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HIGH SCHOOL STUDENTS' MISCONCEPTIONS ABOUT SIMPLE ELECTRIC CIRCUITS

LİSE ÖĞRENCİLERİNİN BASİT ELEKTRİK DEVRELERİ İLE İLGİLİ KAVRAM YANILGILARI

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ABSTRACT: The purpose of this study was to determine 9th grade students' misconceptions about simple electric circuits and to explore the relationship between these misconceptions and some selected variables (students' gender and experience about electric circuits). Review of literature concerning simple electric circuits has shown that high school students have many misconceptions about this topic and in order to assess them, a diagnostic test was developed. The test, which was named as Simple Electric Circuits Concept Test, is formed of 13 practical and 8 theoretical questions. Moreover, a questionnaire was also given to students to determine their experience about simple electric circuits. The study took place during 2000-2001 fall semester with the participation of 76 high school students. Results of analysis showed that high school students had considerable degree of misconceptions concerning simple electric circuits and these misconceptions were closely related with students' gender and previous experiences about simple electric circuits.

KEY WORDS: simple electric circuits, misconceptions, gender difference, experience

ÖZET: Bu çalışmanın amacı lise birinci sınıf öğrencilerinin basit elektrik devreleri konusundaki kavram yanılgılarını saptamak ve bulunan kavram yanılgıları ile cinsiyet ya da tecrübe arasında bir ilişki olup olmadığını ortaya çıkarmaktır. Yapılan kaynak taramaları sonucu lise öğrencilerinin basit elektrik devreleri konusunda kavram yanılgıları olduğu belirlenmiş ve bu kavram yanılgılarını ölçen bir kavram testi geliştirilmiştir. Basit Elektrik Devresi Kavram Testi olarak isimlendirilen test, tecrübeye dayalı 13 ve teoriye dayalı 8 soru olmak üzere toplam 21 sorudan oluşmaktadır. Öğrencilerin basit elektrik devreleri hakkındaki tecrübelerini belirlemek amacıyla, kavram testiyle birlikte bir anket verilmiştir. Çalışma 2000-2001 güz döneminde, toplam 76 lise birinci sınıf öğrencisiyle gerçekleştirilmiştir. Yapılan analizlerin sonuçları öğrencilerde sıklıkla görülen kavram yanılgıları belirlenmiş ve kavram yanılgıları cinsiyet ve tecrübeyle ilişkilendirilmiştir.

ANAHTAR SÖZCÜKLER: basit elektrik devreleri, kavram yanılgıları, cinsiyet farklılıkları, tecrübe

1. INTRODUCTION:

For about 20 years, the role of misconceptions in learning science has been investigated extensively. Numerous interviews with students at various levels have been conducted and it was found that misconceptions were frequent. The roots of misconceptions, how they affect learning of disciplinary knowledge and how they can be remedied have been investigated by many researchers (Chambers & Andre, 1995; Shipstone, 1988; Cohen, Eylon & Ganiel, 1983; Heller & Finley, 1992).

The term misconception refers to the ideas that students have about any phenomena that are inconsistent with scientific conceptions. The goal of effective science instruction is to encourage the student to construct an understanding that is generally consistent with accepted scientific theory. It is known that students use preexisting conceptions constructed from previous experiences to reason about newly presented science concepts (Driver & Easley, 1978; Zietsman & Hewson, 1986). Such preconceptions are often incorrect from a scientific viewpoint and can interfere with students learning of science (Fredette & Clement, 1981).

One active area of research on physics misconceptions is topic of simple electric circuits. Research on students understanding of science showed that students have wide range of misconceptions in the area of simple electric

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circuits. According to these studies in the literature, students' common misconceptions about simple electric circuits are summarised below:

1. Sink Model: Students think that single wire connection allows electricity to sink from power source to device, thereby powering the device (Chambers & Andre, 1997; McDermott & Shaffer, 1992).
2. Clashing Current Model: Students think that positive electricity moves from the positive terminal and negative electricity moves from the negative terminal and they meet at a device and clash (Heller & Finley, 1992; Chambers & Andre, 1997).
3. Weakening Current Model: Students think that current flows in one direction and gradually weakens because each device uses up some of the current (Heller & Finley, 1992; Chambers & Andre, 1997).
4. Shared Current Model: Students think that devices share current equally but less current turns to power supply (Heller & Finley, 1992; Chambers & Andre, 1997).
5. Local Reasoning: When a change is made up in a circuit, students often focus on the point where the change occurs; they do not recognise that change made at one point may result in changes at other parts (Cohen, Eylon & Ganiel, 1983; Heller & Finley, 1992).
6. Short circuit preconception: Students believe that in a circuit, wire connection without devices attached to the wire can be ignored (Shipstone, Jung & Dupin, 1988).
7. Empirical Rule: Students think that the further away the bulb is from the battery the dimmer the bulb (Heller & Finley, 1992).
8. Students regarded battery as a constant current source rather than a constant voltage source (Cohen, Eylon & Ganiel, 1983; Heller & Finley, 1992; Psillos & Koumaras, 1988).
9. Resistance and equivalent resistance: Students think that if the number of resistance increase in a circuit, equivalent resistance also increases as independent from their connection type (Chambers & Andre, 1997).
10. Potential and potential difference: Students did not realise that brightness of identical bulbs depends on how they are connected into circuit not on where they are connected (Shipstone, Jung & Dupin, 1988).
11. Sequential reasoning: If a circuit element changed in a circuit, students analyse circuit in terms of before and after current passes that place (Heller & Finley, 1992).

Main problem of the study is: "What are the effects of gender and experience on 9th grade students' misconceptions about simple electric circuits? " According to this main problem, the sub-problems are as follows:

1. What are the students' misconceptions about the simple electric circuits?
2. What is the effect of gender on students' misconceptions about simple electric circuits?
3. What is the effect of experience on students' misconceptions about simple electric circuits?

2. METHOD

2.1. Subjects

In this study, a total of 76 high school students including 38 ninth grade level students from Anatolian High School in Ankara and 38 ninth grade level students from public High School in Adana participated where the number of males is 50 and number of females is 26.

2.2. Instruments

Two instruments were developed for this study. One of them is Simple Electric Circuit diagnostic test to assess students' conceptual understanding about Simple Electric Circuits. Test consisted of 21 multiple-choice items and it includes two parts: First part is the practical questions included 13 items and the second part is theoretical questions with 8 items. The practical questions assess the students' misconceptions about the practical use of the components of simple electric circuits and interpretations of these components. The theoretical questions are also developed by the same reason for theoretical use of components (example for both types of questions can be seen in Appendix A). While the diagnostic test items were constructed, the steps given below are followed:

1. All questions, found from literature review, were categorised according to the misconception models, which are written in the introduction part,
2. For each misconception 1 or 2 questions were selected and the rest was eliminated,
3. For some models, questions were developed since there was not any question measuring the corresponding misconception model,
4. In practical test, a battery and a bulb were used. Moreover, same type of bulbs and batteries were used in all of the questions in order not to make the students confused,
5. In theoretical questions same type of resistance and the power supplies were used with the same reason,
6. In both practical and theoretical questions the students were asked if the circuit would work,
7. The alternatives indicated that the circuit would or would not work and gave reasons that were consistent with one of the misconception model.

Students' practical and theoretical misconception scores were calculated separately. In other words, each student has two different scores, one of which belongs to the practical and the other one belongs to the theoretical part of the test. Moreover, these scores were calculated by giving 1 point for each misconception that means that low scores indicate few misconceptions and high scores indicate more misconceptions.

Furthermore, a 28-item questionnaire was developed to assess students' experiences and interests towards simple electricity subject. Some items from this scale are given in Appendix B. Reliability estimates of these two instruments were calculated by using Cronbach alpha coefficient and they were obtained as 0.74 and 0.84 respectively. To check the face and content validity, tests were checked by two physics professors, one educator and one high school physics teacher.

2.3. Procedure

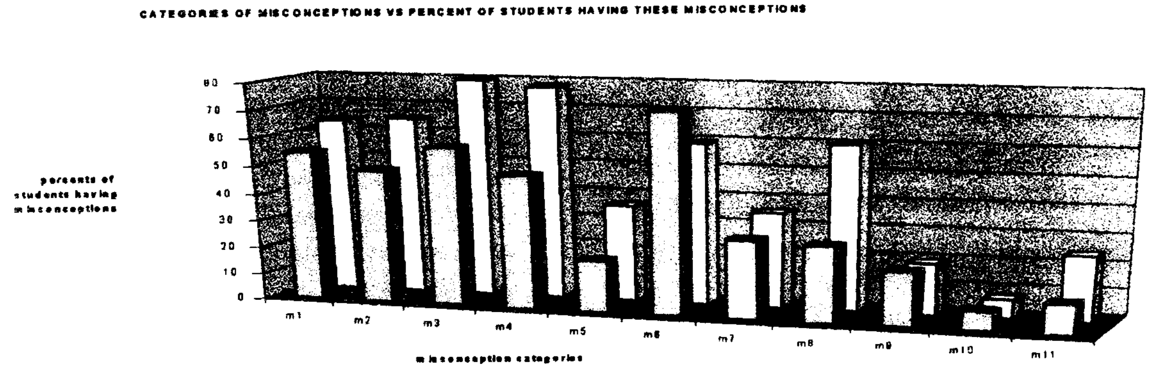
Detailed literature review about students' misconceptions on simple electric circuit was done. All the available journals and articles were obtained and examined one by one to find the related research studies. While making this literature review, all of the misconception models are determined and the questions are examined.

The multiple-choice questions and alternatives were classified according to the misconception models and then diagnostic test was developed as explained before. Moreover, four different forms of the same test were prepared by changing the places of questions and alternatives in order to get more accurate results. This four form of diagnostic test was applied on 76 ninth grade-level students in the presence of the researcher and they are told that scores of this test would not affect their physics grades in the course. In the questionnaire each student wrote down birth-date, gender...etc. The subjects were given 40 minutes class hour for completing the test. After getting the data, diagnostic test and questionnaire of the each subject were scored and data table consisting of gender, birth-date etc. was prepared. Statistical analyses were carried out by using Excel and Statistical Package for Social Sciences.

3. RESULTS

3.1. Descriptive Statistics

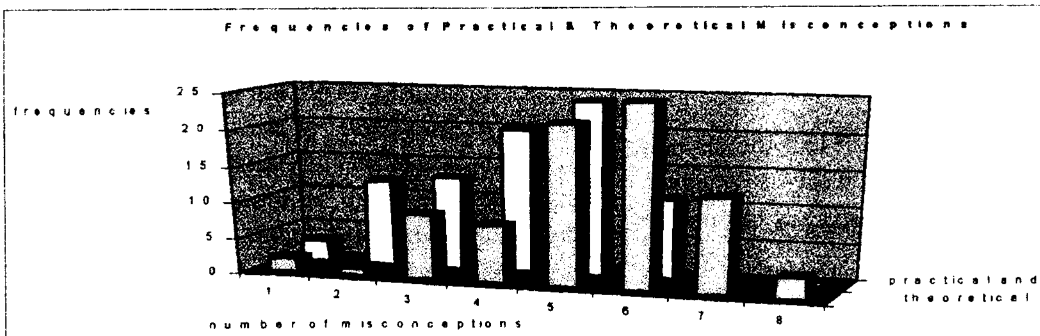
Figure 1 presents the categories of misconceptions and percent of students having these misconceptions. In that figure, m1 indicates the 1st misconception in the introduction part and likewise m2, m3, m4, m5, m6, m7, m8, m9, m10 and m11 indicate the corresponding misconceptions in the introduction part. According to Figure 1, the percentages of the students' misconceptions in practical questions are usually higher than the theoretical ones. Only in the sixth and ninth misconceptions, the percentages of the students' misconceptions in theoretical questions is higher. For example, on practical part of the test, 78 percent of the students thought that current flows in one direction but gradually weakens since each device uses up some of the current. On the other hand, only 49 percent of them thought in a same way in theoretical part. Again, while 60 percent of the students thought power supply as a constant current source on practical part of the test only 28 percent of them thought in that manner on theoretical part.



	m1	m2	m3	m4	m5	m6	m7	m8	m9	m10	m11
TEORIK	55	49	58	49	18	73	29	28	20	7	11
PRATIK	64	65	80	78	38	59	35	60	19	7	24

FIGURE 1: The results of student misconceptions in practical and theoretical questions

Figure 2 presents the frequency analysis results of students' misconceptions in practical and theoretical questions, in practical part of the test most of the students have five or six misconceptions on the other hand, in theoretical part of the test most of the students have four or five misconceptions. Briefly, it can be said that, number of students having misconceptions on



	1	2	3	4	5	6	7	8
practical	2	1	9	8	22	25	13	3
theoretical	3	12	13	20	24	11	0	0

FIGURE 2: Frequencies of students' misconceptions in practical and theoretical questions

practical part of the diagnostic test is more than the number of students having the same misconception in theoretical part of the test. Furthermore, there is no student having all of the misconceptions at the same time and all students have at least one of the misconceptions.

Table 1 gives us the misconception scores of both girl and boy students in theoretical and practical questions. Although it seems that girls have more misconceptions than boys in the practical questions while boys have more misconceptions than girls in theoretical questions, actually means for both male and female students misconception scores are approximately the same.

TABLE 1: Descriptive statistics results for gender difference in students' misconception in practical questions and in theoretical questions

Group Statistics

	GENDER	N	Mean	Std. Deviation	Std. Error Mean
PRA_MIS	1	26	5.27	1.43	.28
	2	50	5.12	1.52	.22
TEO_MIS	1	26	3.92	1.38	.27
	2	50	4.00	1.40	.20

3.2. Inferential Statistics

By using t-test for independent groups, firstly gender difference on misconception scores obtained from practical questions was investigated. Table 2 indicated that with 74 degrees of freedom, the t value of 0.414 was not significant at 0.05 level (p= 0.680) which means that there is no significant difference between misconception scores of male and female students in practical questions.

In a similar way, gender difference in misconception scores obtained from theoretical questions was also investigated by using t-test for independent groups. The results are shown in Table 3. Table 3 indicated that with 74 degrees of freedom, the t value of 0.228 was not significant at 0.05 level (p= 0.820) which means that there is no significant difference between misconception scores of male and female students in theoretical test questions.

Students' experience scores were also examined with respect to gender and as can be seen from Table 4 with 73.877 degrees of freedom, the t value of 0.102 was not significant at 0.05 level (p=0.919) which means that there is no significant difference between experience scores of male and female students.

TABLE 2: Results for gender difference in students' misconceptions in practical questions

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
PRA_MIS	Equal variances assumed	587	.446	414	74	680	15	36	-.57	87
	Equal variances not assumed			422	53.589	674	15	35	-.56	86

TABLE 3: Results for gender difference in students' misconceptions in theoretical questions

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
TEO_MIS	Equal variances assumed	.213	.646	-.228	74	820	-7.69E-02	34	-.75	59
	Equal variances not assumed			-.229	51.285	.820	-7.69E-02	34	-.75	60

TABLE 4: Results for gender difference on experience score

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
EXPER	Equal variances assumed	4.348	.041	085	74	932	24	2.76	-5.25	5.73
	Equal variances not assumed			102	73.877	919	24	2.31	-4.36	4.83

As a result, independent t-test analyses show that there was no significant difference between practical misconception scores, theoretical misconception scores and experience scores in terms of gender.

For the present study, bivariate correlational analyses were used to find if there were significant correlations among the variables. According to Table 5, two correlation coefficients were found as statistically significant (practical misconception scores, experience scores and practical misconception scores, theoretical misconception scores). In other words, the students who have more experience have few misconceptions in practical questions and the students who have misconceptions in practical questions have also misconceptions in theoretical questions.

TABLE 5: The correlations between the students' experience scores in the practical questions and in theoretical questions

Correlations

		EXPER	PRA_MIS	TEO_MIS
EXPER	Pearson Correlation	1.000	-.269*	-.061
	Sig. (2-tailed)	.	.014	.585
	N	83	83	83
PRA_MIS	Pearson Correlation	-.269*	1.000	.421**
	Sig. (2-tailed)	.014	.	.000
	N	83	83	83
TEO_MIS	Pearson Correlation	-.061	.421**	1.000
	Sig. (2-tailed)	.585	.000	.
	N	83	83	83

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

4. RESULTS AND CONCLUSIONS

In this study the effects of gender and experience on students' misconceptions about simple electric circuits were investigated. In order to do this, initially, detailed literature review was made and eleven misconception categories were stated. Then, diagnostic test including 13 practical and 8 theoretical questions was developed. After administering this diagnostic test in anatolian and public high schools to 76 students, the data were obtained and analysed.

Results related to practical questions can be compared with the other studies; Chambers and Andre (1995) have studied on this area and their results showed the significant main effects for gender. Males (mean=18.1) did better on the post-test than did females (mean=13.7). Generally the other researchers have reached the same results (Kahle and Meece, 1994; Shipstone, 1988). All these studies show that the female students' misconceptions are higher than the male students' misconceptions. Although significant difference between male and female students' misconceptions could not be found in this study, results are still consistent with the literature. It is expected to find significant difference between male and female students' misconception scores in simple electric circuits as a result of their different experiences. But, since there is no significant experience difference between male and female students in the study, it is not surprising to meet with such a result. In a more brief way, it can be proposed that, since there is no significant difference between males and females in terms of their experience levels, there is also no significant difference between their theoretical and practical misconception scores. Another reason can be the applying the diagnostic test in Anatolian High School where the students are accepted to the school through entrance examination and special class of the public school where both girls' and boys' abilities are close to each other.

The theoretical questions cannot be compared since the same kinds of questions were not used before. After analysing the data, it was found that there is no difference between the male and female students' misconception scores in theoretical questions.

Moreover, it can be easily seen from the Figure 1 that generally, students' misconceptions in the practical questions are higher than the theoretical ones except the sixth and ninth misconceptions. The reason is clear; when looked at the question related to sixth and ninth misconceptions, it was realised that those questions are difficult to practice in daily life therefore their values are close to each other.

In the light of the above findings obtained by statistical analyses, the following conclusions can be deduced;

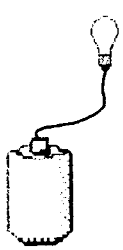
1. There is no significant difference between male students' misconception scores obtained from practical questions and female students' misconception scores obtained from practical questions.
2. There is no significant difference between male students' misconception scores obtained from theoretical questions and female students' misconception scores obtained from theoretical questions.
3. There is no significant difference between male students' experience scores and female students' experience scores.
4. There is a significant relationship between students' misconception scores on practical questions and their experience.

In addition to these, it was realised that, students have considerable degree of misconceptions about simple electric circuits. Actually all the instructors should be aware of these misconceptions and try to remedy them since existing memories and information influence the selection of stimuli, the attention given to stimuli and subsequent meaning generated from stimuli. More briefly, existing concepts play an important role in determining learning outcomes because they provide the foundation for the construction of new information. Moreover, as a result of this study, it can be concluded that although many students can solve the theoretical questions, few are able to solve practical ones requiring experience. Thus, necessity of laboratory activities should also be taken into consideration.

APPENDIX A

An example from practical questions:

1. Şekilde görülen lamba yanar mı?



a. Evet, çünkü elektrik akımı pilin ucundan lambaya doğrudan geçebilir.

b. Evet, çünkü pil ile lamba arasındaki herhangi bir bağlantı lambanın yanmasını sağlar.

c. Hayır, çünkü tel lambanın yanlış noktasına bağlanmış.

d. Hayır, çünkü sistemden akım geçmez.

e. Hayır, çünkü elektrik akımı lambanın bağlı olduğu uçtan değil diğerinden çıkar.

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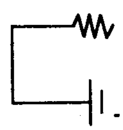
An example from theoretical questions:

1. *Şekilde görülen devredeki direnç üzerinden akım geçer mi?*



a. Evet çünkü elektrik akımı güç kaynağından dirence doğrudan geçebilir.

b. Evet çünkü güç kaynağı ile direnç arasındaki herhangi bir bağlantı dirençten akımın geçmesini sağlar.

c. Hayır çünkü tel dirence yanlış bağlanmış.

d. Hayır çünkü devreden akım geçmez.

e. Hayır çünkü elektrik akımı güç kaynağının bağlı olduğu uçtan değil diğerinden çıkar.

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APPENDIX B

Examples from experience scale:

1)Daha önce elektrik ile ilgili bir deney yaptınız mı?

a. Hiç b. Nadiren c. Sık sık

2)Daha önce hiç pil ve tel kullanarak bir lamba yakmayı denediniz mi?

a. Hiç b. Nadiren c. Sık sık

3)Daha önce hiç elektrikli alet tamir etmeyi denediniz mi?

a. Hiç b. Nadiren c. Sık sık

4)Evinizde bozulan bir lambayı değiştirmeyi denediniz mi?

a. Hiç b. Nadiren c. Sık sık

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