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EXAMINATION OF PRE-SERVICE BIOLOGY TEACHERS' KNOWLEDGE LEVELS AND KNOWLEDGE SOURCES ABOUT GENETIC MATERIAL*

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ABSTRACT

As one of the science lessons, biology courses contain many abstract concepts. Students usually have difficulty in perceiving these concepts. It is necessary to determine effective ways of facilitating and the understanding of them as well as the knowledge level of the students. For this reason, teachers have important tasks in teaching abstract concepts effectively. Molecular biology and genetic material is one of the topics in biology that students have difficulty in understanding. In this respect, the aim of this study is to examine the knowledge levels and knowledge sources about genetic material of pre-service teachers. Within this scope, the knowledge levels of the freshmen who have started the undergraduate education and the seniors who are about to complete the undergraduate education have been compared. Also, sources of pre-service teachers' correct and incorrect knowledge have also been examined. This study has been held in the academic year between 2016 and 2017. The study sample included 91 pre-service teachers studying in the department of biology education in two different public universities in the Central Anatolia region in Turkey. The data have been collected from a questionnaire form which has 23 items related to genetic material and 5 items related to determine the sources of the knowledge. The data have been analyzed with SPSS 22.0 software and in the analysis of the data, various descriptive statistics were applied. As a result of the research, the differences of the knowledge levels about genetic materials between freshmen and seniors have been evaluated. When the averages of the final grade of pre-service teachers' about the genetic material were examined, the knowledge levels of seniors were higher than the freshmen but not at the desired level. The sources of the correct and incorrect knowledge have been evaluated separately. As a result of the analyses, pre-service teachers really have difficulty in understanding the abstract subjects and they have misperceptions.

Key Words: Pre-service teachers, Genetic material, Knowledge level and sources

1. INTRODUCTION

There are many abstract concepts in biology courses. Students generally have problems perceiving abstract concepts. Students' ideas can sometimes differ from scientific facts (Palmer, 1999). Students' inaccurate prior knowledge sometimes causes misconceptions. Misconceptions are defined as incorrect understandings and evaluations that are resistant to changes and scientifically untrue (Trowbridge & McDermott, 1981; Halloun & Hestenes, 1985). Researchers describe experience-based misconceptions as the result of life experiences and teaching-based misconceptions as the result of teaching. Experience-based misconceptions that are formed prior to teaching and resistant to change are formed as the result of logical interaction between students' affective knowledge and their genetic limitations.

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Misconceptions that are related to teaching stem from students' insufficient level of prior knowledge and cognitive development and from the fact that the language used to express concepts and teaching strategies are not appropriate (Bilgin et al., 2003). Students can obtain teaching-based misconceptions as a result of either formal or informal teaching. Students prefer memorization when they encounter more concepts in courses. The fact that concepts cannot be learned meaningfully by memorization increases students' misconceptions (Gülçiçek, 2002). Misconceptions must be remove and/or the correct conception must be built in order for students to achieve a deep understanding (Chi & Roscoe, 2002).

Determining students' levels of knowledge about abstract concepts requires determining effective ways to facilitate understanding topics. For this reason, educators have essential roles in teaching these concepts effectively. In biology courses molecular biology is a topic that students have difficulties to learn. As Johnstone and Mahmoud (1980) stated the topics of high perceived difficulty in school biology syllabus and the topics found to be difficult by students are related to genetics more than thirty years as the same as now. Molecular biology is among the contemporary and attractive research areas, included basically in all biology- related areas such as evolution, genomics, biotechnology, medicine, agriculture, and veterinary. The developments in molecular biology, like the production of genetically modified organisms, are not only in the interest of scientist but also in the interest of the general people as well (Bush, Hart & Russell, 2006). In our modern biotechnological world, an understanding of the basic concepts of genetics is critical for effective scientific literacy of future citizens (Venville, Gribble & Donovan, 2005). As technology continues to expand, biology teachers have a responsibility to keep students informed of technological and scientific advances (Bergland, Lundeberg, Klyezek & Sweet, 2006). Hence, today's teachers' face more challenges than ever, especially biology teachers. There are many studies indicating that in biology courses, molecular biology topics or genetics are difficult to teach and to learn (e.g. Tsui and Treagust 2007; Bahar, Johnstone & Hansell, 1999; Sebitosi, 2007; Chen & Raffan,1999; Venville et al. 2005). Tsui and Treagust (2007) reported that after the students learned genetics in classroom lessons that included BioLogica activities, results of online tests and interview tasks revealed that most of the students improved their understanding of genetics. Venville and Donovan (2006) examined and commented about the potential usefulness of analogies and metaphors used to teach DNA and genes and stated that analogies and metaphors have a significant effect on teaching and learning of these important concepts.

This study was intended to determine preservice biology teachers' knowledge levels and knowledge sources about genetic materials. The knowledge levels of freshmen who had just begun their undergraduate education and the seniors who were about to complete it were determined and compared. The sources of the preservice teachers' accurate and inaccurate knowledge were also investigated. Here are the study's research questions:

1. What is the distribution of the frequencies of the preservice biology teachers' correct and incorrect answers to the questions about genetic materials according to gender?
2. What is the distribution of the frequencies of the preservice biology teachers' correct and incorrect answers to the questions about genetic materials according to high school type?
3. Is there a significant difference among the freshman preservice biology teachers' knowledge levels about genetic materials?
4. Is there a significant difference among the senior preservice biology teachers' knowledge levels about genetic materials?
5. Is there a significant difference between the freshman and senior preservice biology teachers' knowledge levels about genetic materials?
6. What is the distribution of the preservice biology teachers' knowledge sources about genetic materials?

2. METHOD

2.1. Model of the Study

The survey model, a quantitative research model, was used to determine the preservice biology teachers' knowledge levels and sources about genetic materials. The survey model is a method of collecting data

at a certain time to identify the relationship between specific events to achieve particular goals and to compare the relationships between variables (Cohen, Manion and Morrison, 2000).

2.2. Participants

A total of 91 preservice teachers (41 freshmen and 50 seniors) from the departments of biology education in the educational faculties of two state universities in the central Anatolia during the 2016–2017 academic years constituted the participants of the study. The distributions of the preservice teachers according to university and grade level are shown in Table 1. The universities were coded as A and B. There were 20 freshmen and 29 senior preservice teachers at University A, and 21 of each at University B.

Table 1: Frequency Distribution of the Participants According to University and Gender

GRADE		Frequency (f)	Percent(%)	Total	FINAL TOTAL
Fresmen	University A	20	22,0	41	91
	University B	21	23,1		
Senior	University A	29	31,9	50	
	University B	21	23,1		

The frequency distribution of the high school types attended by the preservice teachers is shown in Table 2.

Table 2: Frequency Distribution of the High School Types Attended by the Preservice Teachers

GRADUATION		Anatolian High School	General High School	Science High School	Vacational High School	Religious High School	TOTAL
Fresmen	University A	13	4	0	0	3	41
	University B	11	8	1	1	0	
Senior	University A	11	14	0	3	1	50
	University B	11	8	0	0	2	
Total		46	34	1	4	6	91

Table 2 shows that 50% of the preservice biology teachers graduated from Anatolian high schools (f=46), 37% graduated from fundamental high schools, 7% graduated from religious high schools, 3% graduated from vocational high schools, and 1% graduated from science high schools.

2.3. Data Collection and Analysis

A survey consisting of two parts was used as a data collection tool. It has 23 true or false questions about molecular biology and genetic materials in the first part. The second part asks the preservice teachers to indicate the knowledge source for their answers.

SPSS 22.00 software was used to analyze the data. Various descriptive statistics were used for the data analysis. In the first part of the survey, using parametric and nonparametric independent two-sample tests with test scores, success averages, and frequency and percentage calculations, the preservice teachers' differences according to both university and grade level were compared. The frequencies and percentages of correct and incorrect answers to each question according to high school type were also calculated. The second part of the survey offers five options for describing knowledge sources: high school teachers, high school textbooks, university professors, university textbooks and other for sources other than those listed. Appropriate coding for each option was done, and descriptive analyses were carried out when more than one option was marked.

3. RESULTS AND CONCLUSION

1. The distribution of the preservice biology teachers' correct and incorrect answers to the questions about genetic materials according to grade level are shown in Table 3.

Table 3 shows that the preservice biology teachers gave more incorrect answers (f=15) than correct answers (f=8). More than half of the preservice teachers gave incorrect answers to questions 1, 2, 4, 6, 7, 11, 13, 14, 15, 16, 18, 20, 21, 22 and 23.

Table 3: Frequencies and Percentage Distributions of the Preservice Biology Teachers' Correct and Incorrect Answers According to Grade Level

Item Number	Answers	Grade	Frequence (f)	Percent (%)	Total f	Total %
1	incorrect	Freshmen	29	71	57	63
		Senior	28	56		
	correct	Freshmen	12	29	34	37
		Senior	22	44		
2	incorrect	Freshmen	18	44	50	55
		Senior	32	64		
	correct	Freshmen	23	56	41	45
		Senior	18	36		
3	incorrect	Freshmen	15	37	24	26
		Senior	9	18		
	correct	Freshmen	26	63	67	74
		Senior	41	82		
4	incorrect	Freshmen	34	83	51	56
		Senior	17	34		
	correct	Freshmen	7	17	40	44
		Senior	33	66		
5	incorrect	Freshmen	8	20	15	16
		Senior	7	14		
	correct	Freshmen	33	80	76	84
		Senior	43	86		
6	incorrect	Freshmen	37	90	70	77
		Senior	33	66		
	correct	Freshmen	4	10	21	23
		Senior	17	34		
7	incorrect	Freshmen	27	66	68	75
		Senior	41	82		
	correct	Freshmen	14	34	23	25
		Senior	9	18		
8	incorrect	Freshmen	3	7	6	7
		Senior	3	6		
	correct	Freshmen	38	93	85	93
		Senior	47	94		
9	incorrect	Freshmen	21	51	43	47
		Senior	22	44		
	correct	Freshmen	20	49	48	53
		Senior	28	56		
10	incorrect	Freshmen	11	27	19	21
		Senior	8	16		
	correct	Freshmen	30	73	72	79
		Senior	42	84		
11	incorrect	Freshmen	33	80	77	85
		Senior	44	88		
	correct	Freshmen	8	20	14	15
		Senior	6	12		

Table 3: Frequencies and Percentage Distributions of the Preservice Biology Teachers' Correct and Incorrect Answers According to Grade Level (cont.)

Item Number	Answers	Grade	Frequence (f)	Percent (%)	Total f	Total %
12	incorrect	Freshmen	25	61	41	45
		Senior	16	32		
	correct	Freshmen	16	39	50	55
		Senior	34	68		
13	incorrect	Freshmen	32	78	66	73
		Senior	34	68		
	correct	Freshmen	9	22	25	27
		Senior	16	32		
14	incorrect	Freshmen	20	49	55	60
		Senior	35	70		
	correct	Freshmen	21	51	36	40
		Senior	15	30		
15	incorrect	Freshmen	24	59	49	54
		Senior	25	50		
	correct	Freshmen	17	41	42	46
		Senior	25	50		
16	incorrect	Freshmen	39	95	85	93
		Senior	46	92		
	correct	Freshmen	2	5	6	7
		Senior	4	8		
17	incorrect	Freshmen	10	24	19	21
		Senior	9	18		
	correct	Freshmen	31	76	72	79
		Senior	41	82		
18	incorrect	Freshmen	32	78	63	69
		Senior	31	62		
	correct	Freshmen	9	22	28	31
		Senior	19	38		
19	incorrect	Freshmen	16	39	32	35
		Senior	16	32		
	correct	Freshmen	25	61	59	65
		Senior	34	68		
20	incorrect	Freshmen	23	56	46	51
		Senior	23	46		
	correct	Freshmen	18	44	45	49
		Senior	27	54		
21	incorrect	Freshmen	38	93	71	78
		Senior	33	66		
	correct	Freshmen	3	7	20	22
		Senior	17	34		
22	incorrect	Freshmen	24	59	53	58
		Senior	29	58		
	correct	Freshmen	17	41	38	42
		Senior	21	42		
23	incorrect	Freshmen	31	76	72	79
		Senior	41	82		
	correct	Freshmen	10	24	19	21
		Senior	9	18		

The pre-service teachers had the most incorrect knowledge about questions 16 (93%) and 11 (85%). Questions 23 (79%), 21 (78%), 6 (77%), 7 (75%) and 13 (73%) had rates of incorrect answers higher

than 70%, indicating that the preservice teachers had incorrect knowledge or misconceptions regarding the molecular structure of genetic materials. Here are two examples of these questions:

Question 6: Uracil is a nucleotide RNA. (Urasil is a base, and RNA is a molecule consisting of a large number of nucleotides).

Question 7: Denaturation takes place when the phosphodiester bonds in the DNA molecule break. (In denaturation, the H bonds that hold two DNA strands together are broken).

More than half of the preservice teachers gave correct answers to questions 3, 5, 8, 9, 10, 12, 17, and 19. The preservice teachers had the most correct knowledge about questions 8 (93%) and 5 (84%). The preservice teachers had correct knowledge about questions 3 (74%), 10 (79%) and 17 (79%) and with rates of correct answers higher than 70%. Here are two examples of these questions:

Question 8: The DNA molecule has the shape of a straight staircase. (DNA is not a straight staircase, but a double helix in the shape of a spiral staircase.)

Question 10: Bacterial and human DNA are the same. (Bacterial DNA is circular, and human DNA is linear).

According to grade level, the freshmen answered 14 of the 23 questions incorrectly and 9 questions correctly, and the seniors answered 13 questions incorrectly, nine questions correctly, and one question with an equal percentage of correct and incorrect answers. Nine questions had very high rates of incorrect answers for the freshmen: questions 16 (95%), 21 (93%), 6 (90%), 4 (83%), and 11 (80%) along with four questions (1, 13, 18, 23) with rates of incorrect answers higher than 70%. This result indicates that the freshmen's knowledge levels about genetic materials are quite low or incorrect. The seniors' incorrect answers were given to five questions: 16 (92%), 11 (88%), 7(82%), 23 (82%) and 14 (70%). The decrease in the number of seniors' incorrect answers indicates that their knowledge levels about genetic materials had increased during their undergraduate education. The freshmen successfully answered four questions: 5 (80%), 8 (93%), 10 (73%) and 17 (76%). The seniors successfully answered five questions: 3 (82%), 5 (86%), 8 (94%), 10 (84%) and 17 (82%). According to grade level, there was an increase in terms of correct answer percentages, but not much change in the number of questions.

The percentages of both classes' correct answers were compared, yielding two results. The first was that the seniors had a higher percentage of correct answers than the freshmen for 18 of the 23 questions. The freshmen's percentage of correct answers to question 4 was 17%, while it was 66% for the seniors. Similarly, the freshmen's percentage of correct answers was 39% on question 12 and 68% for the seniors, and the freshmen's percentage of correct answers to question 21 was 6% and 34% for the seniors. The second result was that the freshmen had a higher percentage of correct answers than the seniors on five questions (2, 7, 11, 14 and 23). For example, while the freshmen' percentages of correct answers to questions 2 and 14 were 56% and 51%, for the seniors they were 36% and 30%.

2. Table 4 shows the percentages of the preservice teachers' correct and incorrect answers according to high school type with 41 freshmen and 50 seniors included in the calculations.

The preservice teachers who graduated from Anatolian high schools were more successful than the preservice teachers who graduated from other types of high schools. The preservice teachers from Anatolian high schools have quite high percentages of correct answers to questions 3 (73%), 5 (89%), 8 (96%), 10 (82%) and 17 (78%). However, the same group had considerably less success with questions 6 (77%), 7 (80%), 11 (80%), 13 (78%), 16 (96%), 21 (80%) and 23 (84%).

Table 4: Percentage Distributions of the Preservice Biology Teachers' Correct and Incorrect Answers According to High School Type

Item No	Answers	AHL (%)	GHL (%)	SHL (%)	VHL (%)	RHL (%)	Item No	Answers	AHL (%)	GHL (%)	SHL (%)	VHL (%)	RHL (%)
1	incorrect	56	25	2	4	9	**13**	incorrect	78	25	2	6	4
	correct	46	9	0	4	4		correct	24	9	0	2	9
2	incorrect	46	22	2	6	7	**14**	incorrect	64	19	2	4	9
	correct	30	12	0	2	6		correct	39	15	0	4	4
3	incorrect	30	8	0	2	5	**15**	incorrect	63	18	2	4	0
	correct	73	26	2	6	8		correct	40	16	0	4	13
4	incorrect	63	18	0	4	9	**16**	incorrect	96	32	2	8	11
	correct	39	16	2	4	4		correct	6	2	0	0	2
5	incorrect	14	7	0	2	2	**17**	incorrect	24	6	0	0	4
	correct	89	27	2	6	11		correct	78	28	2	8	9
6	incorrect	77	26	2	8	11	**18**	incorrect	72	26	2	2	7
	correct	25	8	0	0	2		correct	30	8	0	6	6
7	incorrect	80	25	0	6	9	**19**	incorrect	34	11	0	8	4
	correct	23	9	2	2	4		correct	68	23	2	0	9
8	incorrect	7	2	0	0	2	**20**	incorrect	55	39	0	2	6
	correct	96	32	2	8	11		correct	48	34	2	6	7
9	incorrect	49	15	0	6	7	**21**	incorrect	80	26	2	8	11
	correct	53	19	2	2	6		correct	23	8	0	0	2
10	incorrect	20	7	0	2	4	**22**	incorrect	56	22	0	8	4
	correct	82	27	2	6	9		correct	46	12	2	0	9
11	incorrect	80	32	2	8	8	**23**	incorrect	84	26	2	6	9
	correct	23	2	0	0	5		correct	18	8	0	2	4
12	incorrect	53	12	0	4	9							
	correct	49	22	2	4	4							

3. According to the third research question whether there was a significant difference among the freshmen at the two universities in terms of their knowledge levels about genetic materials was

investigated by this study. Since the data had a normal distribution (p>0.05), the independent two-sample t-test, a parametric test, was carried out (Table 5).

Table 5: Arithmetic means, Standard deviations and T-Test Results for the Freshmen's Knowledge Levels

Groups	n	X	ss	sd	t	p
A-1	20	43,57	,09223	,02013	1,511	0,139
B-1	21	39,00	,09110	,01988	1,511	0,139

Table 5 shows that the mean score of the freshmen's answers to the 23 questions was 43.57 for university A, while it was 39 for university B. The t-test result of 0.139 (p>0.05) did not indicate a significant difference between the two groups.

4. According to the fourth research question whether there was a significant difference among the seniors at the two universities in terms of their knowledge levels about genetic materials was investigated by this study. Since the data had a normal distribution (p>0.05), the independent two-sample t-test was carried out (Table 6).

Table 6: Arithmetic Means, Standard Deviations and T-Test Results for the Seniors' Knowledge Levels

Groups	n	X	ss	sd	t	p
A-5	29	52,48	,12966	,02408	1,351	,183
B-5	21	47,43	,13174	,02875	1,348	,185

Table 6 shows that freshmen's mean score was 52.48 at university A, while it was 47.43 at university B. The t-test did not find a significant difference, 0.183 (p>0.05), between the two groups.

5. Whether there was a significant difference among the freshmen and seniors at the two universities in terms of their knowledge levels about genetic materials was investigated by this study. Since the data did not have a normal distribution, the Mann-Whitney U test, a non-parametric test, was conducted (Table 7).

Table 7: Arithmetic Means and Mann-Whitney U Test Results for the Freshmen's and Seniors' Knowledge Levels

Groups	N	Mean	Sig
Freshmen	41	41,28	,000
Senior	50	50,26	

Table 7 shows that while the arithmetic mean of the seniors' answers to the 23 questions was 50.26, the arithmetic mean of the freshmen's answers was 41.28. The Mann-Whitney U test found a significant difference, 0.000 (p<0.05), between the two groups in favor of the seniors. However, the knowledge levels of the seniors were not at the expected level.

6. The distribution of the preservice biology teachers' knowledge sources about the genetic material is shown in Table 8.

Table 8: Frequencies and Percentage Distributions of the Preservice Biology Teachers' Knowledge Sources About Genetic Materials

Item No	Answers	Grade	Teacher in High School	%	Lecturer in University	%	Book in High School	%	Book in University	%	None	%
1	incorrect	Freshmen	19	46	5	12	3	7		0	5	12
		Senior	7	14	15	30		0	4	8	2	4
	correct	Freshmen	5	12	2	5	4	10		0	3	7
		Senior	6	12	16	32	2	4	4	8		0
2	incorrect	Freshmen	12	29	3	7	2	5		0	1	2
		Senior	21	42	11	22	2	4	2	4	1	2
	correct	Freshmen	16	39	5	12	1	2		0	3	7
		Senior	2	4	11	22		0	5	10	3	6
3	incorrect	Freshmen	9	22	4	10	3	7		0	2	5
		Senior	4	8	3	6		0		0	1	2
	correct	Freshmen	12	29	12	29	1	2		0	2	5
		Senior	11	22	29	58	2	4	11	22		0
4	incorrect	Freshmen	25	61	6	15	2	5		0	5	12
		Senior	8	16	8	16	1	2		0		0
	correct	Freshmen	3	7	2	5		0	1	2	1	2
		Senior	2	4	29	58	1	2	9	18		0
5	incorrect	Freshmen	4	10		0		0		0	5	12
		Senior	1	2	4	8		0		0	1	2
	correct	Freshmen	21	51	7	17	3	7		0		0
		Senior	5	10	34	68	3	6	8	16	1	2
6	incorrect	Freshmen	29	71	9	22	3	7		0	2	5
		Senior	19	38	12	24	2	4		0	1	2
	correct	Freshmen	3	7	1	2		0		0		0
		Senior	7	14	11	22	2	4	4	8		0
7	incorrect	Freshmen	15	37	6	15	3	7		0	5	12
		Senior	15	30	24	48	1	2	5	10		0
	correct	Freshmen	8	20	4	10		0		0	2	5
		Senior	3	6	7	14	1	2	2	4		0
8	incorrect	Freshmen	1	2	1	2		0		0	1	2
		Senior	2	4		0	1	2		0		0
	correct	Freshmen	27	66	7	17	6	15	1	2	2	5
		Senior	27	54	18	36	4	8	6	12	2	4
9	incorrect	Freshmen	11	27	3	7	2	5		0	7	17
		Senior	7	14	12	24	2	4	3	6	3	6
	correct	Freshmen	11	27	9	22	2	5		0	1	2
		Senior	10	20	17	34	1	2		0		0
10	incorrect	Freshmen	3	7	4	10		0		0	4	10
		Senior		0	3	6	2	5	1	2	2	4
	correct	Freshmen	20	49	8	20		0		0	3	7
		Senior	9	18	32	64	2	4	6	12	1	2
11	incorrect	Freshmen	11	27	5	12		0		0	2	5
		Senior	5	10	40	80	2	4	6	12		0
	correct	Freshmen	2	5	4	10	2	5		0	2	5
		Senior		0	2	4	1	2	1	2	1	2
12	incorrect	Freshmen	5	12	11	27	1	2		0	8	20
		Senior	1	2	15	30		0	1	2		0
	correct	Freshmen	3	7	13	32		0		0		0
		Senior	2	4	28	56	2	4	7	14	1	2

Table 8: Frequencies and Percentage Distributions of the Preservice Biology Teachers' Knowledge Sources About Genetic Materials (cont.)

Item No	Answers	Grade	Teacher in High School	%	Lecturer in University	%	Book in High School	%	Book in University	%	None	%
13	incorrect	Freshmen	17	41	6	15	3	7		0	9	22
		Senior	4	8	29	58	1	2		0	1	2
	correct	Freshmen	7	17	1	2	2	5		0	1	2
		Senior	2	4	10	20	2	4	6	12		0
14	incorrect	Freshmen	11	27	3	7	2	5	1	2	7	17
		Senior	8	16	21	42	1	2	6	12	5	10
	correct	Freshmen	12	29	6	15	3	7	1	2	1	2
		Senior	6	12	7	14	2	4		0		0
15	incorrect	Freshmen	11	27	7	17	2	5	1	2	4	10
		Senior	6	12	15	30		0		0	3	6
	correct	Freshmen	11	27	5	12	1	2		0	2	5
		Senior	4	8	21	42	2	4	4	8	1	2
16	incorrect	Freshmen	21	51	10	24	5	12		0	6	15
		Senior	10	20	33	66	2	4	7	14	3	6
	correct	Freshmen	1	2		0		0		0	1	2
		Senior	1	2	1	2	1	2		0		0
17	incorrect	Freshmen	3	7	1	2	1	2		0	6	15
		Senior	3	6	1	2	2	4	1	2	1	2
	correct	Freshmen	12	29	19	46	2	5		0		0
		Senior	5	10	34	68	3	6	6	12	2	4
18	incorrect	Freshmen	19	46	7	17	1	2		0	6	15
		Senior	7	14	21	42	4	8	3	6		0
	correct	Freshmen	5	12	2	5	2	5		0		0
		Senior	6	12	11	22	2	4	4	8	1	2
19	incorrect	Freshmen	6	15	4	10	6	15		0	6	15
		Senior	3	6	11	22		0		0	2	4
	correct	Freshmen	15	37	8	20		0		0	2	5
		Senior	5	10	26	52		0	6	12	2	4
20	incorrect	Freshmen	12	29	9	22	3	7		0	2	5
		Senior	3	6	18	36		0	5	10		0
	correct	Freshmen	10	24	6	15		0		0	4	10
		Senior	10	20	12	24	3	6	2	4	6	12
21	incorrect	Freshmen	25	61	12	29	2	5		0	5	12
		Senior	5	10	23	46	5	10		0	1	2
	correct	Freshmen	3	7		0		0		0		0
		Senior	5	10	10	20	2	4	3	6	2	4
22	incorrect	Freshmen	10	24	9	22		0		0	5	12
		Senior	2	4	23	46	2	4	3	6	2	4
	correct	Freshmen	11	27	4	10		0		0	3	7
		Senior	2	4	17	34	2	4	4	8	1	2
23	incorrect	Freshmen	8	20	14	34		0		0	10	24
		Senior		0	39	78	1	2	8	16		0
	correct	Freshmen	6	15	4	10		0		0		0
		Senior		0	6	12		0	2	4	1	2

The pre-service biology teachers did not mark the option, other, and they did not indicate knowledge sources for some questions. Table 8 shows that, rather than textbooks, the preservice teachers more frequently listed teachers and professors as their knowledge sources. When the frequencies and percentages of the knowledge source of the freshmen's incorrect answers regarding the genetic material topic were investigated, the high school teacher option was marked on most of the 23 questions; however, the university professor option was marked on questions 10, 12 and 23. When the knowledge

source of the same group's correct answers, the high school teacher option was also marked more often; however, the university professor option was marked on questions 11, 12 and 17. There was an even split between the high school teacher and university professor on question 3.

When the frequencies and percentages of knowledge sources of the seniors' incorrect answers regarding the genetic material topic were investigated, the university professor option was marked on most of the 23 questions; however, the high school teacher option was marked on questions 3 and 8. Almost all of the seniors gave incorrect answers to questions 11 and 23 due to knowledge from their professors. The knowledge source of the same group's correct answers was marked more often as the university professor option; however, the high school teacher option was marked on questions 8 and 9.

The preservice teachers' answers regarding their knowledge sources indicated that educators are more effective than textbooks. Knowledge obtained from high school teachers was effective for the freshmen, and knowledge obtained from professors at the university was effective for the seniors. However, knowledge from high school teachers was found to be still effective for them on some questions about basic topics.

This study found that the seniors' knowledge levels about genetic materials were higher than the freshmen's levels. However, a general success average less than 50% indicates that students have difficulties learning abstract concepts. Both high school teachers and university professors have important responsibilities for teaching abstract concepts. It is necessary to teach topics using different educational materials and technologies so that students can effectively and easily understand them. In addition, carrying out more assessment activities for topics that are difficult to learn is thought to be useful in detecting whether the topic has been understood by students. Since assessment activities are carried out simultaneously, points that students do not understand or misunderstand can be immediately explained so that they can understand the topic.

4. DISCUSSION

The findings in this study indicate that the averages of the final grade of pre-service teachers' about the genetic material, the knowledge levels of seniors were higher than the freshmen. When the sources of the correct and incorrect knowledge have been evaluated separately, pre-service teachers really have difficulty in understanding the abstract subjects and they have misperceptions. In the literature, understanding of genetic materials and abstract concepts has revealed some similar findings as our study findings. Students have some difficulties in explaining and understanding the relationships between concepts (Chattopadhyay, 2005; Duncan & Reiser, 2007; Garvin-Doxas & Klymkowsky,2008; Kılıç, Taber& Winterbottom, 2016; Orcajo & Aznar,2005; Venville, Gribble &Donovan, 2005). Teachers are also have some difficulties about the topic of molecular genetics as students both to teach and to learn (Marbach-Ad and Stavy 2000; Templin and Fetters 2002).

According to the related studies, teaching and learning with constructivist approach makes the teachers and students to teach and learn much better and easier. Enhancing the teaching of molecular genetics through educational methods (Gilbert, Justi & Aksela, 2003) and using some computer animations provides students to learn better (Rotbain, Marbach &Stavy, 2008). Similarly applying problem-solving method which is one of the constructivist approach showed that the post-test results were better than the pre-test results. Another study indicated that multiple, non-conventional writing had a significant benefit in helping students learn Molecular Biology (Hand, Hohenshell & Prain, 2007). Some studies also suggested that conceptual improvements in this subjects are possible through directed activities (Garvin-Doxas & Klymkowsky,2008; Meir, Perry, Stal, Maruca & Klopfer, 2005).

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