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THE EFFECT OF GENDER DIFFERENCE AND REASONING ABILITY ON THE LEARNING OF HUMAN CIRCULATORY SYSTEM CONCEPTS

CİNSİYET FARKI VE DÜŞÜNME YETENEĞİNİN İNSANDA DOLAŞIM SİSTEMİ KAVRAMLARINI ÖĞRENME BAŞARISI ÜZERİNE ETKİSİ

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ABSTRACT: The present study aims to investigate the effect of gender difference and reasoning ability on the learning of human circulatory system concepts. Group Assessment of Logical Thinking and the Human Circulatory System Concepts Test were administered to 47 tenth grade students to determine their reasoning ability and achievement, respectively. Two-way ANOVA was used to analyze the data. The results revealed that while gender difference did not affect the performance on the achievement test, reasoning ability significantly affected students' achievement.

KEY WORDS: *Reasoning Ability, Gender Difference, Human Circulatory System.*

ÖZET: Bu çalışma, cinsiyet farkı ve düşünme yeteneğinin öğrencilerin insanda dolaşım sistemi kavramlarını öğrenmelerine etkisini araştırmayı hedeflemiştir. Düşünme Yeteneği Testi ve İnsanda Dolaşım Sistemi Kavram Testi, 47 lise 2. sınıf öğrencisine, düşünme yetenekleri ve başarılarını belirlemek amacıyla uygulanmıştır. Verileri analiz etmek için varyans analizi kullanılmıştır. Sonuçlar, cinsiyet farkının başarı testindeki performansı etkilemediğini fakat düşünme yeteneğinin başarı üzerinde anlamlı bir etkisi olduğunu göstermiştir.

ANAHTAR SÖZCÜKLER: *Düşünme Yeteneği, Cinsiyet Farkı, İnsanda Dolaşım Sistemi.*

1. INTRODUCTION

Over the last century, the significance of science, mathematics, and technology education increased noticeably. Clearly, the need for education in these areas will become even more important to each individual and to society as a whole in the 21st century [1]. So there is need for investigating the factors that affect students' achievement in science, mathematics and technology education. In the present study the aim is to investigate the effect of gender difference and reasoning ability on the learning of human circulatory system concepts.

In relation to the gender difference in the learning of life sciences, some indicated no significant difference between boys and girls [1,2], while others reported significant gender differences [3, 4, and 5]. The study carried out by Dimitrov [2], revealed that there was no significant difference between girls (n=1176) and boys (n=1238) with respect to achievement in life sciences. Moreover, Okeke and Ochuba [3] reported no significant difference between boys and girls with respect to achievement in biology tests. On the other hand, Soyibo [4] showed that girls significantly performed better on a test of errors in biological labelling. Another study conducted by Young and Fraser [5] revealed significant gender differences in biology achievements of 14 and 17-year-old Australian students in favor of the boys. Furthermore, Erickson and Erickson [6] indicated gender-related differences in biology favoring of male students. However, generally, in many of such studies the differences found to be statistically significant are not markedly large.

The studies performed in the field of education showed significant relationship between reasoning abilities and biology achievement [7, 8, 9, 10, and 11]. Johnson and Lawson [7] investigated the relative effects of reasoning ability and prior knowledge on biology achievement in expository and inquiry classes. They found that reasoning ability explained a significant portion of variance in final

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examination score in both instructional methods. Moreover, Cavallo [8] reported that reasoning ability best predicted students' achievement in solving genetics problems. Furthermore, Lawson and Thompson [9] tested the hypothesis that formal reasoning ability is essential for seventh-grade students to successfully deal with prior misconceptions and develop scientifically acceptable biological conceptions concerning genetics and natural selection. The results showing that number of misconceptions is consistently and significantly related to the reasoning ability supported this hypothesis. What is more, Lawson [10] found out substantial correlation between formal reasoning and biology achievement. Also, Ehindore [11] reported that the brightness defined by students' performance on the biology tests is significantly related to the cognitive developmental precocity.

In the light of the findings in the literature, the current study aimed to find out answers to the following questions:

1. Is there a gender difference with respect to the learning of human circulatory system concepts?
2. Is there a reasoning ability difference with respect to the learning of human circulatory system concepts?
3. Does the reasoning ability effect depend on the gender (and vice versa)?

2. METHOD

2.1 Subjects of the Study

The subjects of the study are 47 tenth-grade students (26 boys and 21 girls) attending two intact classes of an urban secondary school. Students' ages ranged from 16 to 17 years old. The majority of students were from middle to upper class families. All the students involved in the study were instructed by the same biology teacher and exposed to identical syllabus-prescribed content.

2.2 Instruments

Two instruments, Human Circulatory System Concepts Test (HCSCT) and the Group Assessment of Logical Thinking (GALT) were used for the study. The first was a 16-item multiple-choice test developed by the researchers. The test was administered to 10^{th} graders after instruction to determine students' achievement concerning human circulatory system concepts. The main concepts included in the test were blood, heart, blood vessels and homeostasis. The content validity was provided by a group of experts in biology education, biology, measurement, and evaluation. The internal consistency reliability, (Cronbach's alpha coefficient) of the test was found to be 0.72.

GALT was a 21-item multiple-choice test developed by Roadrangka, Yeany, Padilla [12] to assess the cognitive development of students. It presents options for answers as well as the justification or reason for that answer. In the present study, GALT was used for investigating the effect of reasoning ability on students' achievement concerning human circulatory system concepts. To classify students as concrete, transitional, or formal thinkers on the basis of scores following procedure was followed: scores of 0 to 8 were classified as concrete, 9 to 15 were transitional, and 16 to 21 were recognized as formal thinkers. Reliability of the test was found to be 0.85 by calculating internal consistency values using Cronbach's alpha.

2.3 Procedure

At the beginning of the human circulatory system unit, GALT was administered to participants of the study. After receiving regular classroom instruction, they were given HCSCT. Two-way ANOVA was used to statistically analyze the data obtained from these two test scores and gender. In this analysis, gender and GALT scores were considered as independent variables and HCSCT scores were considered as the dependent variable. The analysis was performed with the significance level of $\alpha = 0.05$

using Statistical Package for Social Sciences (SPSS).

3. RESULTS

Before making interpretations about ANOVA output, the assumptions of ANOVA mentioned below were checked:

a) The populations from which the samples are selected must be normal.

b) The populations from which the samples are selected must have equal variances (homogeneity of variance)

When Skewness and Kurtosis values have been examined, it has been shown that these values ranging from –0.313 to 0.223 and –0.724 to 0.496, respectively are tolerable and therefore there is no violation of normality assumption. When homogeneity of variance assumption has been checked, it has been determined that there is no violation of this assumption ($p= 0.280$).

Descriptive statistics for the data are summarized in Table 1.

Results from ANOVA are reported in Table 2, which shows all the components of the analysis

Table 1. Descriptive Statistics for the Gender and Reasoning Ability with respect to Achievement

Gender	GALT	Mean	S.D
Boy	Concrete	7.00	0.71
	Transitional	8.27	1.90
	Formal	9.50	1.58
	Total	8.50	1.82
Girl	Concrete	8.00	0.00
	Transitional	8.88	2.41
	Formal	10.25	2.05
	Total	9.62	2.22
Total	Concrete	7.17	0.75
	Transitional	8.53	2.09
	Formal	9.91	1.85
	Total	9.00	2.06

Table 2. Tests of Between-Subjects Effects

Source	Sum of Squares	df	Mean Square	F	Significance
Gender	3.46	1	3.46	0.96	0.333
GALT	26.69	2	13.35	3.702	0.033*
Gender*GALT	0.132	2	6.62E-02	0.18	0.982
Error	147.81	41	3.605		

* Analysis was performed with the significance level of $\alpha = 0.05$.

As it can be seen from Table 2, while there is no statistically significant gender difference with respect to the learning of human circulatory system concepts, there is statistically significant reasoning ability difference with respect to the learning of the learning of human circulatory system concepts. The results also revealed that there is no interaction between gender and reasoning ability, that is, the reasoning ability effect does not depend on the gender (and vice versa).

Scheffe test was carried out to determine which pairs cause the significant reasoning ability difference with respect to achievement. As Table 3 shows, there was a significant mean difference between concrete and formal students ($p < 0.05$) while there was no significant mean difference between concrete and transitional, and between transitional and formal students ($p > 0.05$). Students at formal level acquired a better understanding of human circulatory system concepts.

Table 3. Multiple Comparisons

GALT	GALT	Mean Difference	Significance
concrete	transitional	-1.36	0.321
	formal	-2.74	0.012*
transitional	concrete	1.35	0.321
	formal	-1.38	0.079
formal	concrete	2.74	0.012*
	transitional	1.38	0.079

*The mean difference is significant at the 0.05 level

4. DISCUSSION

The results of this study revealed that there is no interaction between gender difference and reasoning ability with respect to the learning of human circulatory system concepts. This finding indicated that mean difference for one factor does not depend on the levels of the other factor. Thus, it is sufficient to use the main effects i.e, gender difference and reasoning ability, as the basis for interpreting the results. Regarding gender difference, it was found that there is no effect of this variable on the students' achievement. The result seemed to be not surprising considering the findings in the literature showing that boys perform better than girls in the physical sciences while the difference is not very large in other subject areas [5, 6].

Steinkamp and Maehr [13] reported that the achievement and cognitive ability relationship was the strongest in biology and physics for both boys and girls. The current study also showed that reasoning ability had a significant influence on students' achievement. Students at the formal level performed significantly better than students at the concrete level on the Human Circulatory System Concepts Test. There was no significant mean difference between transitional students and formal students and transitional students and concrete students. However, students at the formal level were the most successful on the test while students at the concrete level were the least successful. In fact, the items included in HCSCT required students not to memorize isolated facts but to comprehend, relate the concepts and construct a coherent body of scientific knowledge. Moreover, the content covered in the test was abstract in nature. Thus, it was expected that formal students who no longer require concrete objects to make rational judgements and are capable of hypothetical and deductive reasoning would perform better than transitional and concrete student. What is more, Lawson and Renner [14] demonstrated that while concrete-operational students were able to understand only concrete concepts, formal-operational students were able to understand both concrete and formal concepts. As Lawson and Thompson [9] pointed out formal operational students possessing the formal patterns necessary for evaluating competing hypothesis by compering the predicted outcomes can overcome biological misconceptions which interfere with further, meaningful learning. On the other hand, concrete operational students continue to use their misconceptions to make predictions failing to recognize the limitations of these misconceptions and appreciate the merits of the scientific conception. To be able to promote meaningful learning, help students abstract key concepts, realize the interrelationships among the concepts, transfer and integrate what they learn in one course to another and to their daily lives, teachers should be aware of the reasoning ability of their students and design the lesson accordingly. For example, concrete students can be instructed with instructional materials that provide first-hand experiences and concrete problems [14]. Nevertheless, it should be noted that such materials could be inadequate for cognitively precocious students who are capable of assimilating abstract instructional materials [11]. Thus, teachers should provide a rich learning environment for the students to deal with individual differences. Also, to foster formal operations, teachers should pose problem to students and present them with questions and conflicting situations, and encourage them to analyze their own thinking either individually or in groups [15]. Moreover, it is suggested that courses should be taught by learning cycle [16] and inquiry [7] which foster scientific reasoning.

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