of the parts mentioned by this participants are microscope tools (microscope slide and cover glass), and some are the mechanical parts (dial plate, stage). It is noticed that the participant had incorrect knowledge.

Participants' explanations related to the category of "the mechanical part of the microscope";

A sample statement provided in the free word association test;

"Microscope slide, cover glass, dial plate, and stage are the small parts of a microscope." (P42). Some of the parts mentioned by this participants are microscope tools (microscope slide and cover glass), and some are the mechanical parts (dial plate, stage). It is noticed that the participant had incorrect knowledge.

Participants' explanations related to the category of *"the definition of microscope and aims of use"*

A sample statement provided in the free word association test;

"It helps us better see living things" (P9; P27). While the participant is right, it is seen that s/he provides incomplete information.

"It is the material that I used to do analyses in the laboratory..." (P32). Microscopes are not materials. They are tools. It is noticed that the participant had incorrect knowledge

"Microscopes make cells smaller, thus help us see them better." (P37). It was determined that this participant had an alternative misconception, saying that microscopes made cells smaller.

"Microscopes help see living things more clearly." (P8; P40). Microscopes provide clearer images; however, they do this through magnifying these images. It was

determined that the participants had incomplete information.

A sample statement provided in the drawing-writing technique;

"Microscopes are one of the most important inventions that enable us to analyze the physical structures of living things more closely." (P13). Microscopes are one of the tools that enable us to analyze the biological structures of the living things as well as their physical structures at micro and macro levels.

Participants' explanations related to the category of *"fields of microscope use"*;

A sample statement provided in the free word association test;

"Microscopes are the main tools in microbiological studies." (P38). Microscopes are one of the basic tools used in many fields, not just in microbiology.

DISCUSSION, CONCLUSION, AND SUGGESTIONS

Biology is among the most difficult subjects to understand as indicated in the studies conducted at different educational levels (Cimer, 2012; Jones and Rua, 2006; Lukin, 2013; Lazarowitz and Penso, 1992; Prokop et al., 2007; Seymour and Longdon, 1991; Udovic et al., 2002). In this context, it is emphasized in the studies of biology laboratory work and the studies using microscopes to help student understand the subjects in biology that students have difficulty in understanding these subjects and suffer from lack of knowledge (Bacanak et al., 2004; Flannery, 1999; Lazarowitz and Penso, 1992; Mak et al., 1999; Udovic et al., 2002; Treagust, 1988; Tsai, 1999). However, in the studies conducted, microscopes are the most important tools that are associated with scientists by the participants in terms of the image of scientists (Chambers, 1983) and that enable students to observe the hidden world that cannot be seen through naked eyes (Baigrie, 1998).

In this vein, biology student teachers' cognitive structures on the concept of microscope is crucial in terms of their structuring the concepts in biology since when teachers with higher qualifications in the field of biology know the use of microscopes very well and start teaching, they can help students love the field of biology as well as science, biology class, and thus, increase students' success and help them learn easily. Therefore, the current study was conducted to determine Biology student teachers' cognitive structures on microscopes which are such important tools in the field.

At the end of the study, student teachers' conceptual structures on the concept of microscope were grouped under total of 6 categories, including the statements provided in the free word association test. These are determined as *"microscope tools", "the optical part of the microscope", "the mechanical part of the microscope", "the definition of the microscope and aims of use", "fields of microscope use",* and *"types of microscopes".* On the other hand, 5 categories emerged in the data collected through the drawing-writing technique. These are determined as *"microscope tools", "the optical part of the microscope", "the mechanical part of the microscope", "types of microscope",* and *"the definition of the microscope and aims of use"*. The categories obtained through both measurement tools prove to support, elaborate, and explain each other. This result indicates that it is possible to obtain rich data on the conceptual structure on the same issue through using different measurement tools that support each other. In this context, it was determined that Biology student teachers' conceptual structures on the concept of microscope were the strongest and the mostly associated in the category of *"microscope tools"* in both data collection instruments, which was followed by the categories of "the optical part of the microscope and *"the mechanical part of the microscope."* This result shows that student teachers focused more on the materials required to conduct studies using microscopes, rather than being well aware of the technical aspects of the microscope. As microscopes are extremely sensitive, the more information one can obtain about their uses, the more one can use it in laboratory classes. Accordingly, to know the properties of microscopes well means to use them more efficiently and effectively.

The results obtained revealed that ¾ of the biology student teachers had incomplete and inaccurate knowledge about the concept of microscope. The category in which incomplete and inaccurate knowledge emerged in both data collection instruments is the category of "*the definition of the microscope and aims of use*". It is noteworthy that there are incomplete and inaccurate conceptions in this category since this indicates that student teachers' conceptual structures related to the definition of the microscope and aims of use are insufficient. In this content, while in the free word association test, sample statements that included incomplete and inaccurate information emerged such as *"It helps better see the living things"* (P9; P27), *"It is the material that I used to do analyses in the laboratory..."* (P32), *"Microscopes make cells smaller, thus help us see them better"* (P37), and "*Microscopes help see living things clearer"* (P8; P40), in the drawing-writing technique, similar statements emerged such as "*Microscopes are one of the most important inventions that enable us to analyze the physical structures of living things more closely"* (P13). In the related literature, there is not any similar incomplete and inaccurate knowledge, which is among the important results obtained through the current

study conducted with the participation of student teachers. Consequently, it was determined that student teachers had incomplete and inaccurate knowledge in the categories determined through the free word association test and drawing-writing technique. It is possible that student teachers learned this incomplete and inaccurate knowledge during the pre-university education period or during their university education since it is emphasized that if students' misunderstandings and the incomplete information is not determined and compensated for during the work with microscopes, this situation may continue in the later periods (Strike and Posner, 1985). Use of microscopes requires both knowledge and skills.

It is crucial that student teachers had incomplete and inaccurate conceptions in each category determined since these conceptions lead them to misleading results during data collection and analyses in the microscopic studies conducted during the laboratory work (Albanese and Vicentini, 1997; Tsai, 1999) and prevent students from learning new information and structuring this information in their minds. Accordingly, effective teaching-learning activities can be planned to determine and overcome or reduce the emerging incomplete and inaccurate information related to the concept of microscope in each educational level at the prior knowledge phase; appropriate strategies can be developed, and the results of the related studies on this issue can be shared by teachers in the laboratory-classroom context (Kloser et al., 2011; Sundberg, 2003). This result supports the view that non-scientific under-standing in any topic also causes faulty understanding and interpretation of various other topics (Yen et al., 2007). In this direction, starting from primary schools, the use of microscope should be given more importance in biology and laboratory classes. Considering that students have difficulty in correcting the incomplete and inaccurate conceptions even when they are trained (Donovan and Bransford, 2005), the fact that this is a process that must be taken into account should not be ignored.

Moreover, it is important that course books and supplementary learning materials of high quality be prepared to help students creating conceptual structures appropriately and accurately. In this context, activities that ensure the effective use of microscopes such as providing students with the manuals of microscope use, examples of microscope images, and colorful illustrations and images that can be conjugated one to one with the microscopic images, conducting activities in which images are completed with the help of microscopes, using concept maps and using computer simulations will help students create their conceptual structures easier and more accurately. Therefore, in addition to the traditional methods used in biology class (Sundberg et al., 2005), the methods that make information more concrete should be used. Inquiry-based instruction can be provided as an example for this since inquiry-based instruction is widely promoted to increase both students‟ conceptual understanding and their engagement in course content (Buck et al., 2008; Gormally et al. 2011).

One of the factors that are effective in creating conceptual structures accurately and easily is the curriculum of Biology class. The curriculum of biology class can be improved so that it includes more student-centered approaches; it is supported by current technology and encourages the use of microscopes more frequently. Thus, biology classroom can be made more entertaining through more practical activities in the hidden world that can only be explored through microscopes in the laboratory for the students that think that biology class is difficult and boring. This means that both the instructional strategy and biological curriculum in elementary, middle school, high school and college levels education must be changed in order to increase students' interests. The construction of the curriculum must reflect students' biological, psychological and social needs, to a greater extent.

It was determined that the majority of the teachers who did not pay necessary attention to laboratory work in their classes and did not lecture in the laboratory were found to be the teachers who did not have the habit of using the laboratory, did not know the use of laboratory materials in the university that they graduated from, and whose schools where they worked did not have any laboratory (Degirmencay, 1999; Ustuner et al., 2000; Sahin et al., 2000). Despite all these issues, student teachers are required to be well-trained so that they can use micros poses which are among the tools that they must use while working, in the most effective way.

Consequently, biology student teachers need to know microscopes very well, one of the most important tools in terms of teaching Biology and have the necessary skills to use them effectively, which is one of the qualities that they need to have when they start teaching. They need to be trained in this direction, and the levels of knowledge and skills that they have gained after the training can be evaluated through different measurement tools. The current study conducted through free word association test and drawing-writing technique can be replicated using different techniques such as observation, interview, and multiple-choice tests. The factors that affect Biology student teachers' gaining knowledge and skills in using microscopes, laboratory tools, and equipment adversely can be determined.

REFERENCES

Albanese A, Vicentini M (1997). Why do we believe that an atom is colorless? Reflections about the teaching of the particle model. Sci. Educ. 6:251-261.

Atasoy B (2004). Science learning and teaching. Ankara: Asil Publisher.

Aydin F, Tasar MF (2010). An investigation of pre-service science teachers‟ cognitive structures and ideas about the nature of technology. Ahi Evran Univ. J. Kirsehir Educ. Fac. 11(4):209-221.

Bacanak A, Kucuk M, Cepni S (2004). Determination of photosynthesis and respiration in misconceptions elementary students: Trabzon sample. J. Ondokuzmayis Uni. Educ. Fac. 17:67-80.

Backett-Milburn K, McKie L (1999). A critical appraisal of the draw and write technique. Health Educ. Res. Theory & Prac. 14 (3): 387–398.

Bahar M (2003). Misconceptions in biology education and conceptual change strategies. Educ. Sci. Theory Prac. 3: 55-64.

Bahar M, Johnstone AH, Hansell MH (1999). Revisiting learning difficulties in biology. J. Biol. Educ. 33:84-86.

Bahar M, Johnstone AH, Sutcliffe RG (1999). Investigation of students" cognitive structure in elementary genetics through word association tests. J. Biol. Educ. 33:134-141.

Bahar M, Kilicli F (2001). investigating the bonds between the principles of Ataturk through the Method of Word Association Test. X. National Congress of Educational Sciences, Turkey

Bahar M, Ozatli NS (2003).Investigating high school freshman students' cognitive structures about the basic components of living things through word association test method. Balikesir Uni. J. Ins. Sci. Tech. 5:75-85.

Bahar M, Nartgun Z, Durmus S, Bicak B (2006).Traditional and alternative assessment and evaluation of teachers" manual. Ankara: Pegem A Publisher

Bahar M, Ozel M, Prokop P, Usak M (2008). Science student teachers" ideas of the heart. J. Baltic Sci. Educ. 7: 1648-3898.

Baigrie BS (1998). Catherine Wilson's the invisible world: Early modern philosophy and the invention of the microscope. Int. Stu. Philoso. Sci. 12 (2): 165-174.

Bartoszeck AB, Machado DZ, Amann-Gainott M (2008). Representations of internal body image: A study of preadolescents and adolescent students in Araucaria, Paraná, Brazil. Ciências & Cognição, 13 (2): 139-159.

Basey JM, Mendelow TN, Ramos CN (2000). Current trends of community college lab curricula in biology: An analysis of inquiry, technology and content. J Bio. Educ. 34 (2): 80-86.

Buck LB, Bretz SL, Towns MH (2008). Characterizing the level of inquiry in the undergraduate laboratory. J. College Sci. Teach. 38 (1): 52-58.

Cardellini L, Bahar M (2000).Monitoring the learning of chemistry through word association tests. Australian Chem. Res. Book, 19: 59-69.

Cetin G, Ozarslan M, Isik E, Eser H (2013). students" views about health concept by drawing and writing technique. Energy Educ. Sci. Tech. Part B, 5 (1): 597-606.

Chambers WD (1983). Stereotypic images of the scientist: the draw-a-scientist test. Sci. Educ. 67(2):255-265.

Cimer A (2012). What makes biology learning difficult and effective: Students" views? Educ. Res. Rev. 6(8): 592-597.

Cinici A (2013). From caterpillar to butterfly: a window for looking into students" ideas about life cycle and life forms of insects. J. Bio. Educ. DOI:10.1080/00219266.2013.773361.

Cohen L, Manion L (1997). Research methods in education. London: Routledge.

Coyne I (1997). Sampling in qualitative research. Purposeful and theoretical sampling: merging or clear boundaries? J. Adv. Nurs. 26(3):623-630.

CUSE (Committee on Undergraduate Science Education) (1997). Misconceptions as barriers to understanding science. Science teaching reconsidered: A handbook. Washington, D. C.: National Academy Press.

Daskolia M, Flogaitis E, Papageorgiou E (2006). Kindergarten teachers' conceptual framework on the ozone layer depletion. Exploring the associative meanings of a global environmental issue. J. Sci. Educ. Tech. 15(2): 168-178.

Degirmencay SA (1999). Physics teachers" laboratory skills. Unpublished master thesis. Trabzon: Karadeniz Technical University.

Donovan MS, Bransford JD (2005). How students learn: Science in the classroom.National Academies Press.

Dove JE, Everett LA, Preece PFW (1999). Exploring a hydrological concept though children"s drawings. Int. J. Sci. Educ. 21(5):485-497.

Ercan F, Tasdere A, Ercan N (2010). Observation of cognitive structure and conceptual changes through word associations tests. J. Turk. Sci. Educ. 7(2):138-154.

Flannery MC (1999).The conservation aesthetic and the microscopic aesthetic. BioSci. 49 (10):801-808.

Gall MD, Borg WR, Gall JP (2002). Educational research: An introduction. White Plains: Pearson/Allyn & Bacon.

Gilbert JK, Boulter C, Rutherford M (1998a). Models in Explanations, part 1, Horses for courses? Int. J. Sci. Educ. 20:83-97.

Gilbert JK, Boulter C, Rutherford M (1998b). Models in Explanations, part 2, Whose voice? Whose ears? Int. J. Sci. Educ. 20:187-203.

Gilbert JK, Boulter CJ (2000) Learning science through models and modeling. In K Tobin and B Frazer (Eds). The international handbook of science education (pp. 53-66). Dordrecht: Kluwer.

Given LM (2008). The sage encyclopedia of qualitative research methods. Sage: Thousand Oaks CA, 2:697-698.

Gormally C, Brickman P, Hallar B, Armstrong N (2011). Lessons learned about implementing an inquiry-based curriculum in a college biology laboratory classroom. J. College Sci. Teach. 40(3):45-52.

Gussarsky E, Gorodetsky M (1990). On the concept "Chemical Equilibrium: The associative framework. J. Res. Sci. Teach. 27(3):197-204.

Harman G (2012). Analyze the prospective elementary teachers" information"s about laboratory equipments that are used in science and technology teaching. J. Educ. Instruc. Stud. World, 2 (1): 122-127.

Hitchcock G, Hughes D (1995). Research and the teacher. London: Routledge.

Hovardas T, Korfiatis KJ (2006). Word associations as a tool for assessing conceptual change in science education. Learn. Inst. 16: 416-432.

Hruschka DJ, Schwartz D, St.John DC, Picone-Decaro E, Jenkins RA, Carey JW (2004). Reliability in coding open-ended data: Lessons learned from HIV behavioral research. Field Methods 16(3):307-331.

Jones MG, Rua MJ (2006). Conceptual representations of flu and microbial illness held by students, teachers, and medical professionals. Sch. Sci. Math. 108(6):263-278.

Kloser MJ, Brownell SE, Chiariello NR, Fukami T (2011) Integrating teaching and research in undergraduate biology laboratory education. PLoS Biol 9(11): e1001174. doi:10.1371/journal.pbio.1001174.

Knight SL, Nolan J, Lloyd G, Arbaugh F, Edmondson J, Whitney A (2013). Quality teacher education research: How do we know it when we see it? J. Teach. Educ. 64(2): 114-116.

Koseoglu F, Bayir E (2011). Examining cognitive structures of chemistry teacher candidates about gravimetric analysis through word association test method. Trakya Uni. J. Educ. Fac. 1(1): 107-125.

Kostova Z, Radoynovska B (2008). Word association test for studying conceptual structures of teachers and students. Bulgarian J. Sci. Educ. Policy. 2: 209-231.

Kostova Z, Radoynovska B (2010). Motivating students" learning using word association test and concept maps. Bulgarian J. Sci. Educ. Policy 4:62-98.

Kurt H (2013). Biology student teachers" cognitive structure about "Living thing". Educ. Res. Rev. 8 (12):871-880.

Lazarowitz R, Penso S (1992). High school students" difficulties in learning biology concepts. J. Bio. Educ. 26(3):215-224.

Linder CJ (1993). A Challenge to conceptual change. Sci. Educ. 77:293-300.

Lukin K (2013). Exciting middle and high school students about immunology: An easy, inquiry-based lesson. Immunol. Res. 55(1-3):201-209.

Mak SY, Yip DY, Chung CM (1999) Alternative conceptions in biology-related topics of integrated science teachers and implications for teacher education. J. Sci. Educ. Tech. 8(2):161-170.

Marvasti AB (2004). Qualitative research in sociology. London: Sage Publications Ltd.

Miles MB, Huberman AM (1994). Qualitative data analysis: An expanded sourcebook (2nd ed.). Thousand Oaks, California: SAGE. Morahan- Martin.

Nakiboglu C (2008). Using word associations for assessing nonmajor science students" knowledge structure before and after general

chemistry instructions: The case of atomic structure. Chem. Educ. Res. Pract. 9:309-322.

Nyachwayaa JM, Mohameda A-R, Roehriga GH, Woodb NB, Kernc AL, Schneiderd JL (2011). The development of an open-ended drawing tool: An alternative diagnostic tool for assessing students" understanding of the particulate nature of matter. Chem. Educ. Res. Prac. 12 (2):121-132.

Ozatli NS, Bahar M (2010). Revealing students" cognitive structures regarding excretory system by new techniques. J. Abant Izzet Baysal Univ. 10:9-26.

Patton MQ (1990). Qualitative evaluation and research methods. Newbury Park, CA: Sage Publications.

Pines A, West L (1986). Conceptual understanding and science learning: An interpretation of research within sources-of knowledge framework. Sci. Educ. 70(5):583-604.

Pluhar ZF, Piko BF, Kovacs S, Uzzoli A (2009). Air pollution is bad for my health: Hungarian children"s knowledge of the role of environment in health and disease. Health Place 15:239-246.

Posner G, Strike K, Hewson P, Gertzog W (1982). Accommodation of a scientific conception. Toward a theory of conceptual change. Sci. Educ. 66:211-227.

Pridmore P, Bendelow G (1995). Images of health: Exploring beliefs of children using the „draw-and-write" technique. Health Educ. J. 54(4):473-488.

Prokop P, Prokop M, Tunnicliffe SD (2007). Is biology boring? Student attitudes toward biology. J. Bio. Educ. 42 (1): 36-39.

Prokop P, Fancóvicóva J, Tunnicliffe SD (2009). The effect of type of instruction on expression of children"s knowledge: How do children see the endocrine and urinary system? Int. J. Environ .Sci. Educ. 4(1):75-93.

Puckering AL, Synenki LR, Moore K, Steapleton M, Hammond P, Pomart K, Sisken D (2003). Become a laboratory investigator: Detect the presence of nuclei in red blood cells. Sci. Activities, 39 (4): 22-27.

Punch KF (2005). Introduction to social research– quantitative & qualitative approaches. London: Sage.

Reiss MJ, Tunnicliffe SD (2001).Students" understandings of human organs and organ systems. Res. Sci. Educ. 31: 383-399.

Reiss MJ, Tunnicliffe SD, Andersen AM, Bartoszeck A, Carvalho GS, Chen S-Y, Jarman R, Jónsson S, Manokore V, Marchenko N, Mulemwa J, Novikova T, Otuka J, Teppa S, Rooy WV (2002). An international study of young peoples" drawings of what is inside themselves. J. Biol. Educ. 36 (2): 58-64.

Roberts P, Priest H (2006). Reliability and validity in research. Nursing Standard, 20: 41-45.

Sahin N, Sahin B, Ozmen H (2000). Biology teachers in high schools in lessons the ability to treat and comfort of using laboratory experiments. IV. Science Educational Congress, Ankara.

Sato M, James P (1999). "Nature" and "Environment" as perceived by university students and their supervisors. Int. J. Environ. Educ. Informa. 18(2):165-172.

Seymour J, Longdon B (1991). Respiration-that's breathing isn't It? J. Bio. Educ. 23(3):177-184.

Shepardson DP, Wee B, Priddy M, Harbor J (2007). Students" mental models of the environment. J. Res. Sci. Teach. 44 (2):327-348.

Sundberg MD (2003). Strategies to help students change naïve alternative conceptions about evolution and natural selection. Reports of the National Center for Science Education, 23(2):23-26.

Sundberg MD, Armstrong JE, Wischusen EW (2005). A reappraisal of the status of introductory biology laboratory education in U. S. colleges and universities. Am. Bio. Teach. 67:525-529.

Stafstrom CE, Rostasy K, Minster A (2002).The usefulness of children's drawings in the diagnosis of headache. Pediatrics, 109 (3):460-472.

Strike KA, Posner GJ (1985). A conceptual change view of learning and understanding. In: West LHT and Pines AL (Ed.), Cognitive Structure and Conceptual Change. New York: Academic Press.

Udovic D, Morris D, Dickman A, Postlethwait J, Wetherwax P (2002). Workshop biology: Demonstrating the effectiveness of active learning in an introductory biology course. BioSci. 52(3):272-281.

Ustuner I, Yasar SE, Sancar M (2000). Science/Physics teachers wishes in-service training, and Symposiums. IV. Science Education Congress. Ankara.

Uzel N, Diken EH, Yilmaz M, Gul A (2011). The problems that science and technology and biology student teachers face in the use of microscopes and determining the causes of these problems. 2nd International Conference on New Trends in Education and Their Implications 27-29 April, 2011 Antalya-Turkey www.iconte.org, pp.1901-1908.

Timur B, Tasar MF (2011). Developing pre-service science teachers" cognitive structures about technology: word association test (WAT). Western Anatolia J. Educ. Sci. 2011:131-138.

Treagust DF (1988). Development and use of diagnostic tests to evaluate students" misconceptions in science. Int. J. Sci. Educ. 10(2):159-169.

Treagust DF, Duit R, Fraser BJ (1996). Improving teaching and learning in science and mathematics. New York: Teachers College Press.

Torkar G, Bajd B *(*2006).Trainee teachers" ideas about endangered birds. J. Biol. Educ. 41:5-8.

Tsai CC (1999). Overcoming junior high school students" misconceptions about microscopic views of phase change: A study of an analogy activity. J. Sci. Educ. Technol. 8(1):83-91.

Tsai CC, Huang CM (2002). Exploring students" cognitive structures in learning science: A review of relevant methods. J. Bio. Educ. 36:163-169.

Vance K, Miller K, Hand B (1995). Two examples of using constructivist approaches to teach ecology at the middle school level. American Bio. Teach. 37(4):244-249.

Verma GK, Mallick K (1999). Researching education: Perspectives and techniques. Philadelphia: Open University Press.

Wandersee JH, Mintzes JJ, Novak JD (1994). Research on alternative conceptions in science. In Gabel, DL (Ed.). Handbook of research on science teaching and learning, Simon & Schuster and Prentice Hall International, New York.

White R, Gunstone R (1998). Probing understanding. The Falmer Press, USA.

Yayla RG, Eyceyurt G (2011). Mental models of pre-service science teachers about basic concepts in chemistry. Western Anatolia J. Educ. Sci. 2011:285-294.

Yen CF, Yao TW, Mintzes JJ (2007). Taiwanese students" alternative conceptions of animal biodiversity. Int. J. Sci. Educ. 29(4): 535-553.

Yildirim A, Simsek H (2006). Qualitative research methods in social sciences. Ankara: Seckin Publisher.

Yorek N, Sahin M, Ugulu I (2010). Students" representations of the cell concept from 6 to 11 grades: Persistence of the "Fried-Egg Model". Int. J. Phys. Sci. 5(1):15-24.