Effect of Conceptual Change Instruction on Students' Understanding of Electricity Concepts

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Abstract
This study focuses on students' misconceptions regarding static electricity, the effectiveness of conceptual change instruction on students' understanding of static electricity and their attitudes towards physics. The subjects of the present study consisted of 70 tenth-grade students (39 boys and 31 girls) from two physics classes taught by the same teacher in a high school in Turkey. Students' ages ranged from 16 to 17 years.
The results showed that the students have misconceptions and the experimental group students performed better with respect to the success in eliminating the misconception compared to the control group. In addition, it has been found that there was no significant difference between the attitudes of students in the experimental and control groups both before and after teaching. Teaching strategies can be used to determine the misconceptions and enhance students' understanding.

1. Introduction
Misconceptions are very common in all topics of physics such as mechanics [1, 2], electricity [3-5], optics [6], and thermodynamics [7,8]. One of the most important outcomes of research on misconceptions is that educators need to worry about misconceptions for meaningful learning [9,10]. Poor and incorrect knowledge presentation in textbooks, teachers' incorrect or lack of knowledge about the topics, students' incorrect knowledge learned before their school life can cause misconceptions. A large number of research studies in physics education have focused on students' understanding of electrical concepts [11-16].

1.1 Conceptual changes
A conceptual change approach based on Piaget's [17] construct of disequilibrium and dealing with students' alternative conceptions has been developed over the past 20 years, and has become a central organizing concept in both science education research and science teacher education [18]. One particularly influential view of science learning was outlined in the conceptual change model [10,19]. The model has two major components. One is the set of conditions for conceptual change, three of which were originally described as the intelligibility, plausibility, and fruitfulness of a concept as seen by a learner.

1.2 Effectiveness of simulation and conceptual change texts in science education
In this study, simulations and conceptual change texts were used in conjunction to challenge and hopefully change students' misconceptions related to static electricity concepts. Use of computer simulations makes complex systems accessible for students of varying ages, abilities, and learning levels. The computer, instead of the student, can assume the responsibility of processing the underlying mathematics in order to let the student begin exploring a complex system by first focusing on conceptual understanding [20, 21].
The meaning of conceptual change-oriented textual information is not derived wholly from the reading of the text but from the interaction of the reader with the textual information. The construction of meaning occurs when the textual information is concerned with and modifies the students' existing knowledge. The modified prior knowledge is then used to direct subsequent learning. The textual

information for causing better acquisition of scientific conceptions should enable students to progress at their own pace and force them to use their thinking ability. In the present study, a group of texts was grounded in conceptual change approach.

2. Method

2.1 Purpose

The purpose of this study was to determine the students' misconceptions and how conceptual change instruction based on conceptual change text and simulation affects students' understanding of static electricity concepts and their attitude towards physics.

2.2 Subjects of the study

The subjects of the present study consisted of 70 tenth-grade students (39 boys and 31 girls) from two physics classes taught by the same teacher in a high school in Turkey. Students' ages ranged from 16 to 17 years. The data were obtained from 36 students in the experimental group and 34 students in the control group.

2.3 Instruments

2.3.1 Static Electricity Concepts Test (SECT)

This test was developed by the researchers. The test contained 25 multiple-choice questions. Each question had one correct answer and four distracters.

2.3.2 Physics Attitude Scale (PAS)

The purpose of this scale, which was developed by the researchers, was to measure students' attitudes toward physics as a school subject. This instrument contains 34 items in a five-point Likert-type scale (fully agree, agree, undecided, partially disagree, and fully disagree). The reliability was found as 0.88.

2.4 Treatment

This study was conducted over a four-week period. The classroom instruction for both groups was given by the same teacher. The classroom instruction for both groups involved four 50-minute periods per week. The same topics related to electric concepts were covered for both the experimental and control groups. The control group received traditional instruction which involved lessons using lecture/discussion methods to teach concepts. Teaching strategies relied on teacher explanation and textbooks, with no direct consideration of the students' alternative conceptions. The teacher structured the entire class as a unit, wrote notes on the chalkboard about the definition of concepts, and passed out worksheets for students to complete.

In the experimental group, the conceptual change text and simulations were used as conceptual change activities. The teacher provided opportunities for students to be involved in discussion and question-and-answer sessions while studying the conceptual change text. In the conceptual change text, students were asked explicitly to predict what would happen in a situation before being presented with information that demonstrated the inconsistency between common alternative conceptions and the correct scientific conceptions. In each of the texts, the topics were introduced with questions, and students' possible answers that were not scientifically accepted were mentioned directly. In this way students were expected to be dissatisfied with their current conceptions.

The other activity included computer simulations. The simulations were used to illustrate physical concepts in the experimental group. The instructor presented the simulation and focused on particular aspects of the event to highlight a physical concept and asked the students to understand only that particular event. By putting the concept into the context of the simulation, we have an event that the students can visualize while trying to understand the concept. The simulations used in this study were related to charge transfer, electric fields line, movement of the electron between charged plate and Coulomb Law.

3. Results

In this study, the independent group *t*-test was used in order to investigate the effect of treatment on the dependent variables. The dependent variables were students' attitudes towards physics (PAS) and their static electricity concept achievement measured by post-static electricity concept test scores Post-Static Electricity Concept Achievement. The independent variables were students' Pre-static Electricity Concept Achievement measured by pre-static electricity concept test scores. Students' previous learning about static electricity concepts and prior attitude towards physics as a school subject were administered as pre-tests, namely, PRESECA and PAS. It was found that there was no significant difference between the experimental and control groups in terms of achievement (t = –.238, $p > 0.05$, Xexp10.88, Xcontrol11.08=), and attitude towards physics (t = –1.52, $p > 0.05$).

After treatment, the analysis showed that the post-test mean scores of the experimental group and control group with respect to the achievement related to static electricity concepts were significantly different. The experimental group scored significantly higher than the control group (t = 5.01, $p < 0.05$, expX20.66=, controlX16.=). 64

On the other hand, *t*-test analysis showed that there was no significant difference between the mean scores of the experimental group and the control group with respect to their attitudes towards physics after treatment (t = –0.14, $p > 0.05$).

The pre-test average of correct responses of the experimental group was 43.5% and that of the control group was 44.3% and the post-test average of correct responses of the experimental group was 82.7% and that of the control group was 66.7%. When the proportion of correct responses and misconceptions determined by the item analysis for the experimental and control groups was examined, significant differences in several items between the two groups in favour of the experimental group were indicated. For example, the students in the experimental group abandoned the idea that *electric charges can be produced*. However, the students in the control group (19%) still thought that *electric charges can be produced*.

Students in the experimental group (5%) held the misconception that *charge transfer occurs between the two spheres, which have the same electrical potential*. This idea was higher in the control group (about 28%).

The majority of the students in the control group still thought that *electric fields do not equal zero within the conductive spheres*. This idea was abandoned completely by the experimental group students.

The students in the control group (67%) still thought that *the electron moves towards the electric fields line, proton moves oppositely*; this concept was shared by 14% of students in the experimental group.

Most students in the control group (47%) still had difficulties about the concept that *the intensity of the electric field does not depend on distance*. In contrast, a much smaller percentage (8%) of the experimental group held the same idea.

In the experimental group, 9% of the students held the misconception that *the numbers of electric field lines do not depend on amount of charge,* compared to about 26% in the control group.

Students in the control group (34%) still thought that *each object was negatively charged with frictional electrification*. This idea was abandoned completely by the experimental group students.

Majority of the students (63%) in the control group still thought that *electric field lines move towards the positive charge*, compared to 11% in the experimental group.

4. Conclusion

The results of the study revealed that students have inadequate understandings of the concepts of static electricity and that they showed some misconceptions to a large extent. Different instructional strategies can be used to solve this problem. In addition to textbooks used, schools should be organized to enhance students' understanding of conceptual science through learning by thinking, questioning and researching. Similar studies should be carried out in other areas of physics to identify possible misconceptions and improve teaching strategies.

References

[1] Towbridge, D.E. and McDermott, L.C. (1981) 'Investigation of student understanding of concept of acceleration in one dimension', *American Journal of Physics*, Vol. 49, pp.242–253.

[2] Eryılmaz, A. (2002) 'Effects of conceptual assignments and conceptual change discussion on students' misconceptions and achievement regarding force and motion, *Journal of Research in Science Teaching*, Vol. 39, No. 10, pp.1001–1015.

[3] Maloney, D.P., O'kuma, T.L. and Hieggelke, C.J. (2001) 'Surveying students' conceptual knowledge of electricity and magnetism', *American Journal of Physics*, Vol. 69, pp.12–23.

[4] Sencar, S. and Eryılmaz, A. (2004) 'Factors mediating the effect of gender on ninth-grade Turkish students' misconceptions concerning electric circuits', *Journal of Research in Science Teaching*, Vol. 41,

[5] Başer, M. and Geban, Ö. (2008) 'Effect of instruction based on conceptual change activities on students' understanding of static electricity concepts', *Research in Science & Technological Education*, Vol. 25, No. 2, pp.243–267.

[6] Feher, E. and Rice, K. (1992) 'Shadows and anti-images: childrens' conceptions of color', *Journal of Research in Science Teaching*, Vol. 29, pp.505–520.

[7] Bar, V. and Travis, A.S. (1991) 'Children's viewpoints concerning phase changes', *Journal of Research in Science Teaching*, Vol. 28, pp.363–382.

[8] Ma-Naim, C., Bar, V. and Zinn, B. (2002) 'Integrating microscopic macroscopic and energetic descriptions for a conceptual change in thermodynamics', Paper presented at the *Third European Symposium on Conceptual Change*, Turku, Finland, 26–28 June.

[9] Gil-Perez, D. and Carrascosa, J. (1990) 'What to do about science "misconceptions"', *Science Education*, Vol. 74, No. 5, pp.531–540.

[10] Hewson, M.G. and Hewson, P.W. (1983) 'Effect of instruction using students' prior knowledge and conceptual change strategies on science learning', *Journal of Research in Science Teaching*, Vol. 20, No. 8, pp.731–743.

[11] Lee, Y. and Law, N. (2001) 'Exploration in promoting conceptual change in electrical concepts via ontological category shift', *International Journal of Science Education*, Vol. 23, No. 2, pp.111–149.

[12] Wang, T. and Andre, T. (1991) 'Conceptual change text versus traditional text and application questions versus no questions in learning about electricity', *Contemporary Educational Psychology*, Vol. 16, pp.103–116.

[13] Pardhan, H. and Bano, Y. (2001) 'Science teachers' alternate conceptions about direct-currents', *International Journal of Science Education*, Vol. 23, No. 3, pp.301–318.

[14] Cosgrove, M. (1995) 'A study of science-in-the-making as students generate an analogy for electricity', *International Journal of Science Education*, Vol. 17, No. 3, pp.295–310.

[15] Chambers, S. and Andre, T. (1997) 'Gender, prior knowledge, interest and experience in electricity and conceptual change text manipulations in learning about direct current', *Journal of Research in Science Teaching*, Vol. 34, No. 2, pp.107–123.

[16] Millar, R. and King, T. (1993) 'Students' understanding of voltage in simple series electric circuits', *International Journal of Science Education*, Vol. 15, No. 3, pp.339–349.

[17] Piaget, J. (1950) *The Psychology of Intelligence*, New York: Harcourt Brace.

[18] Thorley, N.R. and Stofflett, R.T. (1996) 'Representation of the conceptual change model in science', *Teacher Education*, Vol. 80, No. 3, pp.317–339.

[19] Posner, G.J., Strike, K.A., Hewson, P.W. and Gertzog, W.A. (1982) 'Accommodation of a scientific conception: toward a theory of conceptual change', *Science Education*, Vol. 66, pp.211–227.

[20] De Jong, T. and van Joolingen, W.R. (1998) 'Scientific discovery learning with computer simulations of conceptual domains', *Review of Educational Research*, Vol. 68, No. 2, pp.179–201.

[21] Penner, D.E. (2001) 'Cognition, computers, and synthetic science: building knowledge and meaning through modeling', *Review of Research in Education*, Vol. 25, pp.1–35.