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Effect of Writing-to-Learn Strategy on Undergraduates' Conceptual Understanding of Electrostatics

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Abstract The purpose of this study is to explore the effect of Writing-to-Learn (WTL) strategy on undergraduates' conceptual understanding of electrostatics. The sample of the study was 54 university students registered at elementary school mathematics education department. While the experimental group was asked to conduct WTL activities like explanatory writing, the teachers in the control group carried on their classes with traditional methods like questioning. Conceptual discussions were made during the instruction in both groups. The data of the study were gathered by Electrostatics Conceptual Test. The data were analyzed both qualitatively and quantitatively. The results of the study showed that there was a significant difference between the levels of improvement of conceptual understanding in groups favoring the experimental group. It was suggested that writing-based activities should be used to improve the conceptual understanding of students in numerical calculation-based courses like physics and mathematics.

Keywords Writing-to-learn strategy · Electrostatics · Undergraduate · Conceptual understanding

Introduction

In Turkey, as in many other countries, there is diminishing interest in studying physics. This is despite all of our attempts in the physics education in our introductory courses sensitive to the needs of undergraduates, many of whom exhibit low conceptual understanding. There are several possibilities, some of which give cause for concern. One is that students come to see introductory physics as detached from everyday experience (Redish et al. 1998). Another possibility is that measurement tools used to evaluate students' knowledge do not reflect their epistemologies in contexts of reasoning within the course (Scherr and Hammer 2009). In order to attract students' attention toward physics and improve conceptual understanding, complementary instructional settings in physics education are needed in addition to the established ones. We, therefore, present a study on the use of WTL (Klein 1999) as a complementary educational tool in physics teaching. We know that science or physics educators generally refer to two ways of using writing in courses: knowledge telling and knowledge transforming (Yore et al. 2003). Traditional, knowledge telling writing tasks usually require students to write individually in a limited range of genres for evaluative purposes with the teacher as the only audience (Prain and Hand 1996). Unfortunately, students who use such a writing format do not improve a deep understanding about physics concepts.

Several studies have been conducted on the use of WTL as a means of fostering learning and thinking, and improving conceptual understanding in science (Akkus et al. 2007; Günel et al. 2010; Hand et al. 2004; 2007a; Hohenshell and Hand 2006; Kalman 2011; Mason and Boscolo 2000). Rivard (1994) concluded that when students use WTL strategies, they are more aware of language usage, demonstrate better understanding and better recall, and show more complex thinking about content. Mason and Boscolo (2000) found that the experimental (writing) group students reached a better conceptual understanding of the target concept and more advanced metaconceptual awareness of the changes in their own knowledge structures. Conceptual understanding,

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which deeply involves students in higher-order thinking processes, represents a particularly suitable experience for the need of using writing meaningfully, perceiving and evaluating it as a powerful activity (Mason and Boscolo 2000). Fellows (1994) investigated the effects of writing on conceptual understanding. This 12-week study with sixth graders sought to determine the usefulness of writing for assessing and understanding conceptions. At the beginning of the course, the students' beliefs conflicted with accepted scientific conceptions. The researcher found that students who wrote about relationships among concepts produced better understanding at posttest than others who emphasized non-writing activities. During instructional sessions, as students wrote to explore their own ideas, shared those ideas with peers, the teacher led scaffolded discussions, as an important activity to support students' social and cognitive development. Thus, students can apply their developing cognitive skills to real-life experiences as they engage in more abstract thinking. Furthermore, WTL helps students think about their thinking, a metacognitive skill that is crucial when constructing or modifying conceptual understandings (Swafford and Bryan 2000). In recent years, along with a lot of descriptive researches, there are also several empirical studies in the literature. These studies have been conducted on the effects of WTL strategies on students' learning or understanding concepts in science (Akkus et al. 2007; Günel et al. 2010; Hand et al. 2004; 2007a; Hohenshell and Hand 2006). They compared SWH (Science Writing Heuristic) which is a part of the WTL movement and adapted in laboratory sessions with traditional teaching practices.

There have been various writing studies in physics one of which is writing while preparing experiment reports. Allie et al. (1997) focused on writing-intensive physics laboratory reports in their study. The results of the study showed that students' preparing reports by intensive writing helped them to comprehend the experiment holistically by consolidating the individual experiences in physics laboratory. Klein's (2004) study which was exploratory tried to examine the relationships between university students' writing strategies, and their learning during writing about an experiment. First, students (non-science majors) carried out a physics experiment concerning either buoyancy, or the forces acting on a balance scale. Next, they wrote a journal-style note about the experiment, then provided another explanation of the phenomenon. The students' pre-writing explanations were compared to their post writing explanations, to determine whether each made "explanatory gains." The results generally exemplified a metacognitive, problem solving model of WTL. However, the researcher suggested that setting content goals, applying moderately sophisticated writing strategies, and extensive use of content sources were important for learning. Apart from writing experiment report, there were certain other studies apply writing in physics course. For example, Hein (1999) used a particular writing strategy, called a folder activity, which was used as a learning tool in an introductory physics course for non-science majors at American University. It was reported that folder activity has potential to increase problem solving and critical thinking skills of students. It was also mentioned that writing can help detecting individual misconceptions of students and supporting them to face with these misconceptions (Hein 1999; Kalman and Kalman 1996). Larkin (2011) used free writing activities to determine the opinions of the university students about basic mechanics concepts. The results of this study also proved that writing activities are more effective in detecting student misconceptions than traditional methods. The present study aims to compare WTL strategies such as writing reasoning to prompted questions and journal writing to traditional teaching practices in a physics course.

Students' Understanding of Electrostatics

Several studies stated that students and candidate teachers have some misconceptions and difficulties in understanding many concepts related to electrostatics (Baser and Geban 2007; Criado and García-Carmona 2010; Park et al. 2001). Most of these studies individually sampled electrostatics subtitles like "charge" and "capacitors" and they did not view electrostatics, including Gauss's Law holistically. The misconceptions students bear about electrostatics can be summarized as below (Şekercioğlu 2011):

1. Students have wrong ideas about charge distribution and charge conduction on conductor or insulator objects (Guruswamy et al. 1997; Maloney et al. 2001).
2. Since the wooden bar is an insulator, the needle of the electroscope does not move when wooden object is put between charged object and electroscope (Park et al. 2001).
3. The most distinctive misconception about electric force and Coulomb's Law is the idea accepting that the electric force which two charges apply on each other depends on neither of the charges (Maloney et al. 2001).
4. Students bear wrong interpretations about mathematical formulas of electric force, electric field, electric potential, and electrostatics energy and they confuse which to use (Bagno and Eylon 1997).
5. Gauss's Law is one of the most difficult topics for students. They confuse electric flux concept with electric current; they have the misconception that the electric flux through a Gauss plane does not uniquely depend on the charge in that plane; they confuse electric flux generated by charge in a Gauss plane with electric flux related to a plaque placed in a constant

electric field; so they make their calculations by confusing the formulas with one another (Singh 2006).
6. They have difficulties in explaining; what a capacitor does; what capacitance is, what capacitance depends on and how it changes with regard to distance between plates; how the insulator substance between the plates affects potential and energy.

Electrostatics is an abstract topic indeed. For this reason, students encounter various difficulties in understanding the issue as listed above. There have been very few experimental studies conducted investigating the effects of innovations other than traditional teaching in overcoming these difficulties in student understanding (e.g., Baser and Geban 2007; Şekercioğlu 2011). This review showed that there is a need for innovative instructional methods so as to improve conceptual understanding of the students in electrostatics topic. The previous studies have lacked in demonstrating how instructional methods change or improve conceptual learning. In this study, the student answers were grouped with respect to their understanding levels.

Method

Purpose

The purpose of this study was to examine the effectiveness of physics instruction supported with the WTL strategy over traditionally designed physics instruction on undergraduates' understanding of electrostatics. The specific research questions were:

(1) Are there any significant differences between the effects of WTL and traditionally designed physics instruction on students' understanding of electrostatics?
(2) What is the contribution of WTL to students' conceptual understanding levels?

Participants

The participants of the study were 54 (26 experimental, 28 control group) prospective elementary school mathematics teachers from two classes of physics II course instructed by the same teaching staff in a state university in eastern Turkey. The age of students ranged from 20 to 21 years.

Treatment

Duration of the study was approximately eight weeks. Detailed information is provided below about the instructional activities performed in two classrooms one of which was assigned as experimental and the other as control group during Physics II course in 2010-2011 spring terms.

Experimental Group

The instruction of new units began by asking interesting questions related to real life and with classroom discussions. Then, the teacher made necessary explanations about the topic, wrote the related formulas, and solved a couple of sample questions. After new information about the unit was given to students, the teacher applied the writing activities which are specific to the unit.

Explanatory Writing (EW): EW activities were applied by adapting to the instructional process of "Electric Fields," "Gauss's Law," "Electric Potential," and "Capacitance and Dielectrics" units. In general, the last 15–20 min of the two or four (2 + 2) block class hours were saved for EW. This writing activity was applied eleven times. The topic of them were "The movement of charges," "Electric field of charged sphere shells," "What if there is no water on earth!," "Electric field of objects having continuous charge distribution," "Electric flux of a closed surface," "Gaussian surface and electric flux," "Spherical shells with the same center," "Similarities between the concepts in mechanics and electrics", "Equipotential surfaces (see Appendix I)," "Capacitor and capacitance," and "Dielectric and capacitance." In EW, the students were helped with question prompts to solve problem cases. While these question prompts were being prepared, the topics and concepts which students have difficulty in understanding were emphasized. Students should recall their pre-knowledge and consider the concepts deeply while they were writing explanations for question prompts (Berthold et al. 2007). The process of EW helps students gather the necessary information to solve problems and figure out conceptual or procedural relations. Certain figures and pictures representing physical phenomena were used on sheets where question prompts were printed. They helped students visualize and write more detailed information in response to question prompts. Before students started their explanatory writings, they extensively discussed with each other and their teacher. After these discussions, students were asked to write their ideas in their own words. The combination of talking in peer discussion and writing individually can enhance the positive effects of both activities (Mason 1998; Rivard and Straw 2000). In the present study, the researcher gave 270 sheets of written feedback to individual writings of students on question prompts sheets. This effort demonstrated to students that the teacher was interested in what they wrote and they were encouraged to write more and more accurately about the concerned concepts. Demaree (2007) concluded that written feedback does impact student WTL in physics. Numerous studies have pointed out the importance and value of prompt and thoughtful feedback to students (Harmelink 1998; Hein 1999; Yang 2011). The positive feedbacks like "Good job, well done, you could do better" mean little for students. The feedback given in these exercises aimed to make students realize their weaknesses and their mistakes as well. Here are some examples of such feedback: "Then, what are the charges of M and K?"; "Does insulator matter also conduct charges?"; "You can compare electric fields of these points by using the distance between equipotential surfaces."; "When the charge of the capacitor is constant, the potential difference decreases, so the stored energy also decreases"; "Why do you think so?"; "You should also show the charge distribution." The researcher saved time for making students discuss the explanations by the researcher, fill the gaps in their understanding and ask questions.

Journal Writing: Journal writing was also used in the experimental group. Journal writing has proved effective in improving students' learning in various educational settings and subjects (Nückles et al. 2010). In the study, students were assigned to write daily form sheets including certain prompts at the end of each unit. Nückles et al. (2010) reported that journal writing is typically introduced as a regular follow-up course work activity in school and academic educational settings. Writing a journal entry after each weekly seminar session can be given as an example. In order to be sure that prompts supported the writing of effective learning journals, some specific prompts were used in journal forms (see Appendix II). The students filling the journal form with prompts were expected to review the unit holistically and to determine the points that they had difficulty. Each student wrote four journals in total.

Control Group

The lessons of the control group were presented by lecturing, questioning and with the help of power point presentations. The students in control group made oral discussions about the same questions used in the experimental group and noted the points written by the teacher on the board when the experimental group conducted writing activities.

Instruments

Electrostatics Conceptual Test (ECT)

There were some differences between the pre and post application tests in terms of content. Since the students encounter Gauss's Law and Dielectric subjects for the first time at university, only questions about topics from secondary school curricula were included in the pre-test.

Pre-ECT: 15 electrostatics related items were used from the test originally developed by Maloney et al. (2001). The reliability coefficient of the test was calculated as 0.66 with KR-20 formula.

Post-ECT: Since it was covering all electrostatics topics given in Physics II course, a test developed by Şekercioğlu (2011) with 0.67 Cronbach Alpha was used. The test has 20 items with two stages. While the first stage aims to evaluate conceptual knowledge of the student about electrostatics, the second stage inquires about the reason why students choose that particular choice. The Cronbach Alpha reliability coefficient of the test was calculated as 0.72 for this study, which means the reliability is within acceptable limits. Some sample items are presented in Appendix III.

Analysis of Instruments

Pre-ECT scored with 1 for each correct answer and 0 for wrong answered or unanswered ones. Thus, the maximum score is 15. It was determined whether there was a difference between two groups with regard to pre-knowledge with the application of *independent samples t test.*

In the analysis, process of two stage tests like Post-ECT categories were formed, and these categories were scored with respect to understanding levels (UL) (Çalık et al. 2010). After the pre-analysis of the student answers to Post-ECT was conducted, the categories in Table 1 were formed and they were scored. Categories were formed based on UL of A (3 points), B (2 points), C (1 point), and D (0 points). Whether there is a significant difference between experimental and control group in terms of conceptual achievement was determined with ANCOVA. The obtained data were subjected to graphical analysis to compare groups with respect to their understanding levels.

There are explanations with sample expressions for item 10 in the test about how the responses categorized. Level A represents responses of students marking the right choice in the first stage of the test and explaining the reasons of that answer in the second stage with scientific reasons. Here is a sample student response categorized at CCSU category: "The magnitude of electrical field is constant. Therefore, the electrical field force $F = q.E$ which has the same magnitude in every points of the field affects the charged objects and the magnitude of this force is not zero."

Level B tells that the answer in the first stage is correct and the explanation in the second stage is acceptable. A sample student response categorized at CCPU category: "All the forces are equal since the magnitude of the electrical field is constant and the same in every point."

Level C represents responses with right choice in the first stage but incomplete, irrelevant or no answer in the second stage. A sample student response categorized at

Table 1 Distribution of the categories and scoring of Post-ECT based on student understanding levels

UL	Categories	Point
A	Correct choice with sound understanding (CCSU)	3
B	Correct choice with partial understanding (CCPU)	2
C	Correct choice (CC)	1
	Correct choice with deficient or irrelevant understanding (CCDIU)	1
D	Incorrect choice with deficient or irrelevant understanding (ICDIU)	0
	Incorrect choice (IC)	0
	Incorrect choice with incorrect understanding (ICIU)	0
	No answer (NA)	0

CCDIU category: "Force is the same on every point of the electrical field."

Level D represents responses with wrong choice marked in the first stage and the explanation in the second stage is wrong, incomplete, and irrelevant, with wrong conceptions or the cases with no answer in the second stage. Responses with no answer to either stage were also grouped in Level D. Sample explanations grouped in ICDIU category were: "It gets faster as it goes through the electric field." and "Electric field force is constant." And, some sample student answers in ICIU category were: "The force affecting increases as it goes along the field."; "Since F and E are directly proportional and q values are the same then $F1 > F2$ with reference to $E = F/q = k.q/d$ formula."

Results

In order to investigate the effect of treatment on the dependent variables, and to control the students' previous learning about electrostatics before intervention, pre-test was administered. It was found that there was no significant difference between experimental group and control group in terms of achievement ($t = 0.096$, $p > 0.05$) before intervention.

ANCOVA applied, with pre-test scores controlled, to test the significance of the difference between post-test scores of the experiment and the control groups is presented in Table 2.

When ANCOVA results in Table 2 were examined, concerning the effect of pre-test scores, there was a significant difference between post-test scores of the groups favoring the experimental group ($F_{(1,\ 51)} = 30{,}492$; $p < 0.05$). The post-test scores of the groups were corrected with the effect of pre-test common variable. As seen in Table 3 there was a little change in post-test scores. Within ANCOVA, Benferroni test was used to compare corrected scores.

The second research problem of the study was to determine the effect of WTL strategy on student understanding level. Figure 1 represents the graphical analysis applied on data coming from Post-ECT to compare experimental and control groups with respect to understanding level.

Figure 1 shows that the student in experimental group more frequently gave Level A answers than the students in control group. It shows that the students in the experimental group were more successful than the students in the control group at choosing the right choice in the first stage of the question and making the right explanation. It was determined that the students in control group could not properly explain the reasons although they marked the multiple choices part correctly (Level C). There are no significant differences between the groups for responses categorized under level B and D (Level B: $t = 0.73$, $p > 0.05$, Level D: $t = 0.475$, $p > 0.05$). The students chose the wrong choice in the first stage of the questions at D level (except for NA, which had a very small ratio). In the explanations, there were wrong responses (ICIU) as much as irrelevant and insufficient ones (ICDIU).

Discussion and Conclusion

This study reports the effectiveness of WTL on the conceptual understanding based on a conceptual test on 54 students. It was determined that the activities based on WTL strategy had a positive effect on conceptual understanding in electrostatics unit. Similar previous studies stated that WTL strategy improves students' conceptual understanding (Fellows 1994; Hand et al. 2007b). This result may emerge from the reason that WTL consists of a series of activities requiring deep reflection and reorganization in mind (Hand and Prain 2002). WTL allows the writer to clarify his or her knowledge, organize the ideas to be written, and reflect on the learning experience. In this way, more cognitive understanding may occur in the WTL process. Conceptual understanding was expected to happen as a result of these cognitive processes taking place while writing (Prain 2006). Fellows (1994) found that students who wrote about relationships among concepts produced

Table 2 ANCOVA results of Post-ECT scores with respect to group, corrected according to Pre-ECT

Source	Sum of squares	Df	Mean square	F	Significance level (*p*)
Pre-test	174,240	1	174,240	3,708	0.060
Group	1432,723	1	1432,723	30,492	0.000
Error	2396,324	51	46,987		
Total	3990,000	53			

Table 3 Corrected post-test mean of the groups

Groups	*N*	Post-ECT	
		Mean	Corrected mean
Experimental	26	36,654	36,679
Control	28	26,393	26,369

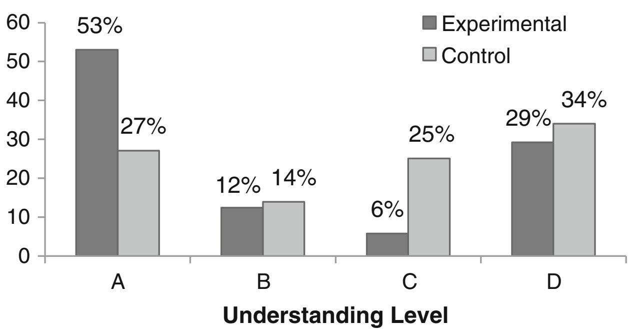


Fig. 1 Comparison of the understanding levels of the groups

better understanding at posttest than others who emphasized non-writing activities. "How writing affects learning" is a foggy issue still attracting the attention of researchers. However, it is a fact that writing can improve the skill of expressing ideas (Rivard 1994; Rivard and Straw 2000).

In addition, whether writing has effects on academic achievement is another popular research topic. Bangert-Drowns et al. (2004) conducted a meta-analysis study which showed that writing could have a small, positive impact on conventional measures of academic achievement. In this context, writing activities were supported with condensed conceptual discussions to secure conceptual development. It can be said that conceptual discussions carried out before EW provided deeper reflection on concepts discussed. One of the reasons why most of the students were engaged in these discussions may be their need for checking the accuracy of their thoughts because a need for organizing everything in detail arises just before writing. To satisfy this need, students needed to interact more with each other and with the teacher, which encouraged them to express their ideas more comfortably. As a result, exchange of knowledge among students was facilitated and constructing scientific thought became easier. In addition, writing these ideas individually requires logical organization in mind, which results in consolidation of knowledge. On the other hand, although conceptual discussions were also made in the control group where traditional writing was applied, the lack of WTL activities made students leave classroom before they organized their thoughts and interacted with peers and the teacher. Thus, the probability of occurrence of conceptual understanding was likely to be lower in students who did not use writing.

A test, with open-ended second stage, was used for this study since it was suitable for detecting conceptual understanding. The second stage of the test was expecting students to explain their ideas by writing. The conducted analysis showed that the students in the experimental group had a higher ratio of responding questions at Level A whereas the students in the control group had a higher ratio at Level C. It can be understood that these students who just copied what the teacher wrote or drew performed worse than the student who applied intensive writing in terms of writing ideas using proper expressions. So, it can be concluded that writing contributed to better description of thoughts by creating proper expressions. In addition, applying WTL activities for a long time may help students in terms of using expressions with scientific proof more frequently and making more logical and consistent explanations. So writing is a practical tool for encouraging heuristic thinking and learning (Mullin 1989). Hand et al. (1999) described writing as having the potential to bring about deeper understanding of science concepts by promoting personal meaning making in relation to scientific explanations. Those authors also promoted writing as a process that developed reasoning, an important aim of education tutors from all disciplines. A number of studies such as Mason and Boscolo (2000) and Kalman (2011) provide evidence for increased conceptual understanding in instructional contexts that include writing.

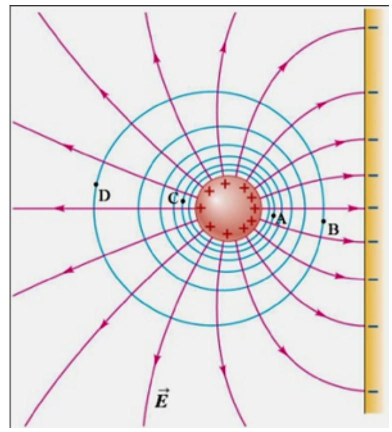
Bangert-Drowns et al. (2004) determined two factors boosting the effects of writing; the use of metacognitive prompts and increased treatment length. In this study, EW and journal writing activities were rendered better organized with the help of question prompts. These question prompts were not just instructions like: "do" or "write" but they were cognitive prompts orienting to form reason-result relationships like: "explain its reason"; "what happens if…?"; "what are the relations?"; and "compare". These prompts were supposed to help students recall their pre-knowledge, focus on logical explanations instead of mathematical operations and explain new concepts in a consistent way. The teacher provided constructive written feedback to students for these prompts without scoring and she set up discussion environments about the prompts. Hein (1999) reported that teachers' performing regular evaluation and feedback to student writings and making explanations about them in the classroom environment encourages students in terms of submitting better examples in the following writing activities. This process makes students more focused on finding out what parts were missing in their writings and what they should do to resolve these weaknesses. Besides EW activities in the classroom, the students were also assigned to write journals out of classroom during the eight application weeks. The teacher also gave feedback regularly to these journals. The feedback which was given regularly directed students to research written scientific resources more frequently. Thanks to this communication pathway developed between students and the teacher, it appeared that the students could tackle the contradictions in their mind more easily.

In this study, the effect of WTL strategy on conceptual understanding was investigated by analyzing some subject-based learning outcomes of the students. The analyses of writings in EW activities and in journals were not evaluated. Proper instruments can be developed and applied to evaluate writing skills or cognitive and affective improvements of students as Wang et al. (2011) and Atasoy (2012) did in their recent studies. Mullin (1989) confirmed that writing on topics in physics could be used to help students improve their writing skills.

Appendix I. An EW Activity

Equipotential Surfaces

The electrical field formed between a positively charged sphere and a negatively charged plate is marked with the red lines in the figure. The blue lines show equipotential surfaces and the points A, B, C, and D on equipotential surfaces.



(a) Sort the potentials of A, B, C, and D in descending order and explain the reason.
(b) What is the relation between the work done to carry a charged particle from point A to B and the work done when it is moved from C to D? Explain and write.
(c) Compare the magnitude of electrical field at A, B, and D points. Explain your answer.
(d) Draw the direction of the force affecting a positively charged particle at A, B, and D points. Compare and explain the forces.

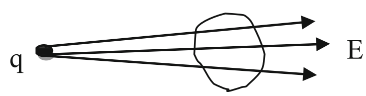
Appendix II. A Sample Student Journal

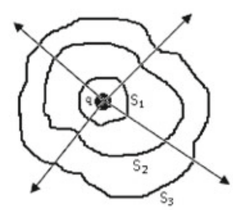
Name: Gökhan
Date: 23/03/2011

Physics Journal-3

Write a letter summarizing what we have learnt today to a friend of yours who was not in the classroom.

Dear friend, we learned electrical flux, Gaussian Surface, Gauss's Law and the applications of this law today. Electric flux is the numerical expression of electric field lines and it is symbolized with Φ. Φ =E.A. When a closed surface is mentioned we should think about Gaussian Surface. The relation between net flux passing through the surface and the charge held by the surface is defined as Gauss's Law. It is explained by $\Phi = E.A = q_{iç}/\varepsilon_o$ *formula. Since the number of electrical field lines going into the surface and coming out of the surface are the same, net flux passing through a closed surface with no charge is zero. Since the amount of charges are the same in different shaped surfaces surrounding a charge q, net fluxes passing through these closed surfaces are the same.*





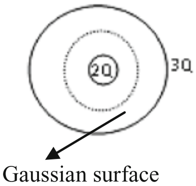
$\Phi_1 = \Phi_2 = \Phi_3$
As q_{encl} *is the same.*

Sequence the concepts talked in the lessons and define the relations.

- *Electric Flux*
- *Gaussian Surface*
- *Gauss's Law*
- *Application of Gauss's Law on planes with spherical symmetry, cylindrical symmetry and insulator surfaces*

Write the difficulties and problems you have faced with the unit.

I had difficulty in understanding the part of a spherical layer called electric field because I didn't know how much charge there was on a given point when we drew a Gaussian Surface. I didn't understand which charge we choose when we want to calculate the flux.



Gaussian surface

What is the most important piece of knowledge that you did not know before the lesson but learned after it?

I used to know that we can calculate flux with Φ=E.A formula. Most of the information was new to me. The most important of them was finding electric field by drawing Gaussian surface.
$\Phi = E.A = q_{encl}/\varepsilon_o$ *Gauss's Law*

Appendix III. Some Pattern Items from Post-ECT

Item 8 and 9 were used in multiple choice formats without expecting any explanation in Pre-ECT, as well. The right choices were written in bold

Explanation for items 8 and 9: A positively charged particle was placed in the middle of a regular, constant, and stable electric field placed in anywhere in 3-dimensional space.

8. Which of the followings is right for the further movement of the particle if it is left free in the center of the field?

A. Moves with constant speed.

B. Moves with constant velocity.

C. Moves with constant acceleration.

D. Moves with linear changing acceleration.

E. Stay motionless on the point initially placed.

Briefly explain your answer.

9. What would be the electric potential energy of the positively charged particle left in the constant electric field?

A. It remains constant because there is a constant electric field.

B. It remains constant because the charged particle is motionless.

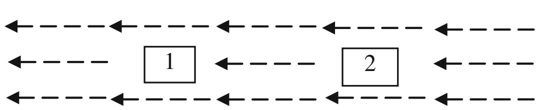
C. It increases because the charged particle moves along the electric field.

D. It decreases because a charged particle moves in opposite way of the electric field.

E. It decreases because a charged particle moves in the same way of the electric field.

Briefly explain your answer.

10. Suppose that a positive charge is placed at one of the two different points 1 and 2 in the constant electric field shown below.



Which of the followings are true for the comparison of the electric forces affecting this charge in position 1 and position 2?

A. The force affecting the charge is greater at position 1.

B. The force affecting the charge is greater at position 2.

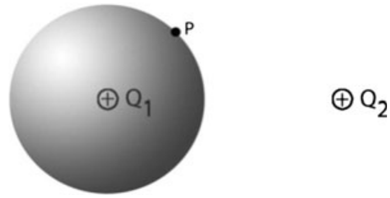
C. The force is zero in both positions.

D. The forces are the same in both positions but it is not zero.

E. The forces are same in magnitude in both positions but align in different directions.

Briefly explain your answer.

18. Imagine a spherical Gaussian Surface with $+Q_1$ point charge placed inside. There is a P point on the surface and $+Q_2$ point charge out of the sphere. The net flux on the surface of the sphere is Φ_s and the electric field at point P is E_p. So which of the following cases is true?



A. Both charges contribute to electric flux (Φ), but only the charge $+Q_1$ forms the electric field at point P.

B. Both charges contribute to electric flux (Φ), but only the charge $+Q_2$ forms the electric field at point P.

C. Both charges contribute to electric field at point P, but only the charge $+Q_1$ forms the electric flux.

D. The charge $+Q_1$ neither has an effect on the electric flux (Φ) nor on the electric field.

E. The charge $+Q_2$ has an effect neither on the electric flux (Φ) nor on the electric field.

Briefly explain your answer.

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