Discussion On The Prospective Teachers' Understanding Level Of Electric Charge

Ali YILDIZ
Atatürk University, Turkey
ayildiz@atauni.edu.tr

ABSTRACT
The present study was conducted to analyze the understanding level of the prospective teachers studying in the second grade of elementary mathematics undergraduate program, on the topic of electric charge which is taught in compulsory Physics II. Totally 45 prospective teachers, 36 women and 9 men, have participated the study. The data of the study were obtained through a feedback form including four different open ended questions, which were prepared by the researcher based on expert opinion. The answers given to the open-ended questions by the prospective teachers were read and analyzed, and grouped according to their content, similarity and closeness. The grouped answers, the number of the prospective teachers writing the answering and their percentages were entered in relevant tables created and the required evaluations are performed. The fact that 22.1% of the prospective teachers do not know that a matter is loaded with electric charge, 62.1% of them do not know that a matter with electric charge can attract another applicable neutral matter, 60.0% do not know grounding of an electric charged matter and 86.7% do not know that electric charge has quantum property show that their understanding level on the static electricity topic is very low. The fact that generally a high percent of the prospective teachers not knowing electrical charge and its properties, a basic topic taught in elementary and secondary school and at the university, brings the requirement of using methods and activities enabling the students to be active rather than a teacher and centred teaching system in the physics courses in undergraduate programmes. The prospective teachers who have performed learning-purpose writing activities stating in the studies that they have better understood and learned physics topics on which they have written letters or summaries brings the opinion of using these activities for teaching the topic of electrostatic.

INTRODUCTION
It is a generally observed or experienced situation that a comb being used for combing hair in a medium with dry air attracts paperpieces. An inflated balloon sticking on the wall or ceiling of a room with dry air for quite a time after being scrubbed with wool is another simple experiment regarding this. Matters that act like a comb or inflated balloon are called electrified matters or matters with electric charge (Serway and Beichner, 2000). Electric charge is an intrinsic property of the fundamental particles that form matters. Under normal circumstances, matters are loaded with two available charges (positive and negative charge) at equal quantities or numbers. Matters with equal negative and positive charge are called as neutral (Halliday, Resnick and Walker, 2014).

When an uncharged (neutral) glass rod is rubbed with a silk cloth, a certain amount of electrons are transferred to the silk cloth from the glass rod and the glass rod is loaded with positive (+) charge. When a neutral plastic rod is rubbed with a piece of fur, a certain amount of electrons are transferred from the fur to the plastic and the plastic rod is loaded with negative (−) electric charge (Young and Freedman, 2010). When a matter is rubbed with another one, the electric charge does not occur at that time, electric charge is already in that matter. Electrification happens when the electric charge (electrons) is transferred from a neutral matter to another. Generally, when two matters interacts one gives away electrons while the other takes, and the matter losing electron is loaded with positive electric charge and the one obtaining electron is loaded with negative electric charge. The situation effective in the loading with electric charge is an electron exchange .

Electrically charged matters interact by applying force to each other. Like charges or matters with like charges apply repelling force to each other, while opposite changers or matters with opposite charges apply attracting force to each other (Serway and Beichner, 2000; Halliday, Resnick and Walker, 2014). When a neutral plastic rod is rubbed with woollen cloth, a certain amount of electrons are transferred from the woollen cloth to the plastic and the plastic rod is loaded with negative (−) electric charge. There remains an excess of positive charge behind at the amount of the negative charge being transferred to the plastic rod, and the total charge never changes, it always remains stable. This property gives the electric charge the characteristic of conservation.

The positive charge belongs to proton while the negative charge belongs to electron. Proton and electron has the same amount of electric charge ($e = 1.6x10^{-19}C$). The smallest electric charge in the nature is the charge that an electron has. Therefore, the load of the electron is accepted as the base load. That an electric charge (Q) is always found in the nature as the integer multiples of electron charge (e), the base load unit, (Q = ne, n = 1, 2, 3…) is defined as being quantized (Serway and Beichner, 2000). In other words, that the electric charge (q) of a matter being equal to the integer multiples of electron charge (2e, 10e, 53e, 95e…) not the rational multiples (2,5e, 14,8e, 51,7e…) of an electron charge ($e = 1.6x10^{-19}C$) shows the electric charge is quantized.

An electrically charged matter may attract any susceptible neutral conductive matter. When a positively charged test globule is approached from the side close enough to a neutral conductive sphere hung on aninsulating stringand that does not contact with any matter or surface, the electrons gather on the side of the neutral sphere close to the test globule, and on the distant side, where electrons are lost, there will be an excess of protons. By this way, quantity of electric charge of the neutral conductive sphere remaining the same (unchanging) gather in two areas on the surface of the sphere. Asthere is an excess of electrons on the side of the neutral conductive sphere closer to the test globule while there is an excess of protons on distant side, electrostatic attracting force applied by the test globule to the neutral conductive neutral sphere is greater than the repelling force. If the stringed neutral conductive sphere is close enough and the friction is very small to be ignored, test globule attracts the neutral sphere. At the time of contact, some of the electrons gathered on the side of the neutral sphere surface close to the test globule are transferred to the test globule and the neutral conductive sphere losing its property of being neutral becomes positive charged and thus is repelled by the test globule. In short, anelectrically charged matter can attract a susceptible neutral conductive sphere, can load with its charge at the time of contact and then repel it.

Although electric charge is a basic topic taught in elementary and secondary schools and at universities, it is thought that the prospective teachers' understanding level on this topic is not at the desired level. It is anticipated that using student-active methods and activities in the teaching of electrostatics will increase the understanding levels of the prospective teachers of this topic.

The purpose of the present study isto analyze the understanding level of the prospective teachers studying in the second grade of elementary mathematics undergraduate program, on the electric charge topic which is taught in compulsory Physics II course.

METHOD

Totally 45 prospective teachers, 36 women and 9 men, who are at the second grade of the department of elementary mathematics, faculty of education in a state university, and who take the compulsory course of electric and magnetism (Physics II) have participated in the study. A feedback form including four different open ended questions, which was prepared by the researcher based on expert opinion is used in the research to determine the understanding level of the prospective teachers electric charge topic. It is thought that open-ended questions may bemore effective in differentiating the candidates'answers to the questions about electrostatics from predictions and determining them in a valid and reliable way. The open-endedquestions used in data collection were asked the prospective teachers two weeks after the electrostatics topic is explained according to the content of the course and in line with the semester program.The answers given to each open ended question by the prospective teachers, the grounds or the explanations of the answers were read and analysed and grouped according to their content, similarity and closeness. Grouped answers, explanations of the answers (if available), total number of the prospective teachers as women and men and their percentages were reflected to the relevant tables in different columns. At the end of each table, comments and explanations about the data were noted. In addition to their written remarks of the prospective teachers on the questions about electric charge, semi-structured interviews were conducted with 6 randomly selected people. In the interviews, it was observed that the prospective teachers used the similar statements that they had written before.

FINDINGS AND COMMENTS

Table 1: The answers of the prospective teachers to the question: "What does a matter loaded with electric charge mean to you (how can it be explained)?"

Answers Written	Number of Women	Number of Men	Total	%
It means the matter is loaded with either (+) or (–) charge	16	2	18	40.0
It means it is not neutral, that is (–) charges are not equal to (+) charges	5	2	7	15.6
It means it exchanges charges with a matter with electric charge	5	1	6	13.3
It means that there are electrons in the matter	1	1	2	4.4
It means that there are positive or negative charges in the matter	1	1	2	4.4
It means that it has an electric field	1	-	1	2.2
It means the creation of protons and electrons	1	-	1	2.2
It means that a comb rubbed with wool attracts the paper pieces	1	-	1	2.2
It means that (+) and (–) charges move in it freely	-	1	1	2.2
It means that matter gains electric as a result of interaction	1	-	1	2.2
Other answers (Electricitymay be connected ...)	4	1	5	11.1
Total	36	9	45	100

The words "to you" added to the end of the question "What does a matter loaded with electric charge mean to you?" has the aim of motivating the prospective teachersto share/write their opinions without hesitation when answering the question. All prospective teachers writing an answer in their points of view without leaving the first question unanswered confirms that these two words had a positive effect.

The first question was actually asked to understand how a a very basic concept is constructed in the prospective teachers's minds. Such answersas "It means that a matter has electrons", "It means the creation of protons and electrons", "It means that (+) and (-) charges freely move in it", "It means that a matters gains electric as a result of interaction" and "Electricity may be connected" among the written ones show that prospective teachers have trouble (22.1%) in a basic definition as a matter loaded with electric charge.

Table 2: The answers of the prospective teachers to the question "Does a positively charged (+) test globule attracts a neutral conductive sphere that is hung with an insulating string, immobile and does not contact with any surface if it is approached to it from the side by holding its non-conductive handle, or not? Why?"

Answers Written	Grounds of the Answers	Number of Women	Number of Men	Total	%
Attracts	Because a neutral sphere has both (+) and (–) charges. Negative charges gather on the side of the neutral sphere close to test sphere and the attraction is provided	8	3	11	24.4
	As the neutral sphere has (–) charges, test globule attracts that negative charges	3	1	4	8.9
	Neutral matter attracts (+) and (–) charged matters	1	-	1	2.2
	-	2	-	2	4.4
Does not attract	Because in neutral sphere, negative and positive charges are equal to each other. Negative charges gather on the side of the neutral sphere close to test globule	5	-	5	11.1
	They have to be loaded with opposite charges in order to attract	5	2	7	15.6
	As the test globule repels (+) charges and attracts (–) charges, it stays in balance	-	1	1	2.2
	Because the load of the neutral mater $F = k\frac{q_1 q_2}{d^2}$ is zero ($q_2 = 0$), no attraction force is created ($F = 0$)	-	1	1	2.2
	-	1	-	1	2.2
Negative charges of the sphere gather on the side of the test globule		3	-	3	6.7
I don't know		5	-	5	11.1
Other answers (I didn't understand what is meant; it should repel, it is better if it repels)		1	1	2	4.4
No reply		2	-	2	4.4
Total		36	9	45	100

When the answers of the prospective teachers in Table 2 are analysed, it can be observed that they mostly do not have the idea that an electrically charged matter can attract a susceptible neutral matter. The percentage of those who find the answer does not attract as true and try to explain it with their own grounds is 31.1%. When we consider the prospective teachers who say does not attract without any grounds, I don't know, give other answers and no answer, this percentage rises up to 62.1%. For the prospective teachers who took electric and magnetism course, this percentage is quite high. In other words, prospective teachers' level of understanding on static electric is low. It is very striking that the number of prospective teachers explaining the answer attracts with acceptable grounds is only 11 (24.4%).

Table 3: The answers of the prospective teachers to the question "What does grounding an electrically charged matter (a conductive sphere, an electroscope) mean to you?"

Written Answers	Number of Women	Number of Men	Total	%
It means the neutralization of a matter	15	3	18	40.0
It means that negative charges are transferred to earth	13	3	16	35.6
It means that excess electric charge is released and the matter is loaded with only one charge	2	-	2	4.4
It means the transfer of excess electric to earth	-	2	2	4.4
It means sharing and decreasing of the charge	1	-	1	2.2
I don't know	2	1	3	6.7
Other answers (It means that the matter is loaded with negative charge, (+) and (–) charges gathers on different sides...)	3	-	3	6.7
Total	36	9	45	100

For the question "What does grounding an electrically charged matter mean to you?", the answers as neutralization of a matter or a matter becoming neutral can be accepted as directly true without any problem. The answer "It means that negative charges are transferred to earth" is problematic. If a matter is negatively charged in the beginning, the answer "It means excess negative charges being transferred to earth" can be acceptable. However, here, a general condition is being asked. It can be seen by reviewing the answers in Table 3 that the percentage of the prospective teachers who could not explain grounding an electrically charged matter is very high (60.0%) and their level of understanding is low.

Table 4: The answers of the prospective teachers to the question "What does a quantized electric charge mean? Explain it."

Written Answers	Number of Women	Number of Men	Total	%
It means that electric charge is an integer	-	1	1	2.2
It means that electric charge consists of packages	3	-	3	6.7
It means that electric charge is conserved	4	1	5	11.1
I guess there was Oil-drop Experiment of Millikan about this	2	-	2	4.4
I know but I can't explain it exactly	2	-	2	4.4
I don't know	20	6	26	57.8
What is quantum?	1	1	2	4.4
Other answers (Quantum ensures charge transfer...)	3	-	3	6.7
No answer	1	-	1	2.2
Total	36	9	45	100

Proton and electron has the same amount of electric charge ($e = 1.6x10^{-19}C$). The smallest electric charge in the nature is the charge that an electron has. Therefore, the load of the electron is accepted as the base load. Electric charge being quantized means that electric charge is always found in the nature as the integer multiples of electron charge (e), the base load unit, ($Q = ne$, $n = 1, 2, 3\ldots$).When the first two answers are examined, it can be said that electric charge is discrete (quantized), it cannot have every value (rational value), they are not stated well and they should be rearranged. In the oil-drop experiment, Robert Millik an may have found/understand the value of the electron charge and that the charge is quantized. However, there, it is not asked by which experiment it was found, but how the property of the electric charge being quantized is explained. We can say that all the other answers are wrong. Considering the answers of the prospective teachers, we can come to the conclusion that they mostly (86.7%) do not know the property that electric charge is quantized.

In addition to the prospective teachers' remarks taken in written to the open ended questions to determine their level of understanding about electric charge, semi-structured interviews were conducted with randomly selected 6 people. In the interviews, it was observed that the opinions and answers of the prospective teachers confirmed their previous written statements/remarks and were very similar to them. Among the original answers obtained from 6 different people for different questions, 4 of them are presented below.

An electrically charged matter means a matter that is not neutral, that is its (+) and (-) charges are not equal

I don't know I wrote the answers just like this for most of the questions

I think grounding is the transfer of the electrons to earth

As I've written previously, what is quantum? If I had known what quantum was, I might have answered that question

CONCLUSION

Of the prospective teachers participated in the study, 22.1% could not explain that a matter is loaded with electric charge, 62.1% could not explain that an electrically charged matter can attract another susceptible neutral matter, 60.0% could not explain the grounding of an electrically charged matter and 86.7% could not explain that electric charge is quantized. Although electric charge is a basic topic taught to the study group in elementary and secondary school and at university, it can be observed from the findings of the study that the prospective teachers' understanding level on this topic is not at the desired level. When the statements in the tables, which include the written answers of the prospective teachers to the questions of the study are reviewed thoroughly, it can be said that electrostatics is not generally conceptually constructed in their minds truly and meaningfully.

Considering the results of some of the semi-experimental studies at elementary, and secondary school and undergraduate levels (Reaves, Floversve and Jewell, 1993; Yıldız and Büyükkasap, 2011a, 2011b, 2011c; Yıldız, 2012; Bozat and Yıldız, 2015), it is thought that using learning purpose writing activities may be useful in teaching electric charge topic. After the electric charge topic is explained to prospective teachers, they maybe asked to write/prepare a learning purpose writing activity (letter, summary, banner, poster...) for high school students.

Since a prospective teacher engaged in a writing activity will be on his own, she/he designs her/his own solutions for the problem, thinks and sees the deficient or sufficient parts of her/his designs, the desire and effort to eliminate the deficiencies may trigger a set of ideas and designs, even results in some small researches to be performed. In short, it may enable the writer to use her/his intelligence and skills. At the stage of writing, asthe respondents are younger high school students, the writer may use examples that can be associated with daily life and can be easily understood in order to be more explanatory. All these may enable the prospective teachers engaging in writing activity for learning to properly construct the electric chargetopic in their minds and learn it permanently.

It has become compulsory for the instructors or teachers to abandon their roles of doingand explaining everything in physics courses. In teaching electrostatics, the instructors should allow for dialogues which the students try to persuade each other by their own statements and explanations relevant to the concepts and properties related to the topic or for discussions which contrary ideas are spoken take place rather than being the one who does and explains everything. Prospective teachers participating in the discussions or just being present in the discussion environment may find the opportunity of thinking and then using their ideas and explanations. The usage of methods and activities, which enable prospective teachers to use their intelligence and skills, is thought to make it possible for them to learn the related topic better and also increase their level of understanding.

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