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An Exploration of Student Misconceptions in Electrical and Electronics Engineering Department

Ahmet Karaarslan [a,1], Şaban Çetin [b]

[a] Energy Systems Engineering Department, Yıldırım Beyazıt University, Ankara TURKEY
[b] Department of Education Science, Gazi University, Ankara TURKEY

Abstract

In this study, the common misconceptions are identified and regarding solutions are offered for Electrical and Electronics Engineering students. From the standpoint of knowledge, most important substructure of education is concept teaching. The biggest obstacle to be faced in concept teaching is misconceptions that can be avoided by researches. According to previous studies, students' success, interest and motivations regarding the electrical and electronics field is lower compared to other fields. One of the reasons of this is that, the concepts being used are notional and students fail to make these concepts meaningful. As a result of this structure, they are faced with learning difficulties. These learning difficulties set the basis of misconceptions of students. By this study, a conception test is created in order to determine misconceptions. The test consists of one right choice, expected misconception and a wrong choice which is not related with the subject. Also, there are open-end questions at the end of each test question in order to determine the students' views regarding their choices. By the result of content analysis, student common misconceptions are determined and solutions are offered to avoid these misconceptions.

Keywords: "Misconceptions, Improving Classroom Teaching, Teaching/Learning Strategies"

1. Introduction

In recent years, a considerable part of the studies conducted on education field is about determining the misconceptions that students face with and make them free from lacking of knowledge. One of education's most important factors is concept teaching. With this scope, concept teaching must be considered generally in all subjects and must be included in teaching plans concordantly. At the end of each lecturing, levels of concept acquisition must be checked and it must be kept in mind that those who didn't understand concepts won't understand subjects either. Even if some students give the right answer in classroom environment, in fact, they only use some statements that they have memorized before. When they are addressed in-depth questions, it can be revealed that these students have not comprehended basic concepts.

Students can often use algorithms and equations without comprehending basic scientific concepts clearly in order to solve numerical problems. Because of this reason, beyond providing students knowledge and effective examples, they must be shown logical processes that precede algorithms and conceptual generalizations. However, for many students, if they cannot comprehend basic concepts clearly starting from the beginning of studies, this situation can also hinder learning next subject. Misconception is a situation which originates from wrong concepts which are taken as correct and used as source in practicing many skills. Misconceptions can differ from random mistakes. A person can recognize his/her mistake by a small notice and correct it. But, when a person, who has a specific misconception, makes mistake and warned by someone, he/she first defense himself/herself. When you fail to satisfy him/her, he/she does not give up the misconception [14].

Many people can have single or a group of misconceptions, and it can also create alternative beliefs. Most of the misconceptions are so insistent that they can't be eliminated. Some misconceptions originate from experiences from the past. This situation may generally arise from genetic origins, experiences by various occasions and teaching in school environment. Language errors come up when the words' daily usage meanings differ from their scientific meanings. Misconceptions also include such knowledge that is learned from unscientific recourses like beliefs and religious, mythological precepts [8].

In order to avoid misconception in the education field, first of all, the new term must be reasonable and logical. Educational environments, which create cognitive dissonance, must be created [21]. Teaching must be organized in the way that reveals students' misconceptions [18, 19]. Activity suggestions, which help eliminating misconceptions of the students, must be created.

[1] Corresponding author. Tel.: +90-506-724-7707.
E-mail address: akaraarslan@gmail.com

Students must be helped in order to make them understand the concepts through verbal and perceptible situations [5]. Teachers must be suggested to use measuring techniques which can help them follow conceptual change [18, 19]. Students must put their current thinking methods into the process of reconstruction and reshaping with their own active participation in order to learn a new concept. The starting point of conceptual change is to make the personal language of the students stand out. This language might differ considerably from scientific language, but it seems more familiar and effective for acquiring new concepts, especially for children [3]. Some methods for determination and elimination of misconception are; card arrangement activity, written opinions activity, thinking experiment, material designing, questionnaire, concept mapping, guess-observe-explain, interviews about situations and events, interviews about concepts, drawings, relation schemes and word association.

Electrical and Electronics Engineering education can have possibilities and chances to enhance creative thinking. In order to create a structure like analyzing occasions and critical thinking, it must be expected the logically and systemically thinking specialties to be acquired by electrical and electronics engineering education and learning teaching activities. However, it is impossible to reach this way of mathematical thinking through conventional teaching methods of mathematics. Most of the academicians cut corners about this issue and provide all the concept characteristics, formulas and theorems about subjects in ultimate forms without any explanation and expecting students to memorize them. This causes students to develop negative attitude for the lesson which they already take as memorizing. Academician can't expect any success, if he/she teaches the subjects in this way. Such approach supports rote learning, rather than usage of the mind. In order to avoid this, instead of providing questions on which students can use these formulas, they must acquire subjects by using such various activities and methods mentioned above.

The students are tested by conceptual questions, and a method is followed for the solution of the resultant conceptual problems. Second part is determining methods of misconceptions, third part is to do list for students to eliminate misconceptions, fourth part is the method conducted to determine the subjects of students' misconceptions, fifth part is the findings and explanation and the last part is the results section.

2. Identification Materials and Methods of Misconceptions

Misconceptions must be determined before they are corrected. Some researchers and teachers have listed the misconceptions they faced. Some certain occupational communities have developed conceptual tests to determine the misconceptions of students. Furthermore, small group discussions and study hours provide effective discussion environment to determine students' misconceptions. A teacher can learn how to go deep into students' conceptual structures by some practices and efforts without putting students to shame or consulting any authority. He/she finds a way to help students control their own structures even at long lesson format in an excused way. Laboratory studies, which help them to test their conceptual basics in movement comprehension, have been used [11]. Homework, which requires logical explanation, is very useful in determining students' misconceptions. This homework can be used as a part of learning process to reveal what and how students think, not for grading. Misconceptions can also occur because of students' comprehension of scientific method as well as their organizing of scientific knowledge. Students generally can't understand that the experiments are for testing ideas and hypothesizes, not for obtaining expected results. Experiments give results to be analyzed for the scientists. Each experiment works in this respect, however it might not end up with the expected result.

Helping students face with their misconceptions, and thinking about possible misconceptions and reviewing them before teaching in a class or laboratory in which a new subject will be introduced is considerably useful. Questions and discussions can be used to go deep into misconceptions. Students can generally get confused with the variety of preliminary information, because of this reason, their explaining and answers must be listened carefully. Teachers can help students by giving hints to support their explanations, and reviewing hard or misunderstood concepts after a couple of days or weeks. Misconceptions mostly go deep inside, are majorly not explained and sometimes defended in a strong way. A teacher shouldn't ignore the importance and resistance against change of these obstacles in order to be efficient and practice comprehension in a correct way. It is really hard to face these for both the teacher and the student. Some misconceptions can be revealed by asking students to explain or picture some objects or a phenomenon. For example, a teacher can ask students to draw picture of the atom before drawing it on the board by him/her. Even the most successful students might draw a tiny core in the center and extra nuclear electrons orbiting in a specific direction around it. A teacher can picture previous models and use them to show the necessity of creating new models by asking for students' own models and their ideas to share with the class.

3. Helping Students to Cope with Misconceptions

Strategies on helping students to correct their misconceptions are based on researches about how we learn [1], [13]. The key to success is that the correct structure students create for their new knowledge or guaranteeing rebuilt ones. A way to build this structure is to prepare discovered "concept map" for students [16]. Students learn a bunch of concepts and visualizing the relationship between them by this technique. The boxes, which include names (and sometimes adjectives), are connected to

relevant boxes by a series of lines, and statements or verbs are written on these lines in order to show the relationships between them. Although some studies showed that this does not increase meaningful learning, some others showed contrary results. It is stated that the students, who created concept maps in cooperative groups, learned more concepts compared to the ones who learn individually, thus concept map usage is based on the way the teaching environment is created [7]. Some other results stated that the cooperative groups in concept based tasks have a significant effect on helping the university students to correct their specific misconceptions, even if they do not include concept maps [2]. Reasons of misconceptions: (a) Misunderstanding or understanding the concepts, which are acquired before, in an incomplete way [4, 6, 10], (b) Terms used in daily language having another meaning in scientific language [15, 17], (c) Being not able to create suitable education environments to teach subjects and concepts [12, 20], (d) Not associating the concepts together or to the daily life [9].

It is a hard task to help students rebuild their own conceptual structures. This process unfortunately takes more time for Electrical and Electronics Engineering students compared to other fields. The method applied to determine this issue is given in the fourth section in detail.

4. The Applied Method for Determination of Misconceptions

In this study, a test, which includes misconceptions of Electrical and Electronics Engineering students, is developed. In this test, there is a correct answer, one or two options which include expected misconception, and wrong options irrelevant with the subject. Students were to write their explanations under each question to determine the criteria on which their answers are based. Application methods and details of the study are stated below.

4.1. Research Model

Quantitative and qualitative research methods are used together in this study to practice method diversification. Misconception Test is used for the quantitative part of this study. For the qualitative part of the study, open-end questions are used in accordance with the data obtained from quantitative part, and more detailed information is obtained about the answers students gave for the misconception test. Thus, it is aimed that different findings obtained by using different methods support each other and this increases the validity and liability of the obtained results.

4.2. Data Collection Tool

The misconception test is developed in order to determine students' misconceptions about the electrical and electronics subjects by researchers. Aims and behaviors were determined about the subject before developing the test. Forty questions were specified by considering aims and behaviors. Test questions were applied to a 120 students for validity and liability. After taking the questions, which decrease the liability of the test, out by the analysis made using ITEMAN package software after the practice, there are 20 items stay in the final form of the test. KR20 reliability coefficient of the test is 0.74 and the difficulty is calculated as 0.526.

4.3. Population Sampling

Research is conducted on 3rd class students who study in Electrical and Electronics Engineering Department of Gazi University. Test is applied to a 120 students consist of 3rd class student sections, approximately all of the students are included in, sampling wasn't practiced.

4.4. Data Acquisition and Analysis

Frequency and percentage tables of the data acquired from the test are created. The option which is chosen as misconception and the right and wrong answers of the questions are determined for each question for the creation of the tables. Students' views at the end of each question, about the options they chose and open-end questions asked to determine the reasons why they have misconceptions are analyzed by content analysis.

5. Obtained Findings and Interpretation

In this part, the findings based on data obtained from this study and interpretations are stated. The frequency distribution about the answers the students gave for the test questions are stated in Table 1.

Table 1. The frequency about the answers the students gave for the test questions

Question	Choice A	Choice B	Choice C	Choice D	Choice E	Blank	Number of Correct	Number of Incorrect
1	64	0	32	**24**	0	0	24	96
2	21	24	19	37	**15**	4	15	101
3	**15**	82	1	19	3	0	15	105
4	15	**18**	23	5	52	7	18	95
5	11	10	27	8	**11**	53	11	56
6	55	17	**18**	14	8	8	18	94
7	5	9	**18**	83	0	5	18	97
8	**85**	6	19	2	0	8	85	27
9	4	68	12	**7**	16	13	7	100
10	21	**40**	30	18	6	5	40	75
11	0	5	39	**72**	0	4	72	48
12	4	12	10	12	**37**	45	37	38
13	37	**45**	14	10	2	12	45	63
14	2	8	**67**	26	7	10	67	43
15	2	16	**81**	6	5	10	81	29
16	17	8	11	**66**	5	13	66	41
17	59	**4**	33	12	4	8	4	116
18	10	**37**	19	8	31	15	37	83
19	**61**	17	0	18	12	12	61	47
20	27	68	9	**4**	0	12	4	104

The distribution about misconceptions of students is stated in Table 2. When the data obtained from the study was analyzed, it is pointed out that 33.8% of the students understood the test questions correct, 53% of them had the expected misconceptions and 13.2% of them got the questions wrong or left them blank. The 33.8% success rate shows that the subject is understood by a little number of the students. The result is significant in this way.

Most of the misconceptions are about zero-grounding (88%) and connection in series (82,1%) concept patterns, and minimum percentage of the misconceptions is about capacitor connections.

According to the distribution table of the subject, other subjects of misconceptions are respectively; direction flow of current (80%), electric field (78,1%), resistance and impedance (78,1%). The concepts which have minimum percentage of the misconceptions are respectively; magnetic field and magnetic flux (17%), stable-movable charge (23,6%) concept patterns.

Table 2. Table of frequency and percentage about the distribution of misconceptions

Question Numbers	Correct Answer	Option(s) Causing misconceptions	The Concept	Percentage of Respondents Correctly	Percentage of Misconception
1	D	A, C	Direction flow of current	% 20,0	% 80,0
2	E	A, B, D	Electric Field	% 12,9	% 78,1
3	A	B	Resistance	% 12,5	% 78,1
4	B	C, E	Energy	% 15,9	% 66,4
5	E	A, C	Transistor, Transducer	% 16,4	% 56,7
6	C	A, B, D	Impedance	% 16,1	% 76,8
7	C	D	Voltage	% 15,7	% 72,2
8	A	C	Magnetic Flux	% 76,9	% 17,0
9	D	B	Active and Reactive Power	% 6,5	% 63,6
10	B	A, C	Power	% 34,8	% 44,3
11	D	C	Current Calculation	% 62,1	% 33,6
12	E	B, C, D	Reactive Power	% 49,3	% 45,3
13	B	A	Magnetic Field	% 41,7	% 34,3
14	C	D	Static-Moving Load	% 60,9	% 23,6
15	C	B	Capacitor Connections	% 73,6	%14,5
16	D	A, C	Source Connections	% 61,7	%26,2
17	B	A, C	Connect in Series	% 3,6	%82,1
18	B	C, E	Semi-Conductivity	% 35,2	%47,6
19	A	B, D	Conductor-Insulator	% 56.5	%32,4
20	D	A, B	Zero-Grounding	% 3,7	%88,0
Average				%33,8	% 53,0

Students are asked to explain, why they think the option they chose is correct under each question of the test, in order to be able to explain students' misconceptions more clearly. After the analysis of the views of the students, results regarding relative concepts are stated in Appendix.

6. Reasons of the Misconceptions Obtained from Content Analysis

After giving students explanations about the answers they have given for the questions, reasons of their misconceptions within the scope of their wrong answers are listed under three topics by performed content analysis. These topics are; "Education methods and techniques used are mostly teacher centered and making students tend to memorize", "Education programs are not up-to-date and irrelevant with the daily life", "Teachers don't have sufficient knowledge about subject", respectively. 70% of the students choose the first, 15% choose the second, and 15% of them choose the third sub-topic. Students' statement examples in regard to their determinated views in these sub-topics are stated in Table 3.

Table 3. Reasons of the misconceptions obtained from content analysis

No	Sub-topics	Students' Answers
1	Education methods and techniques used are mostly teacher centered and making students tend to rote-learn.	***S1*** *"I might have forgotten lots of concepts because I have memorized them."* ***S17*** *"When I memorize concepts once, I never see any reason to question them."* ***S94*** *"Our life consists of rote-learning. This exam has broken my routine."* ***S6*** *"All of these concepts without comprehension causes contradiction in terms."*
2	Education programs are not up-to-date and irrelevant with the daily life.	***S21*** *"I have heard of these concepts but have never used them out of exams."* ***S33*** *"I know the concepts but have these something to do with the daily life?"* ***S68*** *"I think that there are many concepts which do not exist in programs and I have seen them for the first time."*
3	Teachers don't have sufficient knowledge about subject.	***S10*** *"I don't think that the things in books and the teachers say can't be wrong, can they?"* ***S20*** *"Some concepts are way too different than what we have learned."* ***S41*** *"I can't help asking if we have been thought these concepts before."*

7. Descriptions of the Questions used for the Detection of Misconceptions

Q1. Electric current or electrical current is simply the movement of the electron. It means the number of the electrons that passes through conductor per unit of time. It's unit is Ampere. Students generally have the knowledge that, the current moves from positive to negative or from negative to positive. 80% of the students have this misconception.

Q2. The electric force that effects to +1 unit charge at a point is named as 'electric field' at that point. The electric field is a vector magnitude, and its intensity is shown by 'E'. Electric charge's electric field direction at a point is same with direction of the force acting on +1 unit charge at that point. Electrical force is inversely proportional with the square of the distance and continues until forever. Students have the misconception that the field lines start from one point and end in another point, it is exactly from positive to negative, and it moves. The percentage of the students who has this misconception is 78%.

Q3. The voltage and current face some obstacles during going from one end to another end. These obstacles are the forces which affect the flowing of the electrons. These forces are called resistance. Their symbol is ohm (Ω). Resistances do not use charge. The misconception "charges slow down when passing through a resistance" that the students have, originates from the similar things that they associate with during daily life. Misconception rate is 78%.

Q4. Energy means the ability of an object or a system to work. It can't be quantized directly, and it can be quantized by this to be performed to change the state of a physical system or performing various calculations according to the energy type. Energy can't be created or destroyed. It is protected by converting other energy types. The mistake of the students that

some amount of the energy is destroyed during converting shows that they have a misconception. Misconception rate is 66%.

Q5. Transistor used both as a switching element and as an amplifier. Transducer is a detector and performs measuring current, voltage, pressure etc. Students confuse these two terms. Misconception rate is 56%.

Q6. The reason of the misconception here is the similarity between impedance and inductance. They can have the misconception about the difference between these concepts because of their daily language. Impedance is called resistivity, but inductance is another concept consists of turn-shaped conductors and its unit is L. Misconception rate is 77%.

Q7. The misconception about the concept "voltage" originates from a simple word change in the sentence, which is being memorized since secondary education, about potential difference, and students choose this answer still without getting the real meaning. Misconception rate is 72%.

Q8. Majority of students understood the difference between magnetic field and magnetic flux and what it means, but a little amount is confused because of the left-hand rule. Misconception rate is 17%.

Q9. Reason of the misconception is that students couldn't understand the active and reactive power concepts clearly. Almost all of the students who have the misconception have calculated the voltage of the coil and the resistance with the same actual power which is the wrong way. Misconception rate is 64%.

Q10. Students have taken the concept of power as work by confusing power and work concepts. These two concepts are different from each other. Misconception rate is 44%.

Q11. Majority of the students didn't have any misconception about this question. Short circuit over 2Ω is not missed out and they weren't mistaken. But yet, some of the students were mistaken about this. Misconception rate is 34%.

Q12. The concept of reactive power is tested in ninth question and it is obvious that they still couldn't concretize the subject in their minds. It is proved with this question that students always get the meaning that something which is always going to be used or work when they see the concept "power". Misconception rate is 45%.

Q13. Students confuse magnetic field directions that a current flowing through a wire, and they have the misconception that every magnetic field's direction is the same. Magnetic field's direction differs according to the direction of the current flowing through the wire. Misconception rate is 34%.

Q14. Majority of the students didn't have any misconception about this question. It is found out that only some of them think that there is no electrical field around stable charges. Misconception rate is 24%.

Q15. Majority of the students didn't have any misconception about this question. The subject of equivalent capacity measured from series and parallel capacitors is completely understood. Misconception rate is 14,5%.

Q16. Majority of the students didn't have any misconception about this question. But, some of the students think that when an equivalent recourse is connected in parallel, it is going to increase the potential difference or the value the ammeter shows is going to increase. Misconception rate is 26%.

Q17. Students thought of some situations they face in daily life instead of making the calculations and getting the result easily, because of the 220Vms mains voltage. Misconception rate is 82%.

Q18. It is found out that students have only memorized that semi-conductor materials which are normally non-conductors are turned into conductor statement when energy is applied, and they cannot build any semantic relation. The reason of the misconception is that they are affected by the similar subjects in chemistry and physics lessons and chose the wrong answer. Misconception rate is 48%.

Q19. Majority of the students didn't have any misconception about this subject. But, some of them still confuse atomic structure of conductors, non-conductors and semi-conductors. Misconception rate is 32%.

Q20. Almost all of the students have misconception for this question. Students cannot understand the difference between the earth and neutral material, and they get confused. Also, resetting is confused with grounding. Misconception rate is 88%.

8. Conclusion

A concept test is developed in order to determine the reasons which set the basis of the misconceptions that students have. By the result of content analysis, common student misconceptions are determined and solutions offered to avoid these misconceptions. Findings obtained from the results of the researches show that engineering students have some misconceptions about electrical and electronics subjects, and 53% of them have learned some concepts about some subjects in a wrong way.

70% of the students think that the reason of their misconceptions is the teacher-centered and rote-learning based education; other remaining students say that it is because of insufficient teachers and education programs about subjects.

Using conventional methods like monotone expressions and question-answer for concept teaching, starting lessons without determining students' missing information and not using modern techniques like concept maps, concept webs, componential analysis tables cause comprehension of concepts to be more difficult and misconceptions to occur.

In the light of these findings; it is important that the academicians who educate Electrical and Electronics Engineering students be aware of misconceptions, have information about their reasons and how they can be prevented and eliminated. Conceptual changing programs can be prepared for eliminating misconceptions of the students in regard to subjects and the efficiency of the programs can be functionalized by trying it at its field. Concept confusion and misconceptions, which can be originated as a result of this, can be prevented in this way..

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